ASTROPHYSICS AND SPACE SCIENCE PROCEEDINGS

Jarita Holbrook
Rodney Medupe
Johnson Urama
Editors

African Cultural Astronomy

Current Archaeoastronomy and Ethnoastronomy Research in Africa

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Jarita C. Holbrook
Editor

University of Arizona, Tucson, AZ, USA

R. Thebe Medupe
Editor

University of Cape Town, Rondebosch, South Africa

Johnson O. Urama
Editor

University of Nigeria Nsukka, Enuga State, Nigeria

Springer

Editors
Jarita C. Holbrook
University of Arizona
Tucson, AZ
USA

R. Thebe Medupe
University of Cape Town
Rondebosch
South Africa

Johnson O. Urama
University of Nigeria Nsukka
Enuga State
Nigeria

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Contributors

Audra Baleisis
University of Arizona

M.E. Bonine
University of Arizona

Robert Brenmer
40, Kingsway, Aldwick
West Sussex P021 4DL, U.K

Sanlyn Buxner
University of Arizona

Nick Campion
Director of the Sophia Centre for the Study Cosmology in Culture, and Senior Lecturer in Archaeology and Anthropology,
University of Wales, Lampeter, UK.
E-mail: n.campion@lamp.ac.uk

Felix A. Chami
History/Archaeology Department,
University of Dar es Salam
E-mail: fchami@udsm.ac.tz

Barth Chukwuezi
Association of Professor
Department Of Sociology/
Anthropology, University Of Nigeria
Nsukka

Mamadou Dembele
Faculte des Sciences et Techniques
Universite de Bamako, Mali

Drissa Diakite
Faculte des Sciences et Techniques
Universite de Bamako, Mali

Basil U. Eze
Department of Geography and Meteorology, Enugu State
University of Science and Technology,
Enugu, Nigeria

Sharron Hawkes
Dogged Films, Johannesburg,
South Africa

Jarita C Holbrook
Bureau of Applied Research
in Anthropology University of Arizona
Email: holbrook@u.arizona.edu
FAX: +1-520-621-9608

Shawna Holbrook
International Foundation for Education and Self-Help (IFESH), Benin

Shamil Jeppie
History Department
University of Cape Town
South Africa

Mamadou Kanoute
Faculte des Sciences et Techniques
Universite de Bamako, Mali

Ahmed Maiga
Faculte des Sciences et Techniques
Universite de Bamako, Mali

Mohammed Maiga
Faculte des Sciences et Techniques
Universite de Bamako, Mali

J. McKim Malville
University of Colorado
(303) 492-8766
E-mail: kim.malville@colorado.edu

Rodney Thebe Medupe
Astronomy Department
University of Cape Town
E-mail: thebe@saao.ac.za

Hakeem M. Oluseyi
Florida Institute of Technology
(321) 674-7247
E-mail: holuseyi@fit.edu

Salikou Sanogo
Faculte des Sciences et Techniques
Universite de Bamako, Mali

Romauld Schild
Institute of Archaeology and Ethnology
Polish Academy of Science, Warsaw

Aimé Dafon Sègla
ORKESTRA Consulting
16 Place de la Madeleine
75008 Paris
Tel: 01 44 51 51 53/57
Portable: 06 19 31 87 42
E-mail: a_s_aime@yahoo.fr,
asegla@orkestra.biz,
aime.segla@ethnologie.uni-halle.de

Timothy F. Slater
University of Arizona,
933 N. cherry Ave., Tucson,
AZ 85721 USA,
Telephone: (520) 621-7096
Fax (520) 621-1532

Bernard Sodio
Faculte des Sciences et Techniques
Universite de Bamako, Mali

Laya Tembely
Faculte des Sciences et Techniques
Universite de Bamako, Mali

Sibiri Traore
Faculte des Sciences et Techniques
Universite de Bamako, Mali

Johnson Urama
Department of Physics
and Astronomy
University of Nigeria, Nsukka

Brian Warner
Astronomy Department
University of Cape Town
E-mail: thebe@saao.ac.za

Fred Wendorf
Department of Anthropology
Southern Methodist University, Dallas

Damian. U. Opata
Department of English
and Literary Studies,
University of Nigeria, Nsukka, Nigeria
E-mail: optdamian@fastmail.fm

Chasing the Shadow of the Moon: The 2006 Ghana Eclipse Conference

Jarita C. Holbrook

Abstract The March 29, 2006, total solar eclipse was a celestial event fortuitously passing over many of the most modern countries of West Africa: Ghana, Togo, Benin, and Nigeria. For those of us researching the cultural astronomy of Africans, it fit into our discourse: a rare celestial event to which Africans would be responding. And, we upped the ante by organizing a conference on the cultural astronomy of Africans for the week of the eclipse. This report details the process of creating the first international conference dedicated to the cultural astronomy of Africans which was also the first cultural astronomy conference to include workshops and training sessions for non-specialists. The strategies for fund raising, attracting participants, and interacting with the international media are presented. I highlight the achievements of this conference project and include a section on the lessons learned. Because of the establishment of an anthropology internship class for undergraduates; the workshops for undergraduates, teachers, and researchers; and the total solar eclipse the Ghana Eclipse Conference was a unique and also successful project. May our strategies serve as a blueprint for the next African cultural astronomy conference. I next give an overview of this volume of the conference proceedings and end with a discussion of research methods in African cultural astronomy.

African Astronomy: Past and Present

> "... [H]istory in illiterate societies is not different from the pursuit of the past in literate ones, because it uses archaeological, linguistic, anthropological, and even (for dating purposes) astronomical evidence such as eclipses." [53: 1]

The term 'cultural astronomy' emerged from the Oxfords meetings in Archaeoastronomy in the 1980s and 1990s. "Astronomies and Cultures" the title of the conference proceedings from the third Oxford conference in 1990 reflects a fundamental

Jarita C Holbrook
Bureau of Applied Research in Anthropology, University of Arizona
E-mail: holbrook@u.arizona.edu
Fax: +1-520-621-9608

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Fig. 1 Picture taken by S. Buxner of the paper on Saturday after the eclipse. Astronomy and Culture in action in Ghana

shift in thinking about astronomy: the way that astronomy entwines in culture is not universal and that all astronomy is culturally embedded [1]. A shift in terminology tried to capture this by moving towards "astronomies" and "cultural astronomy" [2]. Focusing on the continent of Africa, encompassing both North Africa and South of the Sahara, terminology needs clarification as to what is meant by "African cultural astronomy" or "African astronomy." Neither term is meant to imply an uniform homogenous expression of astronomy Africa wide. Rather that with the term "African astronomy" African is a placeholder for the African ethnic group of interest such as Igbo astronomy, Bamana astronomy, or Sandawe astronomy or equivalently Yoruba cultural astronomy, and so on.

Cultural astronomy combines knowledge and methods from the fields of astronomy, anthropology, and history in order to study the practices and traditions of lay experts and non-experts who relate, in the broadest sense, to the sky. The quote above references how historians of Africa have used astronomy in their research: Eclipses are used to aid in the dating of oral histories [3, 4, 5]. Rather than how astronomy can aid in the study of Africa, there is the cultural astronomy study of the astronomy of Africans. Since 1997, my research has focused on the cultural astronomy of Africa, also referred

Fig. 2 Audra Baleisis with telescope tracking the eclipse on the University of Cape Coast campus. Picture by S. Buxner

to as the indigenous or traditional astronomy or ethnoastronomy of Africa. After many years as an astronomer, my interests and research shifted to studying the ways that non-scientists view the sky, both historically and today.

The modern study of the cultural astronomy of sub-Saharan Africa can be traced back to an archaeoastronomical study of the Great Zimbabwe ruins at the end of the 19th century [6], which involved archaeological surveys and the determination of alignments to celestial bodies, a method popularized by Norman Lockyer's work on Stonehenge and temples in Egypt [7, 8]. However, there is a large corpus of writings in Arabic, English, French, German, and Portuguese describing various aspects of African astronomy spanning five centuries. These sources include primary sources such as administrative reports, Arabic documents, field notes, journal entries, travelers' notes, and secondary sources such as published articles and book chapters.

The most well-known cultures that come to mind when African astronomy is mentioned are the Dogon of Mali and the ancient Egyptians. The Dogon rose to prominence due to the work of French anthropologist, Marcel Griaule [9, 10]. Using participant observation and interviews, Griaule uncovered evidence that people in the Dogon village where he worked had knowledge of the invisible companion

Table 1 Beginning articles in african cultural astronomy

Articles	African Ethnic Groups
Starr 1990	Bantu, Hottentots & Bushmen (Khoisan), Pygmies, Sudanese
Aveni 1993	Batammaliba, Borana, Dogon, Igbo, Khoisan, Mursi, Mbudge, Nuer, Ngas, Tabwa
Warner 1996	Basutu, Chopi, Dogon, Herero, Ibibio, Igbo, Iraqw, Karanga, Khoisan, Kikuyu, Lamba, Luyia, Mapela, Masai, Mursi, Naron, Nyabungu, Nyasa, San, Sandawe, Sotho-Tswana, Swahili, Swazi, Tsonga, Venda, Xhosa, Zande, Zulu
Doyle and Frank 1997	Borana, Dogon, Karanga (Shona)
Snedegar 2000	Ashanti, Bamana, Basutu, Batammaliba, Bemba, Borana, Dogon, Hausa, Hlubi, Igbo, Khoisan, Kuba, Luba, Malagasy, Mamprusi, Mbunda, Mursi, Ndembu, Nyasa, San, Shona, Somali, Sotho, Swahili, Swazi, Tabwa, Tsonga, Tswana, Zulu

star to Sirius before astronomers. Griaule's work has been the basis of many other scholars explorations into the Dogon and their starlore [11, 12, 13, 14, 15, 16, 17], including ancient alien visitor theorists [18]. The Egyptians have many works of art with representations of celestial bodies and celestial Gods [19, 20, 21]. Their pyramids have been subject to archaeoastronomy study with alignments to celestial bodies in mind [8, 22] and, again, some authors have evoked ancient alien visitors [23]. The ancient alien visitor theory, unscholarly as it is, has probably caused the preeminence of these two cultures in popular consciousness. Yet, also has caused the vast diversity of African cultural astronomy knowledge to be overlooked.

A handful of historiographical articles contain a wealth of information about various ethnic groups in Africa and their cultural astronomy. "Sub-Saharan African Astronomical Mythology" [24]; "Africa's Socialized Astronomy" [25]; "Traditional Astronomical Knowledge in Africa" [26]; "Astronomy in Africa" [27]; and "Astronomical Practices in Africa South of the Sahara" [16]. Table 1 shows the ethnic groups presented in these articles. These articles are good for presenting a quick overview of the research that has been done and that which is possible in African cultural astronomy.

This volume is the result of a major event meant to expand the study of African cultural astronomy: the Ghana Eclipse Conference. The Conference was the first meeting held in Africa focused on the astronomy traditions of Africans, the first international cultural astronomy meeting to include workshops, and the first international science meeting to coincide with viewing a total solar eclipse. The Conference brought together scholars with active projects and those who worked on past projects, Africans and international scholars.

The Stakeholders

What follows is a description of the stakeholders for the Ghana Eclipse conference, their backgrounds and some of their motivations.

1) The National Society of Black Physicists – During the early planning stages of the Conference the National Society of Black Physicists (NSBP) took an active role. They specifically wanted the National Science Foundation (NSF) grants and other grants be submitted through their organization. The advantage of this strategy for the Conference was that NSBP does not charge overhead which is 51% at the University of Arizona, my home institution; instead NSBP only includes a support charge depending on the size and type of grant. The planning of this conference coincided with physics communities' around the world plans for conferences honoring the 100th year of Albert Einstein's relativity.
2) The Edward Bouchet Abdus Salaam Institute (EBASI) interest in having their name on the Ghana Eclipse Conference was because they had committed to having their Einstein meeting in Ghana but then changed to South Africa. Thus, they could use the Ghana Eclipse Conference to fulfill their earlier promise. For the conference, EBASI nor NSBP provided web page support and connections to the physics department at the University of Cape Coast. These Black physics organizations see African cultural astronomy as part of their own history but also as a great tool for teaching scientific principles to Black students worldwide.
3) The University of Arizona, the University of Alabama in Huntsville, and Morehouse College supported the conference financially. Morehouse College sent three professors and their Media Arts Department fully funded the creation and broadcast of an hour-long eclipse program that appeared on CNN.com. The University of Arizona sent three professors and nine students subsidized by funds from Jane Hill's Regents Professor Funds, the Magellan circle, the College of Science, and the College of Education. The University of Arizona's College of Optical Sciences and Steward Observatory provided funds to subsidize the travel of the international speakers. The University of Arizona supported the conference because of its connections to astronomy, culture, and solar physics, and because it provided students with an international educational opportunity. The University of Alabama in Huntsville sent one professor and two students. One of the students was supported by a solar physics grant held by NASA scientist Alphonse Stirling at NASA Marshal Spaceflight Center in Huntsville, Alabama, who also attended. Both NASA and the University of Alabama in Huntsville conducted experiments during the eclipse and used the eclipse day activities to encourage students to pursue careers in astronomy and solar physics.
4) Samuel Mensah is the Dean of the Faculty of Sciences at the University of Cape Coast. He is an optical scientist physicists trained in the USSR. His investment is in increasing the international reputation of the University of Cape Coast and fostering international scientific collaborations. He was eager to have the conference occur at the University of Cape Coast and helped tremendously with the local logistics and hotel negotiations. The conference and the eclipse day activities were an opportunity to showcase the University of Cape Coast, its professors, and its programs. Prof Mensah is interested in increasing interactions and exchanges with international students and with Optical Sciences at the University of Arizona. In Ghana, classes are in English and the Cape Coast campus with its

panoramic views of the ocean is a favorite with students making future exchanges a strong possibility.

5) The following Nigerian professors were the major stakeholders in the conference: Alexander Animalu, Johnson Urama, and Damina Opata. These three were instrumental in organizing the first conference on cultural astronomy in Africa: "International Conference On Ethno-Astronomy In West African Subregion." That conference was to be held in Nigeria. However, the events of 9/11/2001 resulted in a marked drop in international travel. There were simply not enough attendees to merit having the conference go forward. But what the announcement of the 2002 conference achieved was that those scholars working in African cultural astronomy became aware of one another and began corresponding regularly. The Nigerian committee members were instrumental in the success of the Ghana eclipse conference.
6) Jarita Holbrook – For me, to bring together as many of the scholars who work on research related to African cultural astronomy today or in the past, was critical to my research, my career, and for future funding. Early on, my path into studying the cultural astronomy of Africa began with first contacting the many reputable researchers working in archaeoastronomy and ethnoastronomy, including Keith Snedegar who focuses on the astronomy of South Africa [16, 28, 29, 30]. However, it was not until the 2002 conference announcement that I discovered African scholars working in this area using a variety of methods and the current network of scholars emerged [31, 32].

The Conference Structure

When applying for funding, the Committee Members discovered the following: The National Science Foundation (USA) only supports workshops that advance science rather than conferences, the Spencer Foundation focuses on educators and pedagogy, and the Department of Education wants proposals to support training and educating students. The easiest way to meet these criteria were to have three separate workshops, thus the idea of having morning workshops was born with conference lectures in the afternoons.

The student workshop provided training in those background subjects and research methods needed to become a leading scholar of astronomy and culture research in Africa. Lecturers Kofi Maison and Oheneba Achaempong were recruited from the University of Cape Coast, Ghana, in Geography and History with a special focus on Africa and how these could relate to cultural astronomy research. Clive Ruggles from Leicester University in the United Kingdom taught archaeoastronomy methods and Thebe Medupe from University of Cape Town, South Africa, focused on naked-eye astronomy. The final topic was cultural anthropology methods taught by Barth Chukwuesi of the University of Nigeria, Nsukka. The students were exposed to African professors who were experts in their fields and also familiar with the cultural astronomy of Africans.

The expert scholars who gave the afternoon conference lectures also participated in a workshop designed to advance the field of African cultural astronomy. The sessions that made up the workshop included considering creating a new organization, a new journal, a new academic program, sources of funding, identifying new UNESCO world heritage sites, and new joint projects. The results of this workshop are presented in the achievements section of this paper.

The goal of the K12 educators workshop was to incorporate African cultural astronomy information into classrooms in the United States and Africa. The session was moderated by Timothy Slater of the University of Arizona. He is an astronomy education specialist and has extensive experience running workshops for K12 educators. The workshop brought together the teachers for the task of creating a lesson plan using African cultural astronomy content.

These workshops were the first of their kind for cultural astronomy conferences and unique for scientific meetings in Africa. Many of the participants, especially the K12 educators and the students, expressed their approval of the structure and hope that it will be adopted for other conferences.

Pre-eclipse Activities: The Ghana Internship Class

To attract more University of Arizona students, a discussion based internship class was created that provided three units of undergraduate or graduate credit to each enrolled student. The goals of the class were to introduce the students to the field of cultural astronomy, cultural astronomy research in Africa, pre-travel arrangements for Ghana, and a final term paper (for the syllabus see the appendix). Students could not take the class unless they were going to Ghana for the eclipse. Four graduate students and six undergraduates participated with all except one graduate student going to Ghana. The graduate students, besides participating in the class and the student training sessions in Ghana, helped organize and run the K12 educators workshop at the Conference. Combining a cultural astronomy class that included classes in Ghana that were part of a conference was not like study abroad programs because the time period abroad was much shorter and the classes were specialized for this particular group of students rather than the students joining in with normal classes. During the conference, the University of Arizona students were joined by students from Nigeria, Ghana, the United Kingdom, and from the University of Alabama, Huntsville, making a class of around 15 students, total. As detailed in the next section, the University of Arizona subsidized the travel of these students.

Strategies for Obtaining Conference Funding

Four major strategies were employed to obtain funding for the conference. (1) The conference was focused on the astronomy and culture of Africans and encompassed historical archival, archaeoastronomical, and anthropological approaches to the topic. Funding organizations supporting research in each of these disciplinary areas were approached either by submitting full proposals or letters of inquiry: The National Science Foundation, the Sloan Foundation, Wenner-Gren, and the International Astronomical Union. (2) The conference had two educational aspects: the training of students and the inclusion of K12 educators. Organizations focused on projects in Africa, higher education in Africa and in education were approached: the Honda Foundation, the Ghana Embassy in the United States, the Nippon Foundation, the Rockefeller Foundation, the Spencer Foundation, the Sloan Foundation, Sony Electronics, and the United States Embassies in Gabon, Ghana, Niger, Nigeria, and South Africa. (3) The home universities of the organizers were approached as well as local businesses that support student activities: University of Alabama in Huntsville, University of Arizona, Morehouse College, and the Pima Federal Credit Union. (4) The topic of the history of astronomy of Africans is part of African-Americans' scientific heritage and appeals were made to this community for support: Oprah's Angels, individual businesspersons, and public appeals at the end of radio interviews.

The only successful funding strategies were (3) the appeals to our universities and local businesses and (4) appeals to the African-American community. Those organizations working in Africa said that they only focus on basic needs and the research organizations did not feel that cultural astronomy was within their disciplines. One of our private African-American contributors organized and paid for filming the entire conference which will result in a television program in the future. The institutions which provided funds for the Conference and eclipse day activities were the University of Arizona's Colleges of Optical Science, Education, Science, Steward Observatory, and the Magellan's Circle; Pima Federal Credit Union; NASA; Morehouse College; and the University of Alabama in Huntsville.

Publicity

Attracting researchers and participants to the conference involved multiple levels of publicity. The scholars were attracted through the various astronomy, African studies, archaeology, anthropology, history, and cultural astronomy associations. To attract participants, I worked with my University's public relations officers and a script that can be downloaded from the NOVA website [33] on how scientists can interact more effectively with the media. I refined my message to two sound bites: 1) There is a total solar eclipse in Ghana and 2) the conference focuses on the astronomy traditions of Africans. Keeping this focus in mind was helpful during the radio interviews with NPR and a Cincinnati radio station. In Ghana, I shifted to a science focus since I was co-interviewed with scientists: As Africa embraces science and technology, they must remember that African already have and have had science in their everyday activities and their lives and this science needs to be highlighted.

Lessons Learned

Organizing Committee: Local and Foreign

All except for two members of the organizing committee were from outside of Ghana. Those two in Ghana were in high demand for every event having to do with Mathematics and Physics around the world. They were excellent co-organizers but busy. The United States members were broken down into two persons focused on the eclipse, one media person, and I was the point person and coordinated all activities related to the conference. Even with email and cellular phones, communications could have been better and our efforts became disjointed instead of complimentary. In fact, we ended up with two separate eclipse day activities events one that was part of the conference and the other that splintered off and had nothing to do with the conference. Fortunately, the conference and our eclipse day activities kept our commitments to the University of Cape Coast and we have plans for future endeavors and collaborations.

Attendance

We had 50 registrations for the conference mostly from the USA, Canada, and the United Kingdom. We had originally projected 100 participants with 50 estimated from Ghana. Those Africans who participated and were registered had their registration paid either through the University of Arizona funds I had raised or through foreign sponsorship mostly from their friends in the United States. No other Africans that participated paid registration, thus they will not receive the conference proceedings and did not receive the conference bag with T-shirt. Though the T-shirts were in great demand, the $20.00 USD price was prohibitive, likewise the $100 USD registration fee was impossible. There were consistently three primary school teachers from the Cape Coast area and three UCC physics undergraduate students who participated in the workshops and attended the afternoon and evening lectures. The African countries represented by the attendees were Ghana, Nigeria, South Africa, and Tanzania. There were no funds raised to subsidize the travel of African students or participants other than experts.

Total Solar Eclipses Rock But . . .

The total solar eclipse occurred on Wednesday, March 29th, 2006, shortly after 9 am. It was a spectacular event bringing together Africans and a dramatic and rare celestial event. The last total solar eclipse occurred in Ghana in the 1940s. Some local reporters actually searched for people who had witnessed that eclipse and interviewed them. In terms of the conference, nothing could be more spectacular or exciting as a total solar eclipse. Everything after the eclipse was anticlimactic. It was very difficult to get settled back into the routine of workshops and lectures on Thursday. As mentioned before, the K12 Educators workshop began Thursday morning and the workshop was designed to explore the works of the experts as potential subject matter for lesson plans. Instead, everyone wanted to develop lesson plans about the eclipse. The eclipse clearly eclipsed all the other research papers presented earlier in the week.

Advice from the Wise

Raising funds for conferences is always difficult but nonetheless an endless supply of money would have greatly alleviated many of the obstacles and setbacks associated with the conference. One way that this could have been addressed was to charge more for the conference registration. However, to encourage African participation, I wanted to keep the registration amount low. Considering that no Africans paid their own registration this ended up not being the best decision.

Particular to the fuel and transportation issues of the University of Cape Coast, it would have been easier to hold the meetings at the Coconut Grove resort rather than at the UCC campus. The extra cost for conference meals, two coffee breaks with snacks, and to pay for the conference facilities would have been absorbed by the participants through the daily hotel rates. For the Coconut Grove, the cost would have risen to $85.00 per double up from the $65.00 a day that was paid. However, given that the Dean of the Faculty wanted to showcase the UCC campus, the meetings were held there. As there was the daily issue of the bus actually arriving in a timely manner to transport participants, again, a large source of money would have made it possible to switch venues to the Coconut Grove in midstream if necessary or to charter a commercial bus for our purposes.

Achievements

New Organization and New President

Rather than start a new organization, the network of scholars working in African cultural astronomy decided to form a loose affiliation called “The African Cultural Astronomy Project”. The first president is Dr. Johnson Urama, a professor of Astronomy and Physics at the University of Nigeria, Nsukka. The goal of the project is to meet annually to discuss achievements in the proceeding year and set goals for the upcoming year. The conference proceedings detailed below, the raising of funds for research, identifying sites in Africa for the UNESCO Astronomy and World Heritage initiative, and organizing the next meeting are among the goals for the project in the coming year. At this time, all the project members will join the International Society for Archaeoastronomy and Astronomy in Culture (ISAAC) and form an Africa subgroup.

The Internship Class

It was surprisingly hard to recruit professors from the University of Cape Coast to participate in the conference. The visit in 2005 had stimulated interest, but my multiple emails to various faculty in the Social Sciences and Humanities over the next year went unanswered. Upon arrival for the conference, many professors had seen my various emails but none had responded or committed. However during the week before the conference two excellent professors agreed to do training sessions with the students in their areas of specialty. Special thanks go to Prof Ohenaba Achaempong of the Geography Department and Prof Kofi Maison of the History Department. Both reported that the students were eager and engaging and they were glad for the experience.

The students were drawn from many majors from physics to anthropology to art. Thus, their comments thus far have emphasized what they have learned outside of their discipline and how it has enriched them intellectually. The most common statements are about how two experiences have profoundly changed their prospective: 1) being in Ghana for the first time, and 2) viewing a total solar eclipse.

Publications

The scholars currently running cultural astronomy projects focused on African ethnic groups met for three days to consider several issues including the possibility of creating a cultural astronomy journal focused only on Africa and Africans. Those scholars living in Africa want their own journal, however, given the limited number of active scholars and the time lag between data collection, analysis, and results, such a journal would at most be published once a year. Instead, Clive Ruggles and Nick Campion both suggested special editions focused on Africa of the journals *Archeoastronomy* and *Culture and Cosmos* as alternatives. Immediately, the conference papers are anticipated through Springer press – this volume. This volume has two sections: Part I: the papers resulting from the student training sessions and Part II: those papers detailing the latest research in African cultural astronomy.

The K12 educators workshop had the goal of producing lesson plans that incorporate cultural astronomy information. There were about 12 participants in the workshop that were divided into two groups that were moderated by Timothy Slater of the University of Arizona. The workshop design was to have the teachers discuss what had interested them about the talks for the previous days that they thought might be made into good lessons for their students. However, since the workshop began the day after the eclipse they were mostly interested in doing lessons focused on the eclipse. The two groups did pull together their ideas into two lesson plans which will be written in standard format and placed on the internet during month after the eclipse. This volume contains two papers about the K12 workshop in Part I:

"Integrating African Cultural Astronomy into the Classroom" by Sanlyn Buxner and Shawna Holbrook, and "A Contemporary Approach to Teaching Eclipses" by Timothy Slater.

Film Projects

A one hour video was produced by Morehouse College and CNN of the total solar eclipse with a focus on the conference including interviews with speakers and students. This conference broadcast is a milestone because it features not just the sun, but includes Africans, cultural astronomy of Africa, and women experts and students. The video can be found on the web linked to http://www.u.arizona.edu/~holbrook/.

A conference DVD was financed, produced, and edited by an African American team lead by Earl Grant and Jerome Johnson. The project is to edit all the videotaped talks and lectures into a multiple DVD set that will be formated for educational use. At the time of this writing, the first DVD is completed and includes the keynot lecture by me, Damian Opata speaking on Igbo astronomy and literature, Clive Ruggles speaking on the Borana and Mursi calendars, and Arletha Williams-Livingston speaking about how to incorporate Dogon cosmology into educational outreach lessons for African American students.

A Starting Point . . .

I had the honor of being the keynote speaker at the Ghana Eclipse Conference and it was my job to provide a starting point for the African cultural astronomy researchers and students. It is important to gain an understanding of the many ways that astronomy entwines with culture in Africa. Given the diversity of Africa, the astronomy of individual ethnic groups is sometimes similar to that of other ethnic groups leading to broad categories, but the differences give rise to new but related categories of classification. Some of the categories are explored below, derived from analysis of published works. However, these simply refer to African astronomy information that has been collected and analyzed, this is an ongoing process.

Classification of the cultural astronomy of Africa resources can be done in a variety of ways, and the categories are subject to debate. My technique is to first classify by ethnic group, and then by the astronomy "cultural expression". The former preserves cultural context and promotes a deeper understanding of the many ways that astronomy knowledge has emerged in cultural practices, rituals, and everyday activities. The latter is useful for cross-cultural comparisons and drawing general statements about human endeavors. A list of categories of astronomy cultural expressions is presented in Table 2.

Table 2 Some "Cultural Expression" categories in african cultural astronomy

Sample Categories	Description
Archaeoastronomy Alignments	Study of alignments at archaeological sites that are not presently occupied.
Architecture	Study of alignments of buildings and structures in occupied sites.
Astrology Divination	Study of the documents, observations, methods, and history of people to make predictions using the positions of celestial bodies.
Astrology and Healing	Study of the documents, observations, methods, and history of traditional healers using the positions of celestial bodies to diagnose illnesses and/or prescribe treatments.
Calendars and Timekeeping	Study of the observations, calculations, and negotiations surrounding the establishment of an accurate calendar.
Celestial and Cosmic Art	Paintings, drawing, designs, murals, and etchings representing celestial bodies, themes, legends, and cosmology.
Celestial and Cosmic Names	What names are giving to celestial bodies and why.
Celestial Navigation	The use of stars and other celestial bodies for navigation.
Dating by Celestial Bodies	Using celestial events such as comets, eclipses, and supernovae to date historical events.
Divine Priests & Cosmic Kings	How knowledge or a perceived relationship to the night sky is used for social and political purposes.
Folklore, Myths, and Legends	Study of stories and tales having to do with celestial beings, celestial bodies, and cosmology.
Writing, Signs, and Symbols	Written representations of celestial bodies and cosmological concepts.

These categories are not all-encompassing but begin the classification process and present a starting point for understanding African cultural astronomy. The one-sentence descriptions are meant to convey ideas about what can be studied, but at the same time are not meant to be limiting. These topics can be explored in many different non-African cultures as well.

Part I: Cultural Astronomy Research Lessons

The study of the cultural astronomy of Africa intersects the fields of African studies, anthropology, astronomy, and history. This volume is divided into two sections: Part I focuses on the tools that students and beginning researchers need to learn for doing cultural astronomy research in Africa. Much of this was taught during the student workshop. Part II a collection of the scientific papers presented at the Ghana Eclipse Conference. Like cultural astronomy itself, the data collection methods are drawn from many different disciplines. The goal of the first section is to present a foundation of data collection methods in African cultural astronomy. Part I includes lessons in geography, astronomy, anthropology, and other topics for the beginning student of African cultural astronomy.

Part I begins with a detailed overview of cultural anthropology methods in 'The Use of Ethnographic Methods in Cultural Astronomy Research' by Barth Chukwuezi. Here I would like to add some tips useful when beginning cultural astronomy research projects. Researchers should understand how to approach their informants with both respect and patience. Depending on the skills of the researcher, the informant may have a greater understanding of celestial phenomena and motions. Thus, the researcher may benefit from training in "studying-up" [34], a concept from anthropology and science studies used to study institutions, physical scientists, and science culture; where the people studied tend to be more knowledgeable than the researcher. The choice of interview type depends upon the researcher and the informant. Informal interviews comprising a few questions can be used to assess whether a formal interview is necessary. Formal interviews are usually recorded either through notes taken during the interview or by tape or digital recorder, and are best for collecting detailed information with a lot of astronomy or mathematical content. Using a translator, I find that formal interviews with predetermined questions are better because they are a more efficient use of the translator's time. Rapid assessment protocol is borrowed from applied anthropology and archeology. A team of researchers in the field gather data using a variety of techniques during the day, either independently or in subgroups, and each evening meet to discuss what techniques are yielding the best results. The decided upon techniques are utilized the next research day and again a meeting is held to discuss the results. After several days it becomes possible to determine the best techniques for the population, type of data, and time limitations. The resulting techniques may differ from researcher to researcher but should be agreed upon by the team. That is, a female researcher may have to present her education and professional credentials in order to be taken seriously before quality data can be collected, or a local researcher may have to honor more local customs than foreign team members. Possibly, one researcher is most effective using a survey and another with informal interviews. The goal is for the team to gather the highest quality data possible regardless of the methods that individual team members use.

Field documentation techniques such as keeping daily fieldnotes, notes of interviews, photographs, sketches, audio tapes and video tapes are critical and borrowed largely from anthropology. Beginning research assistants tend to write down everything in as much detail as possible, but over time learn to organize their notes into relevant categories while writing, with information not directly related to the research questions described at the end. Having research assistants transcribe at least one interview before starting may allow them to pick up some interviewing techniques and learn how to maintain a useful flow of questions and answers.

Starting an interview with a series of questions focusing on positive things such as education or family is useful, followed with questions that will result in a "yes" answer. Also, when the limit of the person's ability to answer questions is reached, the researcher can return to something the person does know and end by asking for more detail about that. This is a way to end the interview on a positive note. The oral history of African astronomy can be probed by asking questions about how their astronomy is learned, who do they think also had this knowledge, and questions about the transmission of astronomy knowledge. Every researcher has their own interview style and what works for one may not necessarily work for another.

Historical methods are necessary to understand the history of African ethnic groups of interest to cultural astronomy scholars. Primary sources, as mentioned previously, are the equivalent of star witnesses in terms of historical research. However, secondary sources are usually easier to locate. The identification of secondary sources, which are then used to locate primary sources and archives is a necessary technique borrowed from history. Using databases, catalogues, and other digitized resources on African ethnic groups, some search terms to find useful information are the names of individual stars, planets and constellations as well as "star," "planet," and "constellation," "sky," "Sun," "moon," "weather," variations on "celestial" and "cosmic." Old dictionaries can be useful for finding these terms in the local languages. The identification of researchers who have focused on particular African ethnic groups should emerge from a study of the secondary literature. These scholars and their students can be contacted either to interview directly or to request copies of their original notes. A working knowledge of Africa is needed to do African cultural astronomy research effectively. Similar to studying the night sky, a deep study of a map of Africa focusing on the names of countries and capitols, geographic and environmental features, rainfall patterns, and population distribution is useful, these are discussed in Basil Eze's paper 'A Brief Outline on the Geographical Background of Africa'. In the field in Africa, people have a detailed knowledge of history and events taking place in other parts of Africa and will often want to discuss these issues with the researcher. Therefore, general knowledge of Africa is needed to simply keep conversations going. Researchers need to identify and disregard common "African" myths, such as big game animals roaming everywhere [35]. Researchers should understand that quality information can be found in urban areas as well as rural areas because of recent migration to urban areas, and the presence of archives, museums, and universities which often house primary source material. The reality of Africa today rarely meets the imagined Africa, so researcher should be prepared for the similarities to life in the United States rather than the differences.

Kim Malville's archaeoastronomy exercises in 'The Gnomon' show the importance of the Sun's annual motion and how to use its shadow for establishing the cardinal directions. Archaeoastronomical measurements usually use the instruments from archaeology to accurately measure the alignments of manmade structures such as temples, megaliths, and graves to celestial bodies. Nothing can replace taking a course or working closely with an archaeologist to learn the proper use of the equipment, measuring, calculations, and mapping necessary for this research. However, laying out an accurate north/south line is a beginning. Astronomer Bradley Schaefer has shown that it is relatively easy to find alignments to celestial bodies at archaeological sites. However, unless there is another source that reveals that the builders intended to build in alignments to celestial bodies, alignments alone are inconclusive [36]. He goes on to suggest that the analysis of multiple related sites all showing the same alignments makes a stronger case for intentionality in the absence of written sources or ethnographic evidence. Other issues that may be of concern to researchers are how the brightness of the night sky changes with the phases of the moon and thus which stars are visible during a particular phase; and on what date is a certain star visible just before sunrise (helical rising). Schaefer addresses these and provides computer programs to calculate accurate values [36, 37, 38, 39, 40]. In the absence of archaeological equipment to measure alignments, a researcher can strategically be present to take photographs to document alignments. For example, the Batammaliba of Togo align the front door of their houses to the midwinter sunset [41]. A photograph from inside one of their houses on December 21^{st} would provide irrefutable evidence of the alignment.

The "Naked Eye Astronomy for Cultural Astronomers" lesson outlines those celestial bodies that a cultural astronomy researcher should be familiar with. Star chart, planispheres, and astronomy software are the tools for identifying and verifying celestial information uncovered in the literature and gathered during fieldwork. Chukwuesi's lesson on ethnography cover much of what is needed for fieldwork, but this chapter suggests what to ask, beginning with developing a common language about the sky. But also suggests common areas of inquiry such as gender issues and the transmission of knowledge.

Shawna Holbrook's paper, 'Leadership', is a report on the student workshop focused on both how to be a team leader and how to become a leader in an academic field. The students were encouraged to brainstorm about various qualities a good leader and to name their favorite leaders. The issue of good leadership arose again around the issue of good mentors. In addition, they brainstormed about actions they could take to become leaders in any academic discipline. With the findings presented in this report new researchers can begin to think through what leadership means in their lives.

The next two papers are about K12 education and cultural astronomy content. The first "Integrating African Cultural Astronomy" by Sanlyn Buxner and Shawna Holbrook reports on the K12 teachers workshop that took place March 30–31, 2006, after the total solar eclipse. Not surprisingly, the teachers decided that lessons about the total solar eclipse were needed. "Contemporary Approach to Teaching Eclipses" by Timothy Slater is an astronomy education paper providing research, results, and suggestions for teaching about eclipses.

"Teaching Cultural Astronomy: On the Development and Evolution of the Syllabus at Bath Spa University" by Nicholas Campion end Part I. Campion provides a detailed description of the Masters of Arts program in Cultural Astronomy and Astrology currently at Bath Spa University in the United Kingdom. His paper is a blueprint for designing graduate programs in cultural astronomy.

Part II: Current Research in African Cultural Astronomy

Part II focuses on the latest cultural astronomy research taking place in Africa. The current research includes ethnoastronomy, archaeoastronomy, and analysis of rock art. It is the last which starts this section: a paper by Felix Chami, "Evidence of Ancient African Beliefs in Celestial Bodies." Chami analyses some of the celestial icons found at many rock art sites in Tanzania. J. McKim Malvilles paper, "Astronomy of Nabta Playa" takes us to the Sahara desert in southern Egypt where a stone circle calender has been discovered as well as an ancient nomadic culture that followed the seasonal rains. "Romans, Astronomy and the Qibla" by Michael Bonine looks at the alignment of mosques in Tunisia. His research answers the questions of why the mosques are aligned to the winter solstice sunrise, but begs the question of why the Romans aligned their cities to the winter solstice sunrise.

After the television program "Wonders of the African World" [42, 43], scholars around the world renewed their efforts to preserve the libraries of Mali written in Arabic. R. Thebe Medupe is one of the South African team of scholars leading efforts to find and analyze manuscripts related to science in general and astronomy in particular. His paper "The Timbuktu Astronomy Project" includes the translation of some of the manuscipts and a discussion of the astronomy found in it.

The next two papers look at the cosmology of the Igbo and the Yoruba-Idààcha in West Africa. Aimé Sègla examines the links between cosmology, sacred numbers, and calendars in his paper "The Cosmological Vision Of The Yoruba-Idààcha Of Benin Republic (West Africa): A Light On Yoruba History And Culture." Barth Chukwuezi introduces Igbo cosmology, the celestial deities, and weatherlore in his paper "The Relationship between Human Destiny and The Cosmic Forces – A Study of the Igbo Worldview." Both papers touch on divination and prediction.

Damian Opata presents a literary analysis of celestial themes in African writings. His paper uniquely explores novels, poems, and folkloric saying from throughout Africa. It provides a great example of the interdisciplinary nature of cultural astronomy research crossing into the humanities, but also the how celestial themes sometimes entwine with political and colonial realities.

The last two papers bring astronomers into the cultural astronomy milieu. Johnson Urama touches on the history of astronomy and ethnoastronomy in his paper "Astronomy and Culture in Nigeria." Hakeem Oluseyi and Johnson Urama provide a history of astronomers of African Descent in "Participation and Research of Astronomers and Astrophysicists of Black African Descent (1900–2005)." Cultural Astronomy researchers internationally include a large number of astronomers, so not surprisingly many African cultural astronomy researchers are both of African descent and trained as astronomers including Hakeem Oluseyi, Johnson Urama, Thebe Medupe, and me.

This volume includes research projects from North, West, and East Africa; and spanning ancient Africa to the present. It shows cultural astronomy to be a unifying yet interdisciplinary concept useful for the examination of Africans and their skies, past and present. This volume is also the result of the first meeting of African cultural astronomy researchers and students who gathered for the March 29, 2006, total solar eclipse. The connection between the cultural astronomy researchers and this celestial event was strong and obvious. Currently, the African Cultural Astronomy Project is tentatively planning the next meeting around the 2010 annular eclipse visible in East Africa.

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The Use of Ethnographic Methods in Cultural Astronomy Research

Barth Chukwuezi

Introduction

The issue of ontology of knowledge and the epistemology of arriving at the truth of knowledge has generated various strands of opinions which tend to favour positivism or empiricism. Social science wants to belong to the school of positivism or empiricism rather than subjectivism and as such has outlined some measure of scientific methods for its epistemological investigation. Some disciplines in social sciences tend to be more quantitative than others in their approach, especially economics and psychology. However, one can posit that the level of scientific investigation in natural sciences tend to be more concrete and experimental than that of social sciences possibly because of different objects of investigation.

The paper will attempt to discuss the concept of qualitative method in ethnographic study which could be used for the study of Cultural Astronomy and the various arguments for and against qualitative method. The need for qualitative method will also be discussed including the various Ethnographic Research methods and how they are used in field research. Finally, there will be the conclusion.

Concept of Ethnographic Method

Qualitative method has become one of the empirical methods in the social sciences. Qualitative method of research and analysis is a major instrument for gathering data on cultural anthropological studies. It does not seem to engross itself with much quantitative complex data that some social scientists use for data analysis (Koltak, 1991).

The qualitative method which is ethnographic technique is what the Anthropologists use to study simple societies, personal relationship and fairly homogenous societies. Ethnographic method is seen as a means of research investigation using

Barth Chukwuezi
Association of Professor, Department Of Sociology/Anthropology, University Of Nigeria, Nsukka

J. Holbrook et al. (eds.), *African Cultural Astronomy – Current Archaeoastronomy and Ethnoastronomy Research in Africa.*

unstructured questions, in-depth interview, observation and employing verbal descriptions and explanations (Nwanunobi, 2002). Ethnographic research method is quite useful in areas where the nature and character of social life are vital for the analysis of all phenomenon especially at small scale and local levels. It is also good in areas where there is the need to understand various aspects and strands of social activities and cultural configurations.

Ethnographic methods have been criticized by some scholars (such as Borman, LeCompt and Goetz, 1980), as being unreliable, lacking measurements and predictability. In the same vein Krent and Sax (1980) have replied to the critics, saying that Quantitative Method has little correspondence between measure and reality and that such research has produced little "truth". They equally criticized the sloppy use of statistics and the problem inherent in lack of understanding causality.

These arguments have encouraged some Anthropologists to evolve a combination of the qualitative and quantitative approach in their research (Bernard, 1988; Fielding and Fielding, 1987; Pelto and Pelto, 1979). It is necessary to add that even those engrossed in quantitative method in social sciences are also turning to the ethnographic tools of field work and personal interview as relevant tools for their study.

Ethnographic Methods

In this segment of the paper, the various ethnographic methods that Anthropologists use in their research will be discussed especially as it relates to Cultural Astronomy. This will take into cognizance some of the new grounds in the areas which tend to make Ethnographic Research more reliable and scientific (Johnson, 1990; Bernard, 1988).

Observation/Participant Observation

One of the major tools of ethnographic research is observation. It has two types – participant observation and non-participant observation. Observation entails that the researcher has to enmesh himself or herself in the society of the studied people and observe every detail of their various activities which form the object of the research. Participant observation involves the situation where the researcher takes up an appropriate status with the research population. According to Nwanunobi (2002: 41), the "researcher sees through the eyes of a member of the community rather than as an outsider". The researcher takes part in various cultural activities of the people and notes their feelings and reactions to various issues that concern his research. The researcher is expected to master the language of the people and establish intimate ties with the people.

He/She has to report the activities the way it is and should not be guided by value judgments. The researcher has to understand the various idioms and symbolic expressions of the community under study. However, there is a limit to the extent one can observe, especially in activities involving secret cults which require researchers not to divulge information. It is also difficult in robbery gangs. A man cannot fit properly in an exclusive women group neither can a woman fit into exclusive male secret cult organizations. At times some researchers could go to extra lengths and Nwanunobi (2002) pointed out a white researcher who painted himself black so as to research on a black group in the United States in the course of participant observation research. There have been opinions expressed by some people that it is quite difficult for an outsider to totally get enmeshed in another persons' culture. There are various constraints including the language and symbolic expressive modes of communications which an outsider may not properly decode. At times, the researcher may be deceived by the cultural members into having false interpretations of some cultural actions.

Observations

There is observation which you may not be a participant. You may not participate directly in the people's cultural activities, rather, you can be an observer. And like participant observation knowledge of people's culture is also important such as the mode of communication in the systems, language, the signs and symbols. The more you know this, the better it is for you to depict the culture configuration within the society. And as you observe you are going to decode the culture based on the fact that you have known the culture to some extent so that you can begin to decode the observations you are making. And in fact it's a major tool in anthropological study. Anthropologists go to the community, stay with the community, learn the aspects of the culture, and begin to decode what the people do. In most of the major anthropologist work, observation is involved. You may not necessarily be a participant, but you have to be a keen observer. There is a problem here in the sense that at times you might observe wrongly. There might be wrong observations because if you are not very much in tune with the cultural information when the people might be gazing at the stars you may think they are gazing at the moon or when they are talking about the moon you may think they are talking about the stars. You have to be very friendly, very open to the people so they can accept you as part of them even though it is very difficult. So there is that element of good rapport with community members for them to divulge some of the sensitive information to you. For example the art of rain making which also includes watching the stars is very secretive. People within the rain making tradition do not allow others to learn because many of their livelihoods depend on this institution. They get money out of this so if they divulge the information to you it means their trade may become extinct.

Observation also has another limitation. It is what they call cultural bias. You may observe a certain particular culture activity but because of your own cultural background, you begin to make value judgments on the cultural practices. You have to report it the way the people say they do it, rather than have your own cultural influences impinge on your study.

Selection of Ethnographic Informants

According to Blum et al. (1997) who developed Ethnographic Protocol of Food Assessment for the International Union of Nutritional Sciences, the selection of informants is the most important aspect of ethnographic research. In addition, notable Anthropologists such as Mead (1955) and Johnson (1990) have argued that selection of informants form the major base of ethnographic study. A good selected sample of informants will help in the reliability of data being collected. The selection of informants is related to the choice of inquiry. In some small scale homogenous group where there is focused Ethnographic Study, Key Informants and other informants are quite necessary.

According to Tretsby quoted in Johnson (1990: 24) "when we use Key Informants we are not randomly sampling from the universe of characteristics under study. Rather we are selecting specialized knowledgeable characteristics". Key Informants are selected based on purposive sampling of the best knowledgeable people in the object of inquiry within the population of study. The researcher is compelled to check out the entire study population for such people.

In addition, there is also the selection of informants purposively from the research population by a form of cross selection. This should reflect the various groups within the population. It could be through stratified, cluster and systematic random sampling to get a representative sample of the studied group.

In ethnographic research, Key Informants guide the terrain of the cultural domain and there should be much interaction between the Key Informants and the researcher. Selection of Key Informants and informants is based on the researcher's theoretically and experientially informed judgment based on the issue of research focus. In a study carried out by Chukwuezi (1998) for UNICEF on Focused Ethnographic Study of Acute Respiratory Infectious (ARI) illness of children under five, in Imo and Kano States of Nigeria, a variety of informants were chosen based on the thematic issue. Key Informants were chosen based on knowledge of Acute Respiratory Infectious (ARI). Other informants were mothers of children with current ARI, mothers of children who had past ARI episode, traditional healers, drug sellers and health clinics staff. The idea is to get a target group which cuts across the community being studied. It is a kind of cross sectional selection of Key Informants.

Data Driven Selection

According to Johnson (1990) the first round of informant selection discussed above could be theory driven and he also explained that one can also select informants based on data. This is also part of the effort to ensure greater reliability and could be quantitatively tested for reliability. Johnson (1990) described how informants were selected based on social networks of those in close contact in a study of a fishing village in North Carolina, USA. The informants were subjected to pile sorting technique and multi-dimensional scaling which reveals the closeness of people to one another. Those with close networks were selected for the study. The selected informants were quite knowledgeable in the social structure and social relationships in the village. The study was on diffusion of technological innovation in the village. At the end of the study it was tested for reliability and it was quite encouraging.

In-depth Interview

This is a process designed to elicit more information on a research topic. In Ethnographic research involving cultural astronomy, in-depth interview and at times intimate interview is used and that is part of the reason for choosing Key Informants. Key Informants are better disposed for in-depth interview since they are quite knowledgeable in the focus of the research.

In-depth interview yields more information than a general survey which picks respondents or informants at random. It is quite necessary in various forms of researches and it is better addressed when the researcher builds intimate relationships with the Key Informants. This form of interview requires more probing and prompting and more exhaustive cross questioning than general interview. It tries to confirm or validate or even question what has been gathered in general interview. It tends to give further clarification on issues addressed about the research.

Case Studies/Case Histories

Case studies refer to a specific study of a particular case as opposed to a general study. For example, one can undertake a specific study within a larger area which represents a smaller area within the larger area studies. Case studies could also refer to a particular study within a larger area of study. For example, one can decide to make a case study of marriage in a particular village as opposed to the entire social cultural activities of the community. Case studies could also refer to specific case studies of social institutions within a study area. When you come to a community there are certain activities that take place but you may choose to study a particular activity out of so many and you call it a case study. For example in a community we have an economic system, the political system, the kinship system, various social organizations systems, and you choose a particular one, say the marriage system to study in detail out of so many different systems. But then a case study can change depending on your view. For example in watching the stars there are various things that inform cultural astronomy. You might say it is the stars, the moon, the earth, the solar system, whatever, and then you might pick a particular issue as a case study and you want to study all that is involved in that particular aspect.

Projective or Scenario Method

This is also a part of ethnographic study in which a future scenario is created in order to know how it could be analyzed or discussed. For example, there could be hypothetical cases to know if informants are able to recognize certain illness signs and symptoms afflicting their children. It could also be a scenario of presenting confederate hypothetical cases to Drug Stores or Pharmacists to know if they can proffer treatment regime for a particular illness being studied. This form of method was used in a focused Ethnographic Study I did for UNICEF in order to ascertain how drug vendors responded to treatment of ARI in Owerrri and Kano states of Nigeria, as mentioned earlier. This form of method could be used to gather information on cultural astronomy. For example, one can present a picture of the eclipse and ask people what they thought of it. You could also present a picture of the various movements in the sky and ask the people what they can interpret from that. It could be hypothetical configuration where various situations that are relevant to a research study are examined to know the peoples reactions to them.

Longitudinal Study

Longitudinal study is also used by Anthropologists to reflect on earlier studies. It takes a historical account of changes from the past to present. Some Anthropologists carry out longitudinal studies of an area right from the earlier study to the present to notice how changes have impacted on the community.

For example, Koltak (1991) has continued to make a progressive study of the Arembpi people of Brazil right from an early visit in the 50s to the 90s in order to study the impact of social change in that small Brazilian community. Cultural Astronomy studies could reflect on what people thought about the cosmic, forces in the past and present to understand the form of changes and perception affecting cultural astronomy among the communities.

Free Listing Method

This involves the system of listing required items in a cultural domain to find out certain required things. It is another form of carrying out a simple qualitative research. This idea is used to find out certain things within a cultural domain. It could also be used to support certain observed things within the same culture area. If more listing of items are required, the number of respondents could also increase depending on what the researcher wants.

Free listing is becoming a popular tool for anthropologists trying to categorize or elicit information on various items in a cultural domain. Romney and D'Andraide (1964) have recommended the approach and Weller (1984) has used such for disease concepts. In Cultural Astronomy, free listing could be used to collect information about the sun, moon, stars, etc., by asking people to list what they think about any category of them. At the end of the listing the likely correct answers are usually the ones with the highest frequency of mentions among the respondents.

Pile Sorts Technique

This is formal interview gathering when study items have been selected. Pile sort is a form of trying to sort out certain things within a given cultural domain by various individuals as a way of identifying their properties, similarities, etc. In pile sort tasks, individuals are given certain designed categories to sort out according to their choice. Pile sorts could be used to collect data on social relations among people. Some Anthropologists have used pile sorts technique to collect information on a variety of things such as relevant behaviors on a number of diverse cultural patterns (Weller and Romney, 1990).

To use the pile sort, the items to be studied are usually presented in cards. Words could be written on cards for those that are literate. Visual stimuli could be presented to non-literate respondents. The cards are shuffled or randomized for the respondents to make their sorting into piles so that similar items are on a pile together. They may be asked to make a specific number or as much as they want. Allow the informants to finish their sorting before asking questions to avoid bias.

Descriptive answers could be used in interpreting final results. Weller and Romney (1990: 22–23) gave example of how simple pile sort could be represented graphically. Assuming we collected data on similarity of seven items and respondents put items A, B, C together in 1 pile; D and E in a pile and left F and G by themselves – we can create a table to tabulate similarity among the items.

Cultural astronomy could use pile sorts to known similarities or relatedness among the various cosmic representations and activities within the community when properly coordinated. The various matrices for the respondents who did the sorting could be drawn and given the relevant description. The advantage of pile sorts is that large items could be sorted out on the bases of similarity or dissimilarity.

Ranking

Ranking is similar to rating but again it depends on what one is studying and the research focus. In Ethnographic Studies ranking could be used to test the popularity of certain items. For example, one could use ranking to establish health institutions that offer better services than others do. In cultural astronomy one could use the ranking method to know the levels of esteem and recognition of the various cosmic forces. You could use it to know the degree of respect and reverence attached to various celestial bodies including the levels of high-ranking categories assigned to them.

Documentary Records

Documentary records are quite relevant in cultural astronomy studies. Documentary records are used to search for written materials on a research focus. It involves looking at the archives, public records, official government records and personal documented records. It is part of secondary data collection. It could reinforce what is already gathered in the field during investigation. It could also serve as a basis for further investigation and better data analysis on the research topic.

At times the documents are readily provided for researchers and at times the classified documents are not easily accessible. Public documents could be in the form of published books, magazines and journals, newspapers and at times statistical reports – annual and census records.

Personal documents include the papers concerning personal memoirs, personal records which is in private custody. In some cases, people's life histories or profiles are made out of personal documents. It is also important to note that there could be oral/symbolic documents. Some communities do not know how to read and write. However, they may document events either orally or by symbolic signs. Issues like the periods of eclipse, bizarre climatic changes may be recorded orally, symbolically or by artistic display, for example in some communities the passages of events are known with signs. They tell you when this happened there was a sign to denote it. It is documented but not in written form. We can begin to look at it and see why it is in this form and we get information for it.

Conclusion

The various forms of ethnographic methods have been discussed as it relates to cultural astronomy studies and each of them has its advantages and problems. However, the various methods represent the various ways anthropologists carry out ethnographic researches, which could be fairly reliable. Depending on the nature of the research, these methods could be all used together or some could be combined in order to get reliable data. Besides, the essence of combing these methods is to ensure rigorous pursuit of reliable data, which could be validated. In many anthropological studies which are much of applied anthropology, anthropologists use these various methods to get at the objectives of their research – cultural astronomy research could benefit immensely when they use some of the methods outlined which are also ethnographic methods.

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A Brief Outline on the Geographical Background of Africa

Basil U. Eze

Introduction

This write-up makes an attempt at presenting a basic outline on some of the physical and human features with which to identify the continent of Africa. Even in a study such as African Cultural Astronomy a researcher needs to know about Africa. This is strictly a basic outline but promises to be an interesting reading.

Physical Features

Size, Shape and Position

Africa, with an area of about 31 million square kilometres (including the Islands), is the second largest continent in the world, second only to Asia. Africa is about three times the area of Europe; and Canada and U.S.A combined represent only about three-fifths of the total area of Africa. It contains about one-fourth of all the land in the world.

As regards shape, compactness is the principal character of Africa. The continent is much more compact than Europe, for example, the coastline is relatively straight with very few indentations (in the form of capes, bays etc). The continental shelf of Africa is also very short. In the same way on the land, one finds sudden rises to high elevations within a short distance. Again, Europe is sometimes, called "Peninsula of Peninsulas." In the case of Africa, the sole prolongation of the coast is the Somaliland Peninsula. Large tracts of Africa lie far distant from the ocean, and in the northern part of the continent; for example, much of the interior lies about 1,200 km from the seaboard.

Africa lies between the Atlantic and Indian oceans and is positioned antipodal to the Pacific ocean and lacks pacific coastline. Africa lies astride the equator and

Basil U. Eze
Department of Geography and Meteorology, Enugu State, University of Science and Technology, Enugu, Nigeria

J. Holbrook et al. (eds.), *African Cultural Astronomy – Current Archaeoastronomy and Ethnoastronomy Research in Africa.*

extends from about latitude 37°N to nearly 35°S almost equal distances north and south of the equator. It stretches for a distance of about 8000 km north to south, from Bizerte in Tunis down to Cape Agulhas in South Africa along longitude 20°E. It is almost equal distance across, stretching for a distance of about 7000 km along latitude 10°N, from its most westerly point – Cape Verde (17°W) in Darkar – to the most easterly point – Cape Ras Hafun (near Cape Guardafui) which lies at about 51½°E (see Fig. 1).

From the foregoing, it is obvious that the equator passes almost through the middle of the continent and in this respect, Africa is unique amongst the great land masses of the world. It is the most tropical of all the continents as three-quarters of the continent or over 24 million square kilometres lie within the tropics. The disparity in the area of Africa north of the equator and Africa South of this line is worthy of note. That part of the continent north of the equator is more than double the area of that division of Africa lying south of equator.

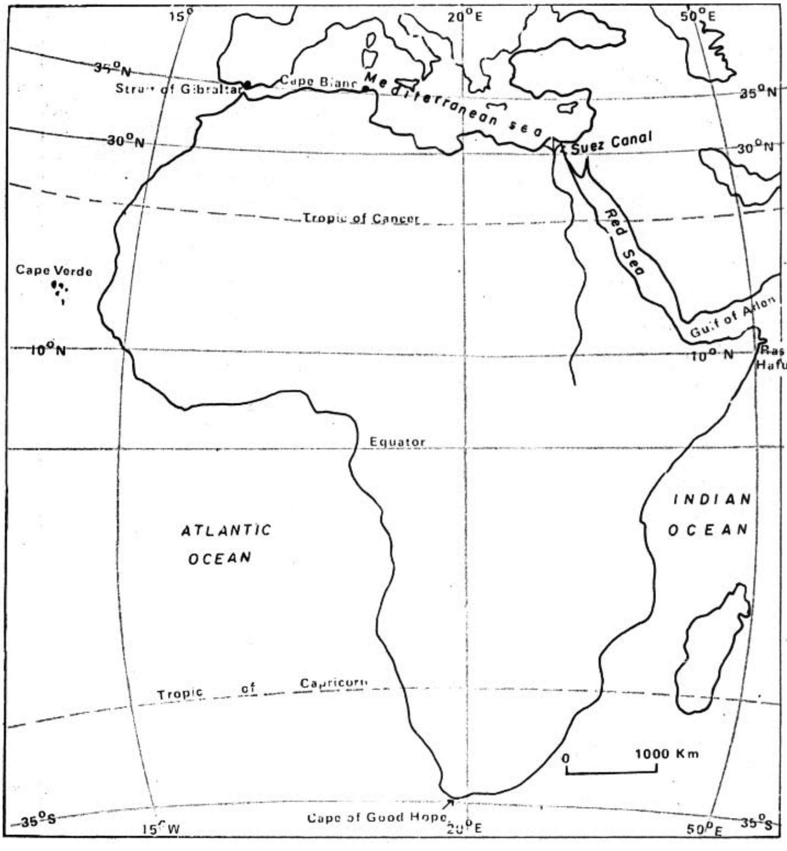

Fig. 1 Map of Africa (location).
Source: Abegunde et al. (1990)

The Relief of Africa

Africa, as a whole consists of a series of rigid plateau surfaces, consisting of ancient rocks; it is generally level and monotonous over vast areas with a narrow coastal plain. The plateaus are higher in the south and east than in the north and west. Thus in respect of this apparent uniformity, there may be distinguished, what has been termed a "High" and a "low" Africa divided by a line drawn from northern Angola, north-eastwards to western Ethiopia around the gulf of Aden. Thus low Africa lies in north and west, while High Africa lies in the south and east (Fig. 2).

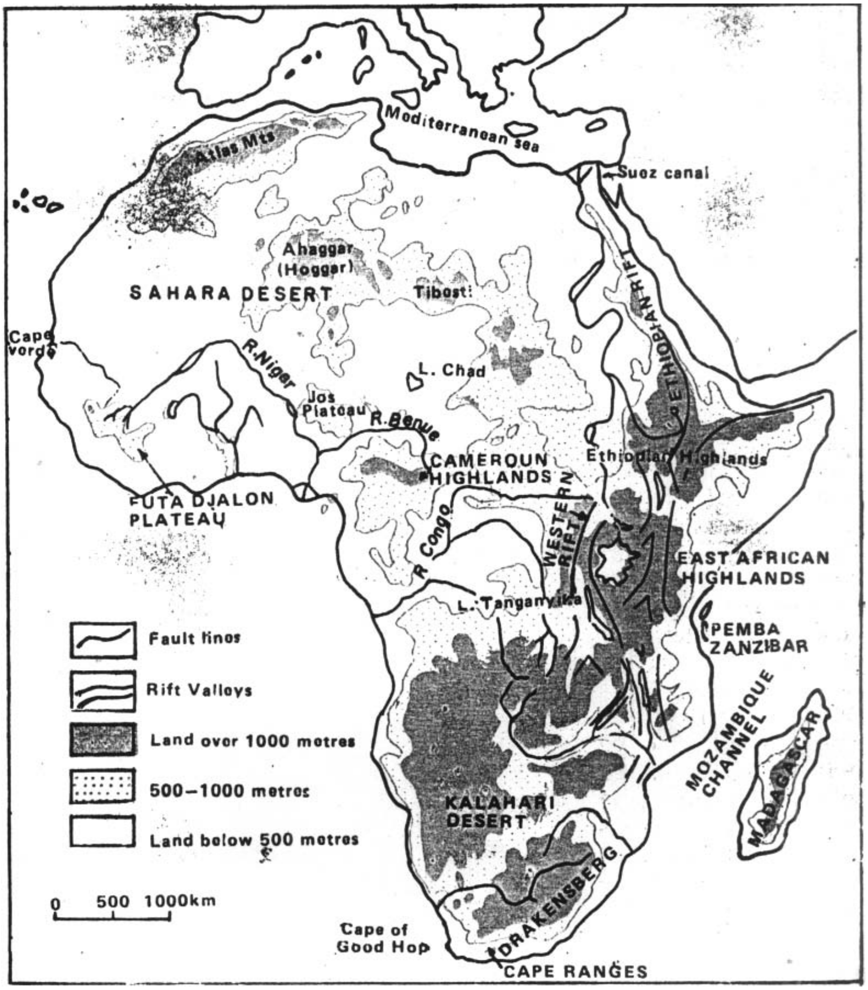

Fig. 2 Africa: main physical features.
Source: Abegunde (1990)

Low Africa is largely made up of upland plains and sedimentary basins from 500 to 2000 ft above sea level, that is from 150–600 metres above sea level. In low Africa there are exceptional ridges or plateaus standing above the general level of the major tableland; among those in the north are found mainly in parts of atlas mountains, the granitic uplands of Dar Fur, Ennedi, Borku, Tasili, Tibesti, Tummo and Ahaggar. In West Africa are the Fouta Djallon and Guinea highlands which are usually less than 900 meters high. To the south and east, High Africa is nearly all above 3000 ft or 900 metres. The exceptions are Somalia which is low lying, the lowlands on either side of Mozambique channel, the narrow coastal plains and valleys along some of the rivers like the River Zambezi, Orange river etc. Even the Kalahari Basin is 3000 ft or more above Mean sea level. The highest point in south Africa is the Drankensberg (Dragon mountain) which is over 3000 m high. In general, the surface of Africa is dominated by great plateaus several thousand feet above mean sea level. The Plateaus are the products of long periods of erosion, uninterrupted by folding and consequently, the whole Block of Africa has been uplifted, but the uplift has been highest in the south and east where most of the areas lie above 3000 ft above mean sea level.

There are some places in Africa which are not part of the plateaus. Among them are the two fold mountain belts; the atlas mountain belt in the north and the cape ranges in the south; also there are the few volcanic cones which have accumulated on the surface of the plateaus building peaks which is above the general level of plateaus. Examples of these are the Cameroun peak (4070 m), the Ethiopian highlands (over 3,500 m), the Elgon (4321 m), Kenyan highland lands (over 3,500 m), and Kilimanjaro (5898 m), which is the highest peak in Africa. Others include Ahagar and Tibesti mountains.

Apart from the mountains, there are six major basins in Africa; these basins are structural basins in which have been accumulated deep layers of sedimentary rock. These basins are surrounded by highlands. These basins are: the Zaire basin; the Sudan basin; the Chad basin; Eljuf basin; the Libyan basin; the Kalahari basin. One common feature of each of these basins is that a major river flows in and out of the basin.

The Rift Valley of Africa

Some of the most striking features in the whole continent are the great rift valleys of east Africa. This huge trough which covers a total of about 9600 km, has been let down between two sets of parallel faults and is simply a continuation of the great rift valley of Asia.

The Rift begins in Jordan and runs south through the red sea. It then passes through Ethiopia and eventually reaches lake Malawi. In this part of its course, the African rift valley carries lake Abaya (Ethiopia), Lake Turkana and other lakes as well as rivers. From Lake Malawi a westerly branch runs northwards to give the whole formation a Y-shape. The latter branch carries lakes Mobutu, Idi Amin Dada and Tanganyika.

The exact course of the Rift valley is best followed by its string of lakes. In Kenya and neighboring states – the faulting has been accompanied by volcanism. Elgon, Kenya and Kilimanjaro are the best known examples of the resultant volcanic mountains.

Drainage

We can distinguish three broad types of drainage areas in Africa namely: Exoreic, Areic and Endoreic drainage areas.

Exoreic drainage involve areas where rivers drain directly to the ocean. Of these areas which drain to the ocean, a large portion consist of broad low shallow basins with flows between 1000 and 3000 meters above mean sea level and these basins are drained by a single outlet. These outlets are narrowly confined where they break through the rifts of the basins and these outlets are the great Rivers of Africa, namely: The Nile (white and blue), the Niger with its tributary – Benue, the Congo river or Zaire river, the Zambezi and the Orange. These major rivers flow into the structural basins and out of it.

The Areic drainage areas are areas without organized surface drainage. They are the semi arid and arid areas, such as the hot deserts, where precipitation is insufficient to give rise to integrated system of drainage but in such areas past pluvial phases are seen.

The remaining areas are those of Endoreic drainage. These areas drain into inland basins, with no river outlet to the sea. They include Lake Chad Basin, the Makarikari basin, Lake Rudulf; the Plateaus of Shotts. Some of them constitute salt pans/salt lakes as can be seen in the case of Makarikari and the Plateaus of Shotts.

Climate

As already known, Africa is the only continent crossed by the Equator and by both Tropics, Cancer and Capricorn. As three-quarters of its land area lie within the tropics, temperatures are generally high and its climates are mostly tropical or subtropical in character with temperatures above 20°C all the year round. Consequently, seasons are determined by rainfall. However, there are temperate climates in the Mediterranean areas of northern Africa and in the southern and south-western parts of Cape Province in South Africa, and in some of the higher areas of the interior plateaus. Oceanic influences are generally restricted especially on the western sides of the continent where the effect of the cold Benguela current, flowing towards the Equator is very limited. The warm currents of the Indian Ocean have more marked effects over larger areas, and from them, warm humid air sometimes penetrates far inland.

Between November and March, the sun is overhead in the southern hemisphere, temperature is high and pressure is low in the central part of southern Africa, while in the northern hemisphere, the opposite is the case. Winds are then drawn to the low pressure areas – thereby giving heavy rainfall to the Zaire basin and the western part of Madagascar (over 100 cm). Most parts of West Africa have dry season.

As the sun is overhead at the tropic of cancer in June, between May and October, temperature is high in the northern hemisphere and pressure is low. Winds are then drawn northwards. The southeast trade winds on crossing the equator are deflected to the right, to become south west winds which give rainfall to West Africa and the greater part of Central Africa. At the southern tip, the northwest wind is drawn inwards to give rain to the Cape Province.

As climate is regulated by the apparent movement of the sun between the two tropics and the associated movement of winds, it (the climate), tends to change in a similar way in the direction of the north or south of the Equator. This gives rise to symmetrical climatic zones in Africa consisting of the central zone of equatorial climate, two tropical zones, two hot deserts and two Mediterranean zones. It is noteworthy, however, that this symmetry is only perfect in West Africa. In East Africa, the climate is modified by altitude and the belts are longitudinal, while in southern Africa, the modifying factors are the contrasting ocean currents, the prevailing winds and the influence of the highlands.

Associated with each of these climatic zones is a vegetation type, since the vegetation of a region is largely controlled by the climate. This close relationship that exists between climate and vegetation in tropical Africa, is most obvious in West Africa where the main vegetation belts, like the climatic regions are arranged in West-East direction. The reason for this is that rainfall is by far the most single important factor influencing the natural vegetation of tropical Africa. Climate is also probably the most important factor in the formation of tropical African soils through its main elements of temperature and rainfall. The direct influence of climate through deep weathering and leaching and its direct influence through the vegetation cover on the profile and humus content of the soil is considerable. In addition the vegetation cover protects the soil from accelerated soil erosion and helps to regulate the moisture content of the soil. Indeed, the relationship between soil and vegetation is so close that some of the major soil groups, such as rain forest soils and desert soils, are named after the corresponding vegetation zones. Thus the close relationship between climate, vegetation and soil is best confirmed by comparing the generalized soil map of tropical Africa and vegetation. Impliedly, therefore, by this observed relationship, climate, especially the climatic element of rainfall is also the most important factor as far as agriculture is concerned in tropical Africa. In most areas, success or failure depends on the amount, distribution and reliability of the rainfall. Furthermore, in many rural areas which are located far away from water courses, rainwater remains the most important source of water for both man and beast.

Historical Orientation

The dearth of knowledge by people about Africa's past made them develop all sorts of misconceptions and wrong judgments about Africa. The vanguards of such misjudgments and misconception were the Europeans who were discouraged by their exploration of the continent by such obstacles as relief, climate, vegetation and soils. In consequence, Europeans knew little of the people and resources of Africa, and so, for many years, their main objective was to find a way around, not to try to move into the land-mass that stretched across the equator and divided the Atlantic from the

Indian Ocean. However, eventually Africa was explored both along the coastal areas and the interior leading to the chase and competition among European nations over the possession of the different territories of Africa and its eventual balkanization. This activity of Europeans in dividing the various territories of Africa to themselves came to be popularly called "THE SCRAMBLE FOR AFRICA".

However, the Europeans gave a verdict on Africa as the "Dark Continent". Some also believe that at the time of colonization, Africa has no political sophistication, economic organization and artistic achievement. This is a false image of Africa's history which has been re-ordered, re-constructed, and re-presented.

The lateness of European invasion of Africa is itself an evidence of the degree to which Africans were organized before colonial invasion. Europe has been in commercial contact with Africa for many centuries but could not penetrate until 19th century. In the area of political consciousness and economic organization, many strong kingdoms developed in Africa, far before contact with Europeans. For example Egypt was the scene of very early civilization. Egyptian pyramids – one of the wonders of the ancient world, the art of writing, surveying, irrigation engineering, embalmment – all took place in Egypt irrespective of Europeans.

In other parts of Africa, there were many strong kingdoms/empires that developed before colonialism, such as Oyo, Borno, Songhai, Mali, Ghana to mention but a few; all these kingdoms stood and prospered politically, economically and artistically.

From Africa's Pleistocene statigraphy, we find orderly sequence of objects made by man's ancestors ranging from the earliest stone pebble tools to the making of hand axe. In a place in Tanzania called Olduvai Gorge, there is a sequence of layers covering 2½ million years and this shows the sequence in development of man much better than can be found in any part of the world. Perhaps, in the later part of this Pleistocene period, the glaciation and alternation of the cold and warmer periods was reflected in wet and dry areas as in the rift valleys of East Africa. It was during this period that the use of fire was discovered in Africa, about 60,000 years ago, perhaps to warm the early man. Man sought shelter in caves, made tools like wooden handle and started to wear the skins of animals. It was at this time that the Homo Sapiens appeared on the scene of Africa and perhaps they form the ancestors to the present Khoisan (Bushmen) we find in some parts of Africa.

Africa's first occupants were hunters and gatherers who spent their life in forests. They lived in small bands, under the guidance of the most skilful hunter who is then the leader. Shelter was simply made using branches and grasses gathered locally, while some lived in rock shelters. Some of these inhabitants left the paintings they made for identification.

In the North East Africa, there was later arrival and that was the Caucasoid type; they came in from the way of the middle East and some of them we still find today. Some of them moved towards the East African lakes and they introduced the idea of barbs for the arrows. They also introduced special chiseling tools and pottery.

Some archeologists, anthropologists, linguists and historians have attempted to reconstruct the coming of man to Africa using language/linguistic phenomena as their guide. They distinguished between Semitic and Kushitic groups of people – all found in the North East of Africa. There is a group that spoke the Khoisan language – these existed in southern part of Africa about 5000 years ago.

The third group – the Niger-Congo stock are found west of lake Chad and are called West Sudanic people. A study of the individual languages in each group makes it clear that each group have been developing in separate way from other groups e.g. the Bantu language are much more related than the others.

Contact with Asia brought some migrants into Africa who settled along the shores of East Africa and Malagasy where they formed the ancestors of the present day Malagasy people (Indonesia).

Agricultural revolution in Africa started about 3000 BC. and it is believed that agriculture was invented in West Africa independent of other countries like South East Asia. This started with the growing of cereals, learnt first in the Savanna land and so spread to forest lands and East Africa. Contact with other parts of world resulted in the introduction of other crops from other areas. After Africans learnt agriculture, it enabled them to live in groups, and villages with political and economic consciousness.

Africa in the Recent History

As already established, Africa was eventually colonized and between about 1880 and the beginning of twentieth century, several European states including Great Britain, France, Belgium Germany and Portugal were all involved in the "scramble for Africa". By the outbreak of the first world war in 1914 nearly every part of African continent had been occupied by some European nation so that inevitably many areas were affected by the events of the war and by the subsequent peace treaties. Some of the colonial powers organized the development of trade, built railways, road, and ports, and encouraged the production of cash crops gotten cheaply because of the tropical nature of the continent to feed the industrial and commercial interests of western Europe – this being the burning reason for their blatant scramble for African territories.

In some countries, efforts were made to establish settlements of white people using African domestic and farm labour, as in South Africa, Zimbabwe, and Kenya. In places minerals were discovered and exploited. Elsewhere the coming of colonial rule meant little more than establishment of law and order and the imposition of taxes and sometimes of military conscription.

Political Independence

During the first half of the twentieth century most of Africa was still being administered by these colonial powers, but internal political movements together with a new understanding of the hopes and ambitions of the African peoples have changed the political map of Africa during the last five decades. Before the second world

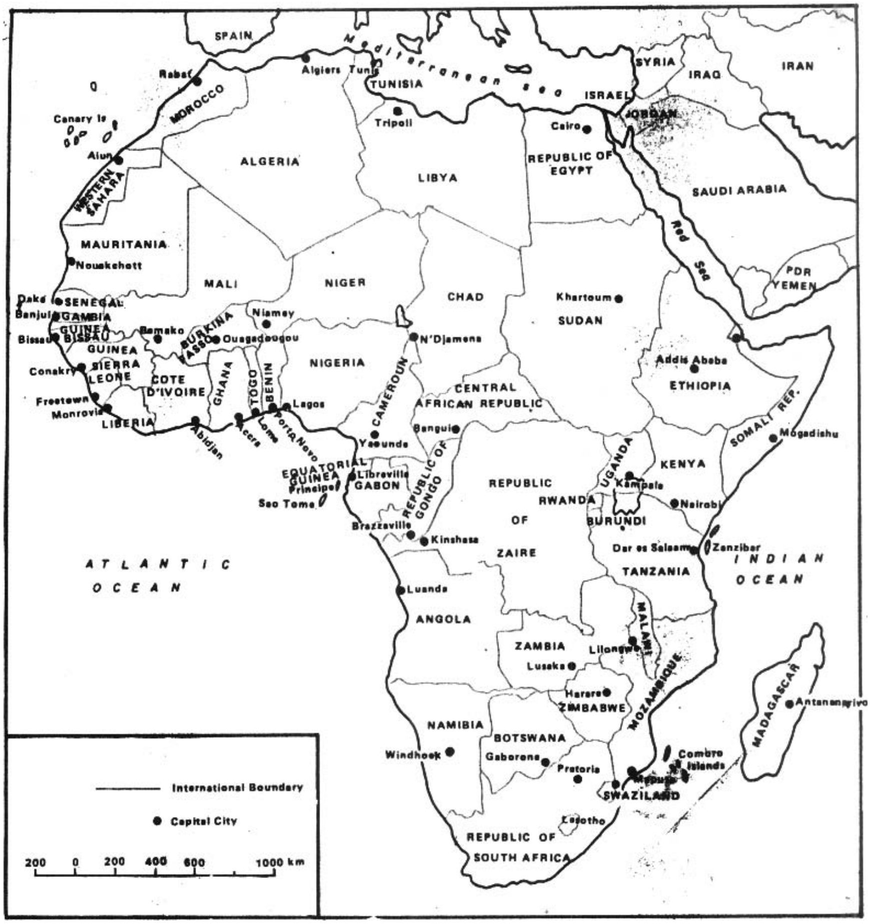

Fig. 3 Africa: political divisions
Source: Abegunde et al. (1990)

war only Liberia, a republic since 1847, Egypt with its independence recognized from 1922, and South Africa, where the union was created in 1910, could claim real political independence. Today by contrast, all parts of Africa (Fig. 3) can be said to have gotten political independence.

Population Distribution

Africa as a whole is not a densely populated continent having a figure of 8.6 per sq.km. Figures for the individual countries are, of course, misleading and sometimes hide as much as they reveal. Egypt for example has an average density of

33 per sq. km, but it includes large areas that are almost uninhabited whereas the average density of population is well over 200 per sq. km along the Nile valley.

In very general terms, it may be said that the greater the rainfall in any part of Africa, the denser the population, with Egypt as exception to the rule, which through irrigation application, the arid lands along the Nile supports one of the densest populations in Africa. In the Sahara, however, the scanty rainfall has produced a vast region of 6½ million sq. km where there is scarcely any settled population at all except at occasional oases; this same scanty population applies to the Namib and the Kalahari deserts and greater parts of the dense tropical rain forests.

In conclusion, it should be noted that the population density of Africa is above the average for the continent in Egypt, in the Guinealands, on the East African plateau around the lakes e.g. lake Victoria, on the coastlands of East Africa, the Mediterranean coastlands of North-West Africa and in Ethiopia. With the single exception of irrigated Egypt, all these areas have a mean annual rainfall of over 600 mm. Favourable climate, good soil, accessibility and presence of minerals favour high population density in Africa. Nigeria is the most populous country in Africa with a population of approximately 140 million as at year 2006.

General Conclusion

In the introductory note of this work, it was made abundantly clear that this was going to be a basic outline and this promise has been kept true. Not all the necessary topics came in and even those that came in received just a cursory examination. However, one hopes that no matter how skeletal the presentation, a casual onlooker would have been familiarized to an extent with the continent – AFRICA.

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The Astronomical Gnomon

A Series of Interactive Experiments in Archaeoastronomy

J. McKim Malville

The gnomon is the part of a sundial that casts the shadow, and it is probably also the world's oldest astronomical instrument. As basic as a pole stuck in sand, the gnomon may have been used to measure the passage of time by nomadic cultures of the Sahara for millennia. In the much later high cultures of the Nile Valley, the gnomon could have been used to determine the direction to true north for pyramids, palaces, and temples.

For those who carefully watched, the moving shadow of the gnomon revealed a profound symmetry in nature, a space-time pattern that connected heaven and earth. In the afternoon the tip of the shadow traces a pattern in the sand similar to that of the morning. The patterns are mirror images of each other, lying across an imaginary line of symmetry. That line pointed to a mysterious area to the north, around which all the stars of the sky revolve. This realm of the north, where stars never set, was viewed by the Egyptians as a timeless place of eternity.

There is more to the gnomon, for it also measures time by the tip of its moving shadow. The patterns on the sand are symmetrical about that time when the sun reaches its highest point in the sky, when the shadow is shortest.

Over the centuries the simple wooden pole in the sand was transformed into the tall stone obelisks of Egypt, a symbol of the axis mundi the line connecting heaven and earth. Obylists and gnomons may also have been perceived symbolic ladders to climb to the heavenly realms.

The earliest evidence of attention in Egypt to the norther regions of the sky comes from Nabta Playa where a ceremonial center was built by cattle herders on the edge of a seasonal lake, watered by summer solstice rains The area was occupied by nomadic pastoralists starting about 9000 B.C. and around 4500 B.C. it developed into a regional ceremonial center. In the area Nabta Playa, a gnomon (Figure 1), human and cow burials as well as a calendar circle (Figures 2 & 3) reveal the importance of north to these nomads.

Now we have Polaris, but for most of human history there has been no star at the north celestial pole. Previous cultured need a more indirect method of establishing

J. McKim Malville
University of Colorado, (303) 492-8766
E-mail: kim.malville@colorado.edu

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Fig. 1 Gnomon at Nabta Playa

north than simply aligning themselves with a pole star. One way is pay attention the rising and setting stars around the northern regions. Since the horizon is so nearly flat in much of the Saharan desert ancient sky watchers could have observed the rising and setting positions of the sun or bright stars in the north such as Arcturus and then split the difference to determine north. The problem with such a method is that is requires that the horizon be really flat. Any irregularities would have shifted the rising positions of the sun or stars. At low latitudes, however, the shift would be small.

The approximate direction to north could have simply been estimated by aligning with the vacant center of the zone of the sky where stars never set. Or, they could have used shadow casting by a gnomon, as we shall demonstrate in this experiment.

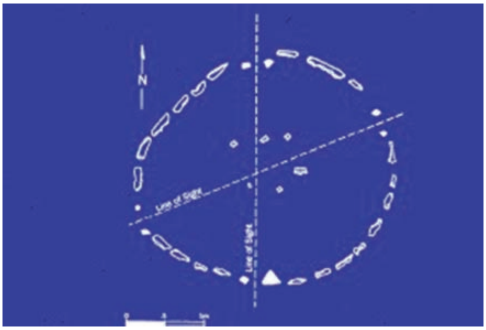


Fig. 2 Diagram of Nabta calendar circle

The History of the Gnomon

The incorporation of gnomons in sun dials extends at least to the 6th century BCE. Anaximander of Miletus is believed to have introduced sundials to Greece during the 6th century BCE. The Greeks had many public sundials consisting of tall columns casting shadows onto the ground, and many citizens had their own sundials. Aristophanes' play "The Frogs" written in 405 BCE (Tucker 1906) contains the line "When the shadow is ten steps long, come to dinner."

About 340BCE Berosus, a Chaldean astronomer-priest living in Egypt during the time of Alexander the Great, developed the hemisphericum, in which a vertical post was placed centrally inside a hollowed out hemisphere. The inside surface of the hemisphere had vertical lines carved on it to divide the daylight period into 12 hours, and horizontal lines to show the seasons. The shadow cast on the inside hemispherical marked out the path of the sun as it traveled across the sky; the hemisphere on earth mirrored that of the heavens, making this device an obvious metaphor for the parallelism of macrocosm and microcosm.

About 100 BCE the Tower of the Winds was erected in Athens at the foot of the north slope of the Acropolis. This octagonal tower had walls which faced the 8 cardinal and inter-cardinal directions North, South, East, West, North-East, North-West,

Fig. 3 Nabta calendar circle

South-East and South-West. It is so named because each wall features a carving with allegorical representations of the wind which blows from that particular direction. A horizontal rod gnomon was reportedly carved into each wall, although it is not clear how a horizontal gnomon on the north wall would have functioned. The angle of the shadow on each sundial told the time, while the length of the shadows told the date, and the tower building thereby acted as both clock and calendar. The Tower was accurately aligned North-South, so the sundial markings on the complementary faces (e.g., NE and SW) were repeated as mirror images, usable in the morning and afternoons, respectively.

Some time in the 14th century in Europe the gnomon of a sundial ceased being either vertical or horizontal, and was first inclined at an angle equal to the latitude to make it parallel to the axis of rotation of the Earth. The result was that the varying length of the shadow of gnomon-sundial no longer established north-south. However, when so constructed the shadow moved uniformly with the sun and thus the sundials began to tell time according to the system of equal hours. By about this time mechanical clocks which divided the day into 24 equal hours started to appear. They were rare, expensive, and not very accurate, often wrong by several hours. The mechanical clocks needed to be calibrated by sundials, probably at the time of local solar noon.

When the entire dial is tilted toward the north celestial pole and the gnomon is exactly parallel to the axis of the earth, one has constructed a miniature earth. When the dial is tilted to the earth's pole it mimics the earths equatorial plane, as illustrated in this picture of the sun dial at the University of Colorado (Figure 4).

Experiments

1. **Establish the direction to true north.**

   a. **Approximate Method**: The easiest method to establish north-south is to erect a gnomon and place markers at the tip of the shadow over the course of the day and note where is it shortest. You will notice that the tip of the shadow is diffuse because of the penumbra of the shadow. Try to be consistent in marking the center of the shadow. An approximate north-south line can be drawn between the gnomon and the place where the shadow is shortest. Because the speed of the earth in its orbit varies throughout the year, solar noon differs from 12:00 standard time by up to 16 minutes. That difference is known as the equation of time. Because it is difficult to establish the time when the shadow is shortest, this method is not as accurate as the next one described below. But, you can use the length of that line to determine the altitude of the sun at noon (Figure 5). Once the altitude is determined, you can calculate the declination of the sun (Figure 6) (which is, declination (δ) = altitude + latitude − 90) and you can develop a table for the annual variation of the declination of the sun.

Fig. 4 Sundial at the University of Colorado. The gnomon is pointing toward the north celestial pole, which in Boulder is 30° above the horizon

b. **Standard Method:** Take a pole around 4–6 feet tall and place it in the ground, getting it as vertical as possible using a plumb bob (Figure 7). In order to achieve the greatest precision in the measurement of true north (or south), the ground should be as flat as possible. Using a rope attached to the pole, mark out a circle of such diameter that at mid-morning and mid- afternoon the

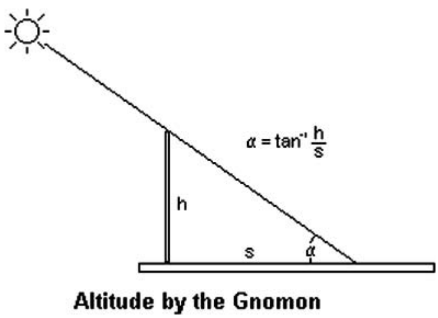
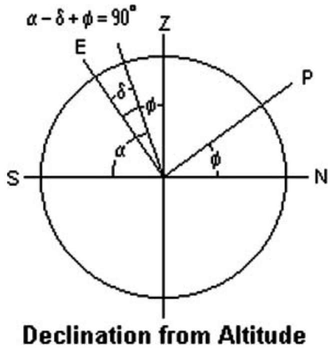


Fig. 5 Altitude of the sun as determined by the length of the shadow of the gnomon

Fig. 6 Declination of the sun as determined by its altitude (E: ecliptic; P, north celestial pole; S, southern horizon; N, northern horizon, α, measured altitude of the sun; ϕ, latitude; δ, declination)



shadow crosses the circle. The line connecting those two crossing establishes east-west. A perpendicular to that line established north-south.

This technique relies on the almost perfect symmetry of the sun's motion across the sky around the north-south line, which is known as the local meridian. The symmetry is perfect at the solstices when the declination of the sun does not change between morning and evening. The broken symmetry becomes greatest at equinox when the sun is changing its declination most rapidly, but even then the effect is small. In their attempt to achieve absolute perfection in constructing Hindu temples, the architects of ancient India developed several methods for correcting for the broken symmetry, which are discussed in the Appendix.

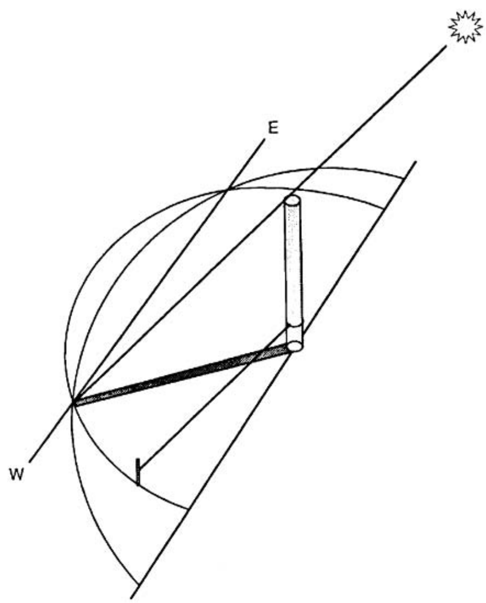


Fig. 7 Standard method for determining true north

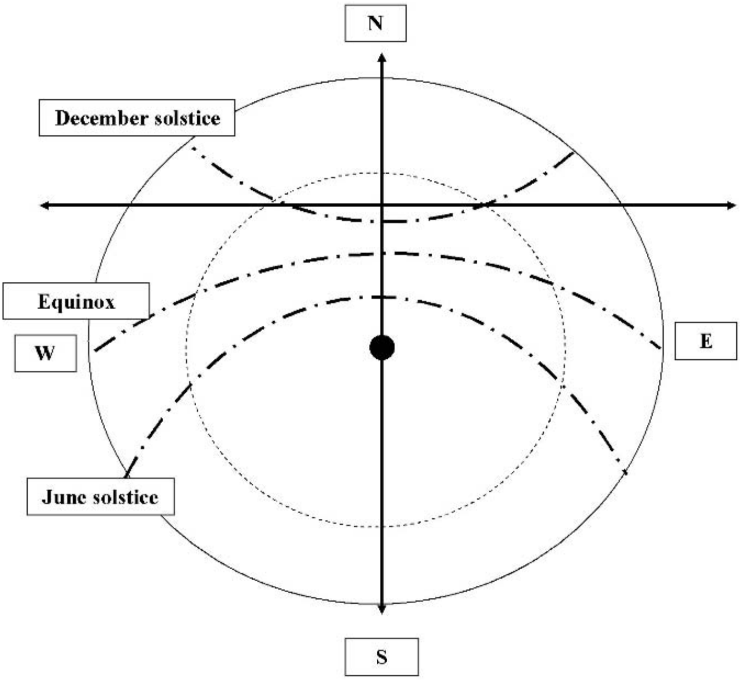


Fig. 8 Gnomon shadows at northern mid-latitudes. The arrow indicates east-west as established by the two places where the shadow crosses the circle drawn around the gnomon. The dot indicates the position of the gnomon

Patterns of the gnomon shadow for mid-northern latitudes (Figure 8) and the equator (Figure 9a) are shown below. Note that at the equator, there is no shadow cast by the gnomon at solar noon on the day of equinox. Throughout the tropics, between the Tropic of Cancer and Tropic of Capricorn, there will be days when the sun is at the zenith and the gnomon will cast no shadow. The shadow pattern is unique at the equator, on the Tropics of Cancer and Capricorn, on the Antarctic and Arctic circles, as well as at the poles. With their symmetries, these patterns have great aesthetic appeal. It is not unreasonable to imagine that some formed the inspiration for the designs of rock art, ceramic decorations, and weaving patterns in the ancient world.

2. **Compare with Magnetic Compass**: Measure the difference between true north established with north determined by a magnetic compass and your measurement of north. The difference is the magnetic declination. Compare your measured magnetic declination with that established by a theoretical model of the earth's magnetic field found at www.ngdc.noaa.gov/seg/geomag/jsp/**Declination**.jsp
3. **GPS Measurements**: Because the uncertainty of positions by a Global Positioning System Unite (GPS) is typically plus/minus 5 meters, you will need a long base line to establish the line precisely. With your GPS measure latitude

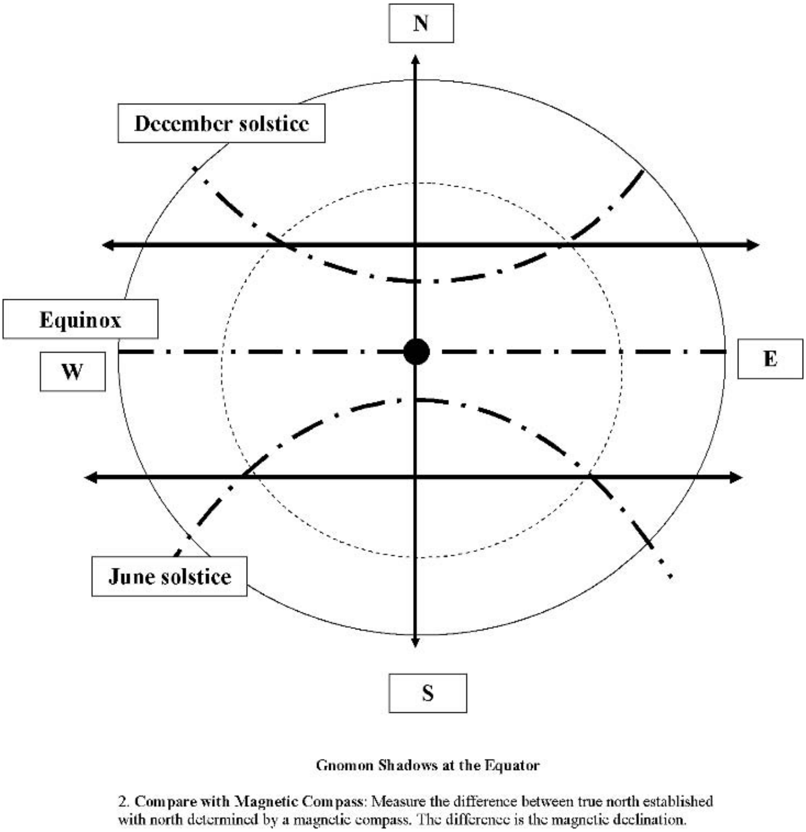


Fig. 9a Gnomon shadows at the equator

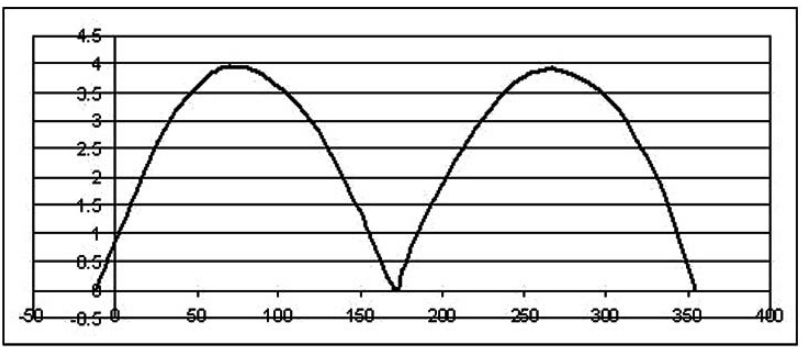


Fig. 9b Asymmetry of shadow patterns: difference in minutes of arc between morning and evening due to the changing declination of the sun over a four hour period

and longitude of the gnomon. Move either north or south away from the gnomon along the north-south line established by the shadow casting by the gnomon. A friend positioned behind the gnomon can assist you in keeping in line. Go to the greatest distance you can go and still see the GPS from the gnomon, measure its latitude and longitude at this distance. Determine the difference in latitude and longitude between the gnomon and the end of the north-south line.

The angular distance between true north determined by the GPS and that of the gnomon is j = arctan[(difference in longitude x cos(lat))/difference in latitude)]

4. **North Star** (Figure 10): If you are north of the equator, using a second person with a flashlight, establish a north-south line using the North Star and then compare with your other north-south lines. Polaris is now nearly 45'/cos(lat) away from the north celestial pole; in order to reduce the error in azimuth one could observe Polaris when it is in upper or lower culmination, i.e. exactly above or below the pole. Tables in the Astronomical Almanac can be used to determine the true azimuth of the Pole Star and when best to observe it. It is only in the last few centuries that the star we know as Polaris has been close enough to be useful for determining true north.
5. **Theodolite:** If you can get access to a theodolite, some of these measurements of true north-south can be made more precisely, such as the location of polaris or a distant GPS. High precision can be achieved by measuring the position of Polaris or a person holding a GPS at a distance of several miles.

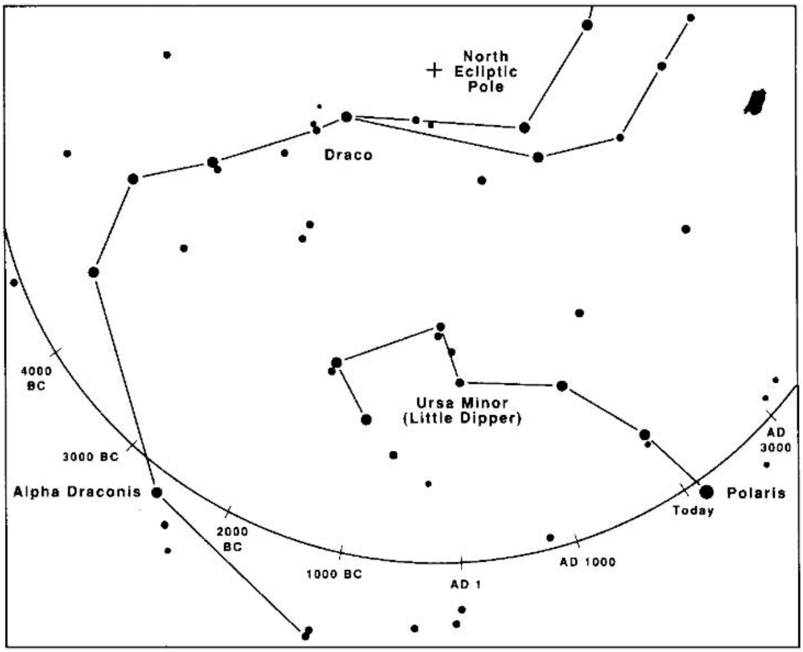


Fig. 10 Changing position of the north celestial pole from 4000 BC to AD 3000

Appendix

Shadow Casting by the Gnomon in India

Measurement as Ritual

The achievement of such extraordinary accuracy in locating the north-south axis of certain Hindu temples and cities results from two reinforcing themes in Indian architecture. Not only were techniques developed for precision measurements of the sun, but there was a robust religious support for such precision. The very act of measurement was understood to be a re-enactment of creation.

In Hindu tradition Prajapati, who is the Year, measures the world, both in space and time, with his eye, the sun. Purusha, identified with Visvakarman, the architect of the universe, "bears the measuring rod (*mana)*, knows divisions, and thinks himself composed of parts (*Vayu-purana* IV.30–31: Kramrisch 1941:131).

Both Vishnu and Varuna use the sun as their measuring instrument to measure the earth (*Rig Veda* VI.49.13; V.85.5). "What precedes the sun is timeless (*akala)* and undivided (*akala);* but what begins with the sun is Time that has divisions and its form is the year" (*Maitri Upanisad* VII.11.8). In its daily movement from dawn to sunset the sun measures the earth along its east-west path and establishes those two directions of space. At its highest point the sun establishes the north-south axis. On certain days of the year between the Tropics of Cancer and Capricorn, the sun reaches the zenith of the sky, thereby establishing the fifth and six directions of zenith and anti-zenith. During its annual movement the sun moves eastward along the ecliptic approximately 1° per day, marking thereby the days, the four seasons, as well as the dates when the sun emerges from the cosmic ocean (at vernal equinox) and sinks back into the cosmic ocean (at autumnal equinox).

To measure *ma* is to give existence to a thing, to give it reality in our world. *Maya*, or manifestation, refers to division of the original, undivided Whole, and is the illusory world created when Purusa performed division upon himself (Zimmer 1946).

Recognition of the role of measurement in cosmogony extends far back into the past time of India. The Vedic altar was reconstructed each year near the time of vernal equinox as a symbolic reconstruction of Prajapati, the year (Kramrisch 1981). Built of five layers, representing the five seasons and the five directions, the altar was surrounded by a wall of 360 bricks acknowledging that the year is bounded by 360 days. During the building of the wall 1200 syllables were recited at the laying of each stone, resulting in a total of 432,000 syllables built into the wall (*Satapatha Brahmana* X.4.2.30). There are 432,000 syllables in the Rig Veda, and 432,000 years in the Kali Yuga. The altar itself was constructed with 10,800 bricks corresponding to the number of hours in the year with 30 hour days (*Satapatha Brahmana* X.4.2.18).

The importance of precise orientation and measurement in construction of the temple reveals the cosmogonic symbolism involved in the act. The Sanskrit term referring to the temple, *vimana*, means "well-measured" or "well-proportioned". Texts on temple architecture give extensive discussions of the system of proportional measurements which should determine all feature of the temple. The basic unit used in the *Ajitagama* and *Rauravagama* (Dagens 1984) is a “speck of dust” *(rajas)* as seen in a beam of light. The series of units extends upward through a hair end, nit, louse, to the barley grain which is 8^5 specks of dust in size. Other common units are the digit, *angula*, which may be 6, 7, or 8 barley grains and the cubit, which for the measurement of temples is 25 *angula* (Dagens 1984). Only if the temple was built with proper and precise units could it function effectively (Michell 1988).

The orientation of the site had to be established at the time when the sun was in the northern part of the sky, i.e. when it was above the cosmic ocean, on a day when there were no spots on its visible surface. A pillar, the gnomon, was erected and used to cast measured shadows. At one level of meaning that pillar represents the God Indra who “pillared apart” heaven and earth, supported the heaven and steadied the earth (Kramrisch 1991). “The building of every sacred shrine was a paradigmatic reiteration of the archetypal separation of heaven and earth” (Irwin 1991). Irwin (1981, 1983) has extensively discussed the symbolism of Asokan (and pre-Asokan) pillars with regard to pillar worship in India. The *yupa*, a sacrificial post, the *lingam*, the central pole of a tent used for dance, and the tree are other examples of sacred or ritual pillars. The stalk of the lotus bearing Brahma, the four-faced creator of the universe, is another cosmogonic pillar from which creation emanates.

In the gnomon we encounter the remarkable union of a technical device used to determine true cardinality with a powerful cosmogonic symbol. The gnomon should have a circumference at its base equal to its height, tapering to 1/3 this circumference at its top (*Ajitagama:* Dagens 1984). It is placed in a square area, which had to be “as smooth as a mirror”, checked with a water level. Around the gnomon is traced a circle with a radius equal to the height of the gnomon. Two points are marked on the circle where the shadow of the gnomon touches it at midmorning and midafternoon. These two points are joined by a straight line which is close to true east-west.

This method, often referred to as the Indian Circle method, produces an alignment to the true cardinal directions which is only approximately accurate during most of the year. Moving between its winter and southern extremes at the solstices, the sun changes declination most rapidly at the equinoxes (Figure 9b: in the figure the day count starts at spring equinox where the difference is zero; at 90 days and 270 days the difference is at a maximum). At the time of vernal equinox, for example, since the sun moves northward between midmorning and midafternoon, the eastern point, produced by the afternoon shadow is shifted slightly southward of the western point. The line connecting the two points would thus be tilted south of east in the spring and north of east in the fall.

Brahmagupta (born AD 598) is credited with the first recorded recognition of this defect of the method (Yano 1986), although he did not give a formula for correction. Apparently in AD 864, Prithudakasvamin knew of the formula but did not succeed in versifying it in Sanskrit and hence was not given full credit. In the classical age of India, one could not claim priority for a scientific discovery, unless one could express it in Sanskrit verse. Sripati (AD 1039) was the first who successfully versified the formula, and after him the formula apparently became common knowledge among Indian astronomers (Yano 1986):

$$s = h[\sin(dec_1) - \sin(dec_2)]/\sin(\text{co-latitude})$$

where s is the distance of the tip of the shadow from the east-west line, h is the hypotenuse of the shadow, and dec_1 and dec_2 are the respective declinations of the sun at the time in the morning and afternoon when the shadows touch the circle.

Even on the days of equinox, the effects of the movement of the sun in declination are quite slight. During 6 hours from midmorning to midafternoon, the declination of the sun varies at most by 6 minutes of arc. On the ground beneath the gnomon the error would amount to 2.6 cm for a 10 meter tall pole at latitude of 20° on the day of equinox.

The amount, by which the sun changes its declination during the day, decreases as the sun moves away from equinox and at solstice the change is zero. For the two month period around solstice, the maximum error is only 3' and within 10 days of solstice, the maximum error has fallen to 1', and the correction formula is hardly needed.

A second method of correcting the gnomon technique involved drawing three concentric circles around the base of the gnomon. This method did not require the equation of Sripati nor knowledge of the declination of the sun or the latitude of the site. At equinox the lines connecting the three pairs of point could differ from true east-west by 9′, 6′, and 3′ and the trend of these of deviations could be used to correct any one of the lines.

A third approach was to measure the shadow length on two successive days at the same time in the morning. The position of the afternoon shadow on the first day was corrected by 1/3 the difference of the morning positions.

Measurements with a gnomon could have been limited to periods around the solstices when the method yielded accurate cardinality, but additional considerations such as auspicious dates for the patron may have demanded dates closer to equinox. The vernal equinox, itself, was a significant time when the sun moved from the lower celestial waters to the more auspicious upper waters. Since the sun rises due east at equinox, that date may also have seemed most appropriate for laying out the ground plan of the temple which faces east.

Glossary

Prajapati: The Lord of the Creatures; primordial creator; the constellation of Orion, associated in the sky with his daughter, Rohini (Aldebaran).

Purusha: Another cosmogonic figure similar to Prajapati; a creative source; a creator who was sacrificed; his dismembered body became all of the world and heavens.

Varuna: An early Vedic god representing the sky and representing celestial order.

Vijananagara: Great Hindu kingdom of southern India, destroyed in 1565; largest ruined city in the world.

Vishnu: Preserver of the universe.

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Naked-eye Astronomy for Cultural Astronomers

J. C. Holbrook and Audra Baleisis

Abstract Cultural astronomy is an interdisciplinary field that attracts students from a variety of backgrounds. Many students have a background in astronomy, but even in astronomy departments students are not taught some of the most basic elements of the night sky needed for cultural astronomy research. For example, few students are taught constellation identification which is part of the foundation of cultural astronomy research. This paper seeks to introduce students to the information and skills needed to do cultural astronomy research effectively.

The Night Sky

The most difficult task for cultural astronomy students is to learn the night sky. Most students are familiar with the beautiful images taken with telescopes and satellites such as the Orion Nebula and the Andromeda galaxy. However, students are not as familiar with the night sky's stars and constellations visible without the aid of telescopes or binoculars. There are 88 constellations as set forth by the International Astronomical Union (IAU) (Table 1). However, knowing the names of the constellations is not as useful as knowing their locations in the night sky and their "shapes." It is useful to know what constellations are immediately adjacent to each other, as well.

For example, an informant points to a dim set of stars to the east of the constellation Cassiopeia. The constellations bordering the east side of Cassiopeia are Camelopardalis and Perseus, whose :"shapes" are markedly different with Perseus being composed of relatively bright stars but a less recognizable shape than Cassiopeia. Thus, the researcher first identifies Cassiopeia, then whether the informant is pointing to Perseus or Camelopardalis, then can identify a particular star, etc. Further, the informant may only be familiar with local names of asterisms – groupings of stars, which may not correspond in any way to the IAU constellations. The Big Dipper, for example, is one of the most famous asterisms, and is part of the formal

Jarita C Holbrook
Bureau of Applied Research in Anthropology, University of Arizona
FAX: +1-520-621-9608
E-mail: holbrook@u.arizona.edu

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Table 1 The names of the 88 constellations

Andromeda	Centaurus	Fornax	Monoceros	Scorpius
Antlia	Cepheus	Gemini	Musca	Sculptor
Apus	Cetus	Grus	Norma	Scutum
Aquarius	Chamaleon	Hercules	Octans	Serpens
Aquila	Circinus	Horologium	Ophiucus	Sextans
Ara	Columba	Hydra	Orion	Taurus
Aries	Coma Berenices	Hydrus	Pavo	Telescopium
Auriga	Corona Australis	Indus	Pegasus	Triangulum
Bootes	Corona Borealis	Lacerta	Perseus	Triangulum Australe
Caelum	Corvus	Leo	Phoenix	Tucana
Camelopardalis	Crater	Leo Minor	Pictor	Ursa Major
Cancer	Crux	Lepus	Pisces	Ursa Minor
Canes Venatici	Cygnus	Libra	Pisces Austrinus	Vela
Canis Major	Delphinus	Lupus	Puppis	Virgo
Canis Minor	Dorado	Lynx	Pyxis	Volans
Capricornus	Draco	Lyra	Reticulum	Vulpecula
Carina	Equuleus	Mensa	Sagitta	
Cassiopeia	Eridanus	Microscopium	Sagittarius	

IAU constellation, Ursa Major. Thus, it is very important that the researcher is able to identify both the constellation and the star of interest to be able cross list local names with the IAU standard names.

What is the Easiest Way to Learn the Constellations?

There are several ways to learn the constellations and their locations in the sky. Probably, the easiest is to get planispheres of the northern and southern hemisphere and start memorizing! A planisphere is a circular map of the night sky showing the stars and constellations. Planispheres are made for observing the night sky at different latitudes. For observing in the United States, a planisphere of latitude 40 degrees north is usually sufficient. Planispheres are usually available for purchase at planetariums and observatories, they can also be ordered online at “Shop at Sky”[2] and other shopping sites.

Paper star charts can be downloaded from the internet via “Your Sky” [3], “Starmaps.com” [4], “Sky & Telescope” [5], and “The Night Sky” [6]. Star charts without labels can be used to practice identifying constellations. Or star charts with the shapes of the constellations can be used for easier identification.

Having access to a good software program, that can recreate the night sky at any location and at anytime during the last 6000 years, is very important for cultural astronomy researchers. The software allows the user to adjust multiple variables to recreate what the sky looks like at a field site. Most researchers do not have the money or time to spend an entire year at a field site, so via the software they can explore the sky at other times during the year. For example: A researcher collected drawings from an informant of the positions of many stars rising in the east at sunset on the day of an important ceremony. The researcher can then use the night sky software to watch

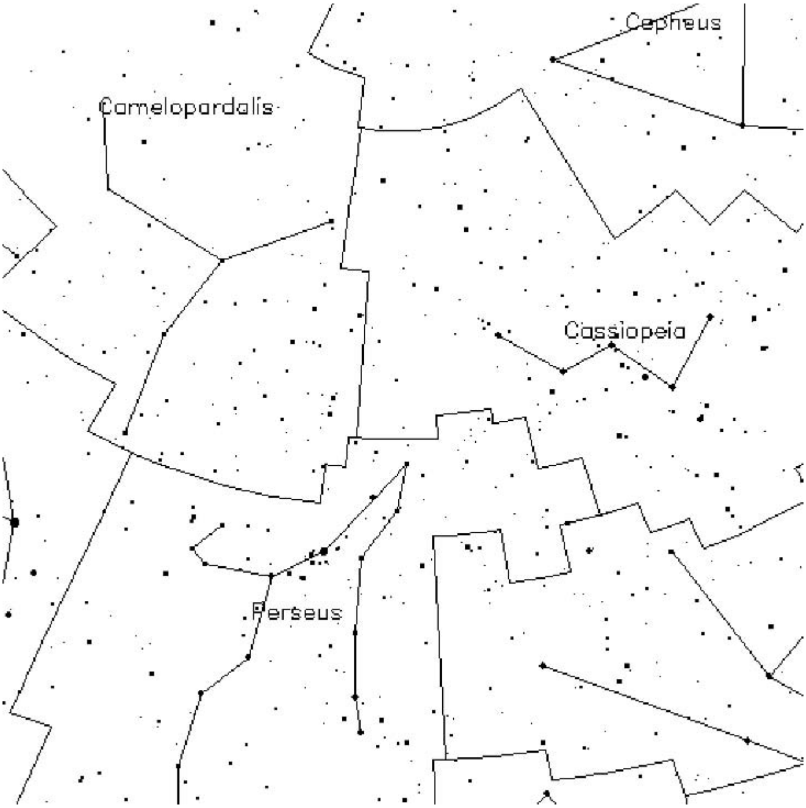

Fig. 1 HPLANET night sky image of Cassiopeia, Camelopardalis, and Perseus. With constellation borders
Source: Walker, J., Home Planet – HPLANET. 1994, Fourmi Laboratory. Software. http://www.fourmilab.ch/homeplanet/homeplanet.htm

the eastern horizon over time until the star positions match the drawing. Night sky software that is available free of charge is HPLANET [7] and Stellarium [8].

Another way to start learning your way across the night sky is to find someone who is already familiar with the constellations and is willing to give you an introduction. This is also a good way to bring the knowledge you gain from using a planisphere, a sky chart or with a software program, outside to the real sky. The actual night sky can look very different from anything on paper or a computer screen. It is very useful to learn to find a star that is shown on a chart also in the night sky and vice versa.

Finally, this introduction to the night sky is descriptive – we are pointing out facts about motions in the sky rather than spending much time explaining the underlying models of these motions. If you are interested in learning the underlying ideas about why the stars and planets move the way they do, we recommend you find an introductory astronomy book. A book for non-science majors in college may be a good place to start. If you have the time and resources, an introductory course

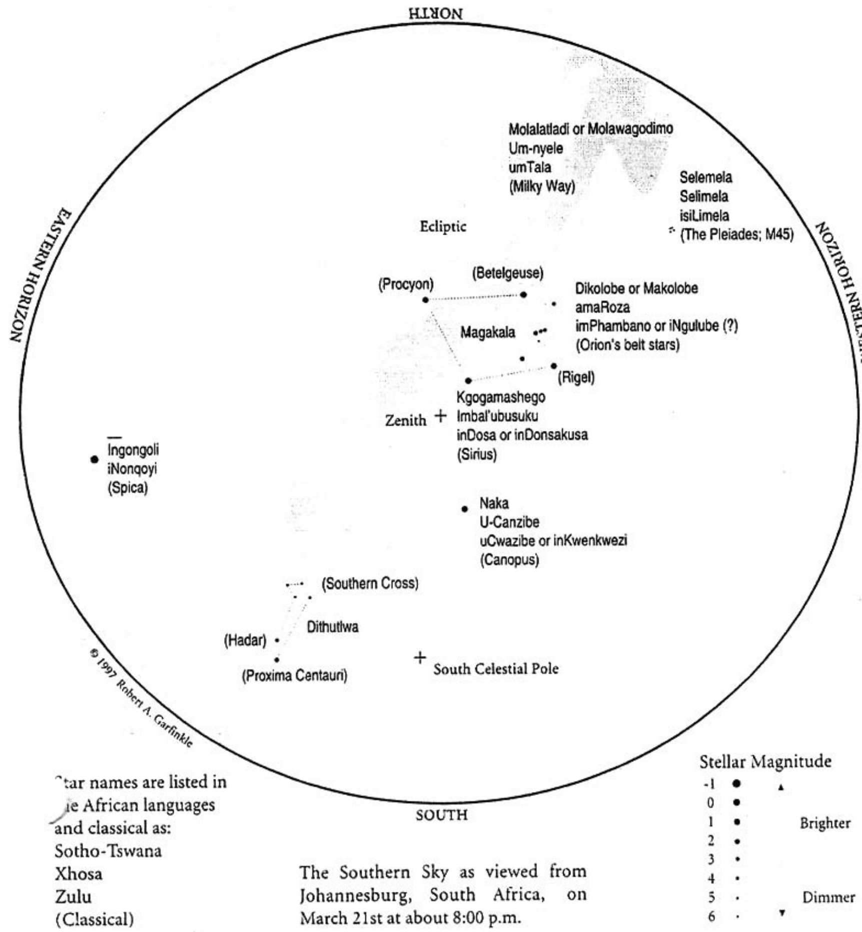

Fig. 2 Zulu night sky from Snedegar [1]

is even better. By learning about the space motions of Earth, the Sun, the Moon and the stars, you will better understand why the Sun does not always rise exactly East and set exactly West, why the stars visible in the night sky change throughout the year, and be able to bring that understanding with you to the field as an additional tool for cultural astronomy research.

The Bright Stars

Star brightness is measured in magnitudes, where the smaller the magnitude the brighter the star. Given low levels of light pollution, humans can see stars to a limit of about 6 magnitudes. At 5.5 magnitudes 2860 stars are visible [9]. However, not all of these have names nor are easily identifiable. Table 2 lists the thirty brightest

Table 2 Thirty brightest stars

Star	Name	M
alpha Canis Major	Sirius	−1.46
alpha Carina	Canopus	−0.72
alpha Centaurus	Rigil Kent	−0.01
alpha Bootes	Arcturus	−0.04
alpha Lyra	Vega	0.03
alpha Auriga	Capella	0.08
beta Orion	Rigel	0.12
alpha Canis Minor	Procyon	0.38
alpha Eridani	Archenar	0.46
alpha Orion	Beteigeuse	0.5
beta Centaurus	Hadar	0.61
alpha Aquila	Altair	0.77
alpha Taurus	Aldebaran	0.85
alpha Virgo	Spica	0.98
alpha Scorpius	Antares	0.96
beta Gemini	Pollux	1.14
alpha Piscis Austrinus	Fomalhaut	1.16
alpha Cygnus	Deneb	1.25
beta Crux	Mimosa	1.25
alpha Leo	Regulus	1.35
epsilon Canis Major	Adhara	1.5
alpha Crux	Acrux	1.58
alpha Gemini	Castor	1.58
gamma Crux	Gacrux	1.63
lambda Scorpius	Shaula	1.63
gamma Orion	Bellatrix	1.64
beta Taurus	El Nath	1.65
beta Carina	Miaplacidus	1.68
epsilon Orion	Alnilam	1.7
alpha Grus	Al Na'ir	1.74
epsilon Ursa Major	Alioth	1.77
gamma Vela	Regor	1.78
alpha Perseus	Marfak (Algenib)	1.79
alpha Ursa Major	Dubhe	1.79
delta Canis Major	Al Wazor	1.84
epsilon Sagittarius	Kaus Australis	1.85

stars in the night sky. It includes both northern and southern hemisphere stars and in which constellation they are located. Knowing the bright stars helps in the identification of fainter stars and their constellations.

Learning how to identify stars and constellations takes time, months and years, not hours. If you need help identifying constellations, again, check with your local amateur astronomy club. These clubs consist of astronomy enthusiasts who host "star parties" to which they bring their telescopes out for the public to use and to teach about the night sky. Members of these clubs can know a lot about the naked-eye night sky.

Fig. 3 Image of a northern hemisphere planisphere

Going Outside

Armed with your star chart or planisphere go outside and look up. It may take as long as 15 or 20 minutes for your eyes to adjust to the dark, and for you to see many stars. Only one flash of a white car headlight or misdirected flashlight can force you to start over! So, in order to read your starchart or find your way around, you need a red flashlight or red laser pointer. Using red light keeps your eyes dark adapted.

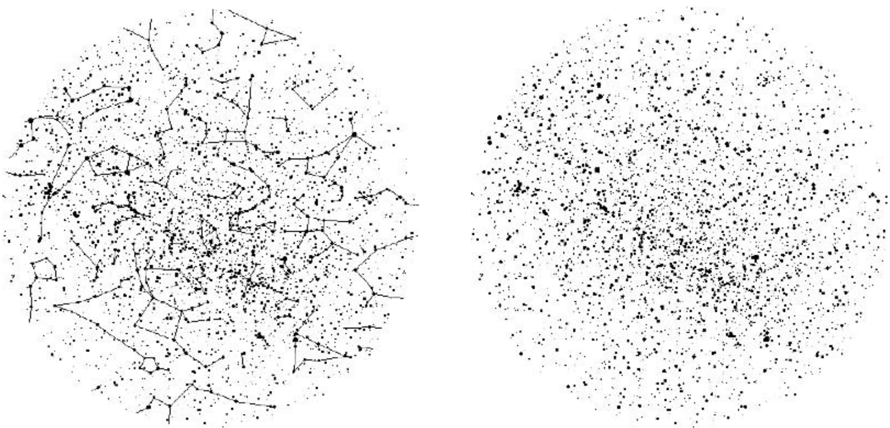

Fig. 4 Planisphere of the northern hemisphere with constellation shapes and without
Source: Walker, J., Home Planet – HPLANET. 1994, Fourmi Laboratory. Software. http://www.fourmilab.ch/homeplanet/homeplanet.htm

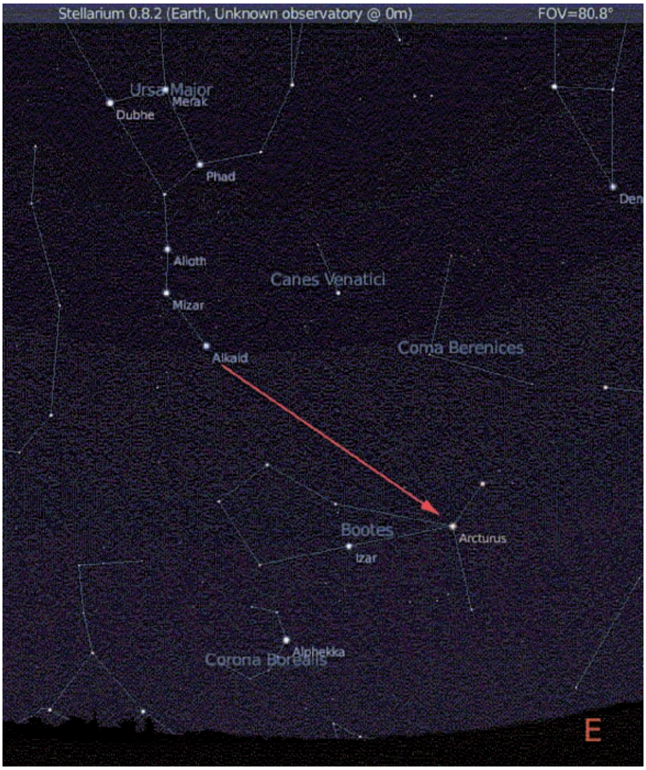

Fig. 5 Part of a Stellarium screenshot with an arrow inserted showing how to find Arcturus from the handle of the big dipper
Source: Chereau, F., Stellarium Software. 2001. http:// stellarium.sourceforge.net/

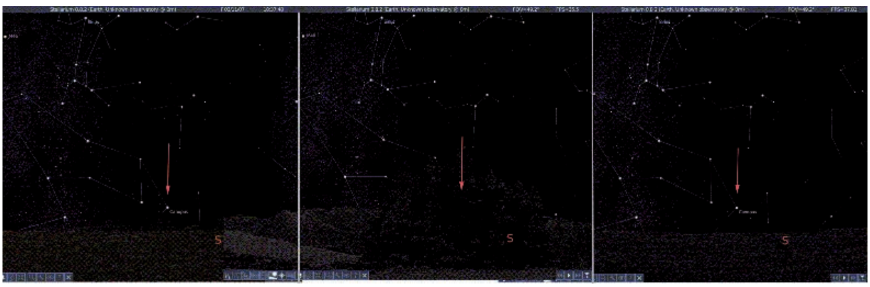

Fig. 6 Deciding when the star Canopus rises over a horizon may depend on what is on your horizon. Here there is (1) a farmland horizon, (2) a forest horizon, and (3) and ocean horizon, which is also the ideal horizon
Source: Chereau

Once your eyes are adapted to the dark, start looking up and noticing what you see. Finding stars and constellations in the sky does not just depend on your eyes being dark adapted – it also depends on how familiar you are with what you are looking for. The first time you go out may be frustrating, but remember it is part of a learning process, which means that you will get better with practice. If you can identify one constellation at first, you've begun. Next you might try to figure out some way to find a second constellation using a star chart, and the first constellation.

For instance, most Northern Hemisphere observers can find the Big Dipper. You can use this asterism to find a number of other stars and constellations. If you follow the curve of the handle of the dipper, away from the dipper itself, you "arc to Arcturus," the bright orange-tinted star in the constellation Bootes. Look on your map or chart first, see how this is done, and then try it outside.

Looking Around

If you were only interested in learning to identify constellations and didn't need to go further, you might stop here. But for doing cultural astronomy, there are a number of other important variables related to the sky. Considered here are the horizon, the cardinal direction, apparent distances, and direction angles.

The Horizon

To judge when a star (whether in the night sky, or you're looking for the Sun) or a planet rises or sets, you need to have a reference point, and this will depend on where you are when you are doing your observations. The first important reference point is the horizon. The horizon is the line at which the Earth's surface and the sky seem to meet. In real life, there might be mountains or forests or a city skyline in the distance from where you are standing. An extreme example of this is if you go out to look at the sky and stand very close to the building you just left. There will be part of the sky that is blocked by that building. Just keep in mind that where you stand (e.g. changes in distance of only a mile or so) might affect what your distant horizon looks like, and in turn, when celestial objects will rise or set past it. The ideal horizon, the one that you will be dealing with if you use any night sky software, is where the Earth's surface, at sea-level, would meet the sky if you could flatten all the mountains and remove all the trees. When you are looking out over an ocean or a sea, you can see an ideal horizon.

The Cardinal Points: N, E, S, W

The horizon is not the only reference system that is relative to you, the observer. There are also the cardinal points – the compass directions: North, East, South and West. It is important to know where these are along a horizon because they will help you interpret certain measurements like the rising and setting of objects in the sky. A compass can help you find these directions at a field site. Or ideally, you should learn which direction is north from the position of the constellations. The Big Dipper

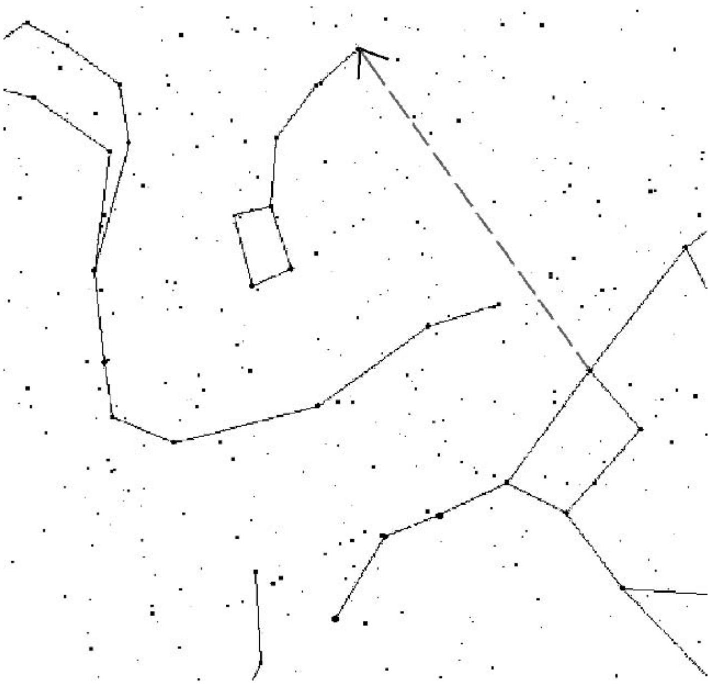

Fig. 7 Diagram of Ursa major and how to find Polaris
Source: Walker

and Cassiopea are two of the northernmost easily identified constellations. Both can be used to find Polaris, the star that marks north, also called the North Star.

Figure 7 and 8 show how a researcher uses these constellations to find north.

Similarly, there are the southernmost constellations. The Magellanic Clouds and the Southern Cross are used to find the general direction of south (Fig. 9). Unfortunately, there is no star like Polaris to mark south.

Distances in the Sky

There is one last basic reference system to consider. Think about answering the question, "how far west of the mountain peak did the star Canis Major rise?" This is not a question that can be answered with traditional distance units like miles, meters or kilometers. The reason is that the separation between objects in the night sky is measured in angles, not distances, because objects in the night sky only seem to all be located on a spherical shell around the Earth. In truth, the Moon is 384,000 km away from Earth, and the Sun is 150,000,000 km away. So, during a solar eclipse, the apparent separation in the sky between the Moon and Sun is almost zero, when in reality, they are 149,616,000 km apart from each other in space! Luckily, we are not worrying about how far they are from each other in space. We only need to learn the system of angles, where opposite sides of the sky – like North and South, or straight above and straight below – are 180° apart, and from the horizon to straight

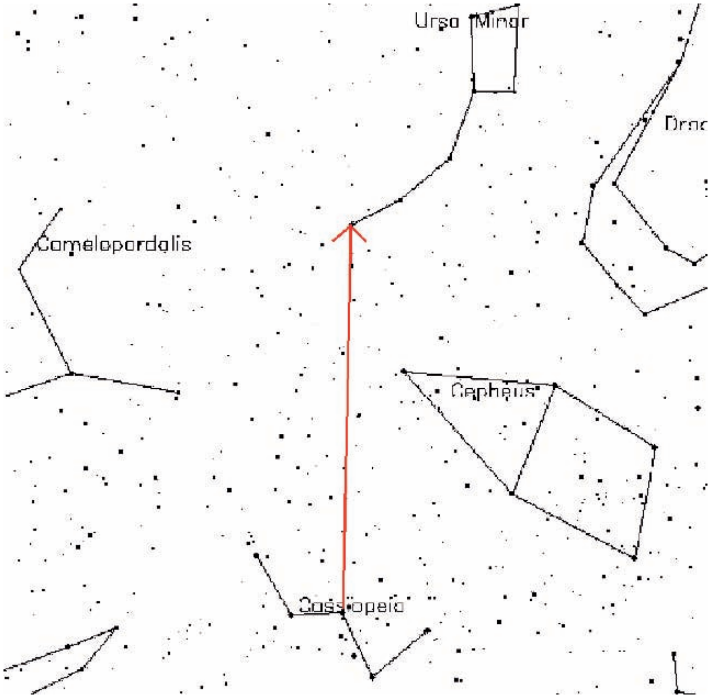

Fig. 8 Diagram of Cassiopeia and how to find Polaris
Source: Walker

above is 90°. This that lets us say that during a solar eclipse, the Moon and Sun are 0° apart in the sky, and during a Full Moon, they are 180° apart in the sky. To go from a point in the sky, all the way around the sky (in the largest circle you can draw) is 360°. From one cardinal point to the next, for instance from North to East, is 90°, as is from the horizon to the point directly above your head, the zenith.

When looking along the horizon you also note the rising and setting position of celestial bodies using angles. There is a convention of North as 0°, East as 90°, South as 180°, and West as 270°. Estimating the rising and setting positions using this convention will make finding the same positions in Stellarium or HPLANET easier.

But what about smaller separations? There happens to be one observing tool that most of us bring with us to any field site – our hands. It is a strange coincidence of human anatomy that the angular size of a person's hand, seen by them at arm's length is similar for most people. And there are rules of thumb, fist, and index finger, that help with angular separation measurement. At arm's length:

Your fist =10°
Your thumb to pinky outstretched = 20°
The width of your index finger = 1°

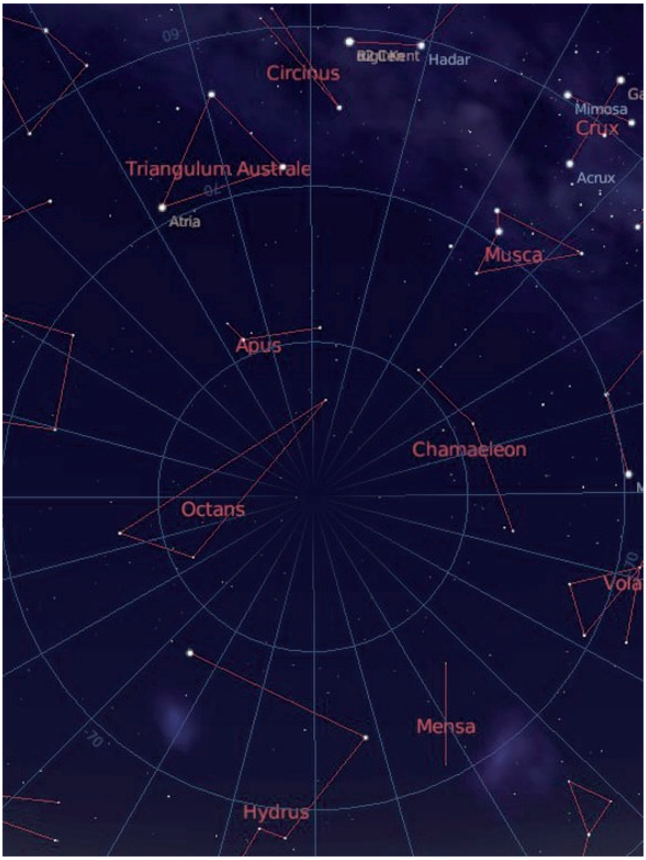

Fig. 9 Southern hemisphere constellations near the south celestial pole
Source: Chereau

A good way to check this for your own hand is to compare your fist, outstretched fingers and index finger to known angles on the sky. The distance between the two stars that mark the end of the Big Dipper is about 5° on the sky, which should be about half the width of your fist. The distance between the star Dubhe and Polaris, the North Star, is about 30°, which should be the width of one outstretched hand and a half. In the Southern Hemisphere, the long arm of the constellation Crux (the Southern Cross) is about 6° across.

Finally, the Moon is about 1/2° across, which is half the width of your index finger, held at arm's length. Testing this out at night is especially interesting when there is a full Moon, because often it can look much larger in the sky when it is near the horizon than when it is high in the night sky. Try to measure the angular size of the full Moon close to the horizon and then a few hours later, when it is higher in the sky. What do you find?

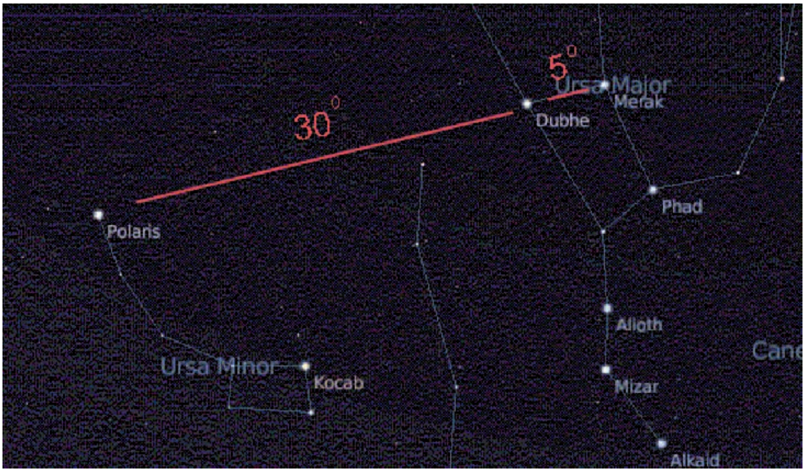

Fig. 10 Finding Polaris and measuring apparent angles
Source: Chereau

Directions in the Sky

There is a related complexity about judging position in the night sky, and that comes about when more than one person is looking up at an object. Try this at home – have a friend stand a few feet away and point at something at the other side of the room. You point at the same time. If you were to look where he/she is pointing, would you be observing the same object? How can you remedy this? Standing very close to the person is not always possible due to different customs and ideas about personal space. One way you might get around this is to use a flashlight with a strong, very straight light beam, try to locate an object you both agree on (like the Moon) and have the person direct you from there verbally and with compass directions, such as "the star I am looking at is 20° west of the Moon."

The Sun

CAUTION: You can cause permanent damage to your eyes if you observe the Sun incorrectly. Do not observe the Sun with your naked eye – always use a proper filter, obtained from a trusted source such as a local planetarium. Sunglasses or eyeglasses DO NOT provide enough protection to your eyes for looking directly at the Sun. NEVER look at the Sun through binoculars or a telescope that hasn't been professionally set up with a solar filter. Binoculars and telescopes do not just magnify an image, they concentrate light, which makes them potentially very harmful if you look through them when they are pointed at the Sun.

A wonderful alternative to getting a solar filter is to look at a projected image of the Sun. All this requires is a sheet of paper or cardboard with a pin hole in it. Use a second sheet of paper or light surface to project the image onto. By adjusting the distance between the two pieces of paper, you will adjust the size and focus of the image of the Sun. During solar eclipses, this is especially interesting, because as the Moon blocks out more of the Sun's disk, the projected image will look like more of a crescent. This technique works with any other medium that has small holes in it – leaves on trees, or holes between the fibers of a straw hat.

The Apparent Annual Motion of the Sun

As the Earth spins on its axis, the Sun and stars seems to move across the sky. There are many parts to this motion. The simplest one is that the Earth makes almost one complete turn around its axis every 24 hours – one day. But the path the Sun makes across the sky due to the Earth's spin looks different depending where on your latitude and what time of year it is. Where do you think the Sun will be tomorrow at noon if you go out to look? (Make a prediction now, and then check your prediction tomorrow).

Where you live is there a room that never gets sunlight? What direction do the windows in those rooms face? Is there a room that gets sunlight only in the morning or the evening? What direction do the windows in that room face?

For observers in the Northern Hemisphere, the Sun travels an apparent a path across the sky (remember, really the Earth is turning), that starts approximately in the East, ends approximately in the West, and arcs towards the South. This means that at local noon, even though the Sun is the highest it will be in the sky, and that it is halfway between rising and setting, it is not directly above your head. In winter, the path of the Sun is lower (reaches a lower maximum altitude above the southern horizon) than in summer.

In the Southern Hemisphere, the Sun still rises approximately in the East and sets approximately in the West, but its path is tilted towards the North. Near the equator, the direction of the Sun's path will depend on the time of the year. Near the equator, twice a year the Sun will pass directly overhead. Keep in mind, also, that winter in the Northern Hemisphere is summer in the Southern Hemisphere.

There are four important dates related to the Sun's path through our sky, that mark the beginning of Summer, Fall, Winter, and Spring. In the Northern Hemisphere, they are summer solstice, near June 21st, autumnal equinox, near September 21st, winter solstice, near December 21st, and vernal equinox, near March 21st. The summer solstice will be the longest day of the year, while the winter solstice is the shortest. The date of summer solstice in the Northern Hemisphere corresponds to winter solstice in the Southern Hemisphere. The equinoxes mark the days of the year that have equal hours of day and night, and when the Sun rises exactly in the East and sets exactly in the West, regardless of your latitude. There are many African cultures that have aligned structures to the solstices or have ceremonies associated with the solstices [10, 11, 12]. Cultural astronomy researchers should be sure to include asking about the solstices and equinoxes during their fieldwork.

Solar Eclipses

The rising and setting of the Sun are everyday events, even if they are shrouded in clouds or rain. But there are rarer events that involve the Sun, that are spectacular – solar eclipses. We live in a very special time in our solar system's history – the Moon orbits the Earth at just the right distance that it has about the same angular size in the sky as does the Sun. A simpler way of saying this is that the Moon and the Sun both appear to be about $^1\!/_2{}^\circ$ across. This would not be a very remarkable fact except that sometimes the Moon passes exactly between the Earth and the Sun and blocks out the Sun completely – a total solar eclipse. Total solar eclipses only happen every few years, are only visible for a maximum of 7 minutes (they can be as short as tens of seconds), and only visible from a small number of places on Earth each time. A map found at NASA Sun Earth Connection shows the path of recent and future solar eclipses (Fig. 11). This map shows the shadow of the Moon as it moves across the face of the Earth. A simple way to imagine this is to have a friend stand with you in a sunny place, and have them block the Sun from their eyes with their fist – when they say they can no longer see the Sun, you should see a shadow on their face, a kind of solar eclipse. The difference is that since the Moon is outside the Earth's atmosphere (which scatters sunlight and makes the daytime sky bright), when the Moon covers the Sun in a total solar eclipse, the sky gets very dark – like nighttime. It is an unforgettable event to witness: the air gets colder, some stars and planets may be visible, and even animals act differently during the short, unexpected night. During the eclipse that was visible from Cape Coast, Ghana, during this meeting, one college student who saw it broke into a smile after it was over saying "it was Wednesday before the eclipse, and I had an exam on Wednesday night, but since the Sun set behind the Moon, it should now be Thursday and there should be no more exam."

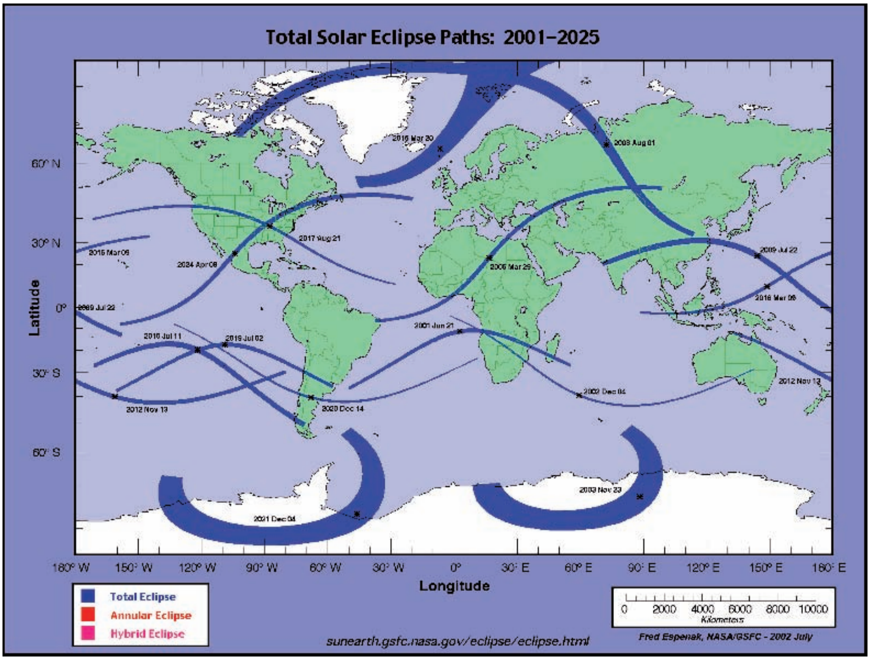

Fig. 11 Solar eclipses: 2001–2025 [13]

There are times when the Moon is a bit farther from Earth, but still directly between Earth and the Sun. When this happens, it is not large enough (in the sky) to completely block the Sun, and an annular eclipse happens. The name refers to the fact that the Sun's rays show around the edges of the Moon in a ring, or annulus, shape. Finally, at times the Moon is almost exactly between the Earth and the Sun, and it will only cover part of the Sun's disc, which is called a partial eclipse.

The Sun and the Constellations

One final point to make about the apparent motion of the Sun through the sky is relevant to nighttime. As the Earth travels around the Sun throughout the year, making one trip every 365 days or so, different stars are visible at night, and the Sun appears to travel through different constellations. If the Sun were an important character in the sky to cultures that noticed it, the constellations it went through would also be significant. Can you guess which constellations these might be? They are listed in many magazines and newspapers – the Zodiac constellations. Because of the shape of our solar system (all of the planets orbit the Sun in a plane and the Moon orbits Earth in approximately the same plane), the planets and the Moon also move through the Zodiac constellations. So, the bright light you observe in Orion or the Big Dipper or Crux, which are not Zodiac constellations, cannot be a planet, it must be a star (or an airplane!). As mentioned, the standard constellations and boundaries are set forth by the IAU. Because of this, there are 13 constellations that the Sun travels through not twelve (Table 4).

Table 3 Major meteor showers for 2007 [24]

Shower	Activity Period	Maximum		Radiant		Velocity	r	ZHR	Class	Moon
		Date	S. L.	R.A.	Dec.	km/s				
Quadrantids (QUA)	Jan 01–Jan 05	Jan 04	283°16	15:20	+49°	41	2.1	120	I	15
Lyrids (LYR)	Apr 16–Apr 25	Apr 22	032°32	18:04	+34°	49	2.1	18	I	5
Eta Aquarids (ETA)	Apr 19–May 28	May 06	045°5	22:32	−01°	66	2.4	60	I	18
Delta Aquarids (SDA)	Jul 12–Aug 19	Jul 28	125°	22:36	−16°	41	3.2	20	I	12
Perseids (PER)	Jul 17–Aug 24	Aug 13	140°	03:04	+58°	59	2.6	100	I	00
Orionids (ORI)	Oct 02–Nov 07	Oct 21	208°	06:20	+16°	66	2.5	23	I	9
Puppid/Velids (PUP)	Dec 01–Dec 15	Dec 07	255°	08:12	−45°	40	2.9	10	I	27
Geminids (GEM)	Dec 07–Dec 17	Dec 14	262°2	07:28	+33°	35	2.6	120	I	5
Ursids (URS)	Dec 17–Dec 26	Dec 23	270°7	14:28	+76°	33	3.0	10	I	13

Table 4 The Path of the sun through the zodiac constellations

Constellation	Dates in Constellation (2007 CE).
Aries	April 19–May 13
Taurus	May 14–June 19
Gemini	June 20–July 20
Cancer	July 21–August 9
Leo	August 10–September 15
Virgo	September 16–October 30
Libra	October 31–November 22
Scorpius	November 23–November 29
Ophiuchus	November 30–December 17
Sagittarius	December 18–January 18
Capricornus	January 19–February 15
Aquarius	February 16–March 11
Pisces	March 12–April 18

The Moon

Phases of the Moon

When is the Moon in the sky and what does it look like? For some people, who have spent a lifetime looking at the sky and noticing changes, this may be fairly easy to answer. But for those of us who find ourselves surrounded by buildings or by many cloudy nights, the answer may not be so obvious. The phases of the Moon are due to the relative positions of the Earth, Moon and Sun. This means that the phase of the Moon is directly related to how close it looks to the Sun in the sky.

Simply reading the previous two sentences is not a good way to learn about Moon phases, however. Over the course of a month, look for the Moon in the sky every day, and note in a journal when you saw it and sketch how it looked. Be sure to look for the Moon during the day, as well. At the end of your month, you should find that you never saw a thin, crescent Moon high in the sky, and that a full Moon was not visible during the day. There are names for the different phases of the Moon, and they cycle over about 29 days. So if you have a Full Moon tonight (when the Moon is in the opposite part of our sky from the Sun), in two weeks there will be a New Moon (when the Moon is very close to the Sun in the sky, an thus not visible). In between Full and New Moon are phases called Gibbous (more than half lit), Quarter (half lit), and Crescent (less than half lit). For these in-between phases, there is also added information about if they occur when the Moon is getting more (waxing) or less (waning) lit on future nights.

Figure 12 is an example of what you might see when you observe the Moon over two weeks. From left to right, these represent what phase the Moon was in on March 15, 2007, March 23, March 25, and March 29. Keep in mind that the different phases of the Moon will be up in the sky at different times.

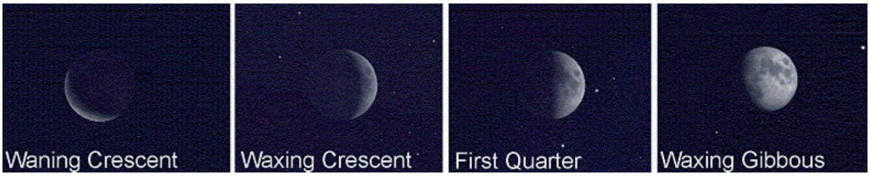

Fig. 12 The phases of the moon.
Source: Chereau

Apparent Motion of the Moon

The Moon is in orbit around the Earth and it does appear to rotate around the Earth. However, the Moon takes 28 days to complete one orbit around the Earth. The daily motion is due to the Earth rotating on its axis, the same as with the apparent daily motion of the Sun. To make things more complicated, the phases of the moon which are determined by the angular distance between the Sun and the moon repeat after 29.5 days. This is because over the course of a "month" the Earth moves within its own orbit taking the moon with it.

The path the moon takes through the stars is close to the ecliptic which is the path the Sun takes through the stars. The Moon stays within five degrees of the ecliptic. But over a month it usually spends half the month above the ecliptic and half below because of the tilt of its orbit around the Earth compared to the Earths orbit around the Sun. Nonetheless, the Moon remains close enough to the ecliptic to pass through the same constellations as the Sun (Table 4).

Metonic Cycle

The Moon appears in a particular location in the sky with a specific phase only once every 19 years. Thus, a full moon near a particular star in Leo only occurs in that exact same location and also as a full moon nineteen years later. Thus, far no scholars have explored knowledge of the Metonic cycle among Africans except in the literate cultures. In our society, nineteen years is close to when children become legally adults and thus noting the Metonic cycle could have possible significance. But, research on African adult initiation rites place initiation ages much younger, between twelve and fifteen years old.

Lunar Eclipses

If a solar eclipse happens when the Moon blocks the Sun from reaching a part of the Earth's surface, what is a lunar eclipse? It is not very logically named – a lunar eclipse happens when the Earth blocks the Sun from reaching a part of the Moon's surface.

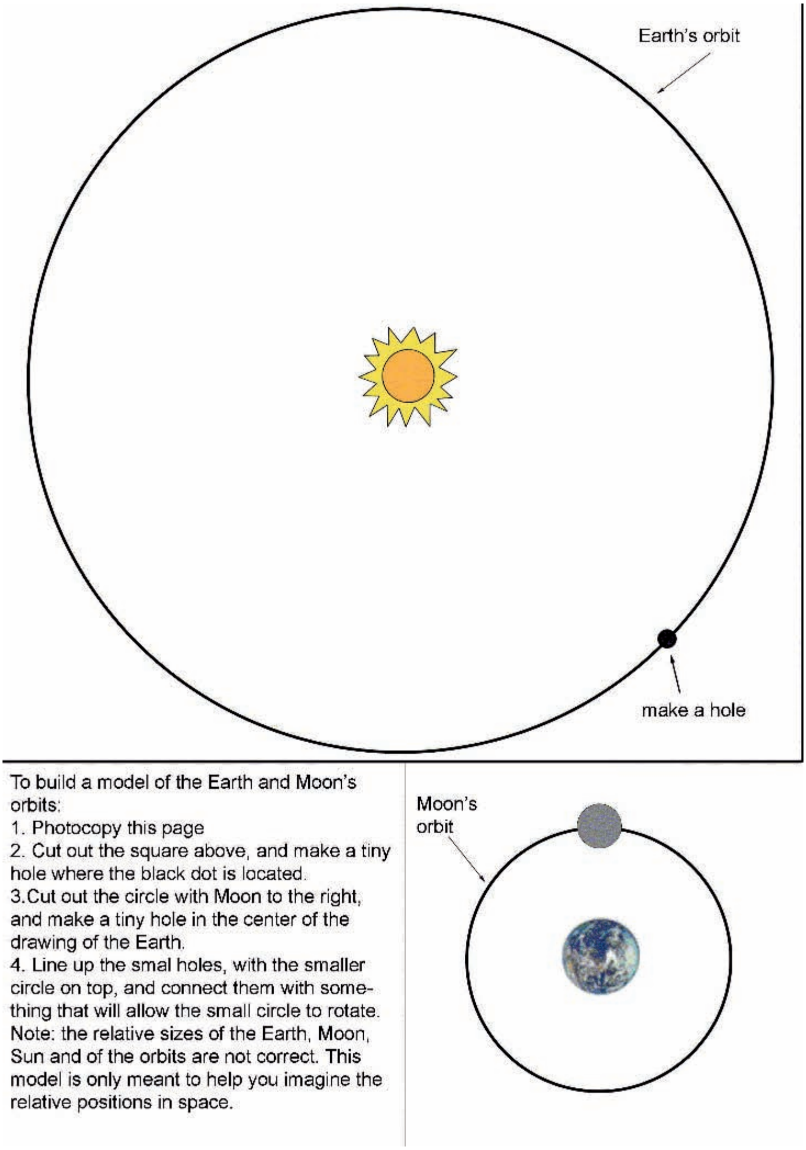

Fig. 13 Create a model of the Earth – Moon – Sun system. (Designed by A. Baleisis)

Because the Earth has to come between the Moon and the Sun, a lunar eclipse can only happen during a Full Moon. Because it is safe to look at a Full Moon with the naked eye, it is also safe to look at a lunar eclipse with the naked eye. As the Moon moves into the Earth's shadow, its surface will get darker – ranging from dark grey to a deep red, depending on conditions in the Earth's atmosphere. Also because of the Earth's atmosphere, its shadow does not make a sharp curve on the Moon. Lunar eclipses occur more frequently than solar eclipses do, due to the fact that from the Moon, the angular size of the Earth is much bigger than the angular size of the Sun – so it is easier to get a lunar eclipse and they last longer (up to 3 hours). They take place one to two times per year, and are visible by everyone for whom it is night.

Field Research

After learning the night sky at home, learning how to use the night sky software, and armed with star charts and planisphere the researcher is prepared for field research. Upon arriving at the research site, the researcher should begin learning the night sky at that location. Ultimately, the research should be able to identify an object that an informant points to. But, there are two techniques that are also helpful for identifying stars and constellations in the field: photographing the night sky and creating sketches of the night sky. But as a cultural astronomy researcher what are you looking for? What are you trying to learn? Ruggles suggests three broad areas – 1. To document and analyze how people use the sky. 2. To learn how people perceive and think about the sky. 3. To determine how competent people are at observing the sky [14]. But, these skip an essential first step which is collecting the local names for celestial bodies. Collecting myths and legends about celestial bodies compliment learning the names. And, a new area of research for African cultural astronomy is highlighted: to look at the interplay of light and shadows.

Data Collection Aids

Photography

Taking images of the night sky takes practice and patience. However, to take images of the alignments of moon and sun rises and sets is easy and instantly offers concrete proof that such alignments exist. For example if an informant says that a temple is aligned such that sunlight enters the main door on the summer solstice. A researcher should make an archaeological map of the temple with north indicated and using accurate scale lengths and correct angles. Then, the direction of the temple main door (using the latitude and longitude of the temple, plus the direction angle of the door) can be checked using the astronomy software for the June 21st sunrise location on the horizon. However, such confirmation is easier if on June 21st, the researcher takes pictures from inside the temple facing the main door as the sun rises. The proof is if the pictures capture the alignment. Such a process is the same for moonrises. Both the sun and moon are bright and easy to photograph. Photographing the stars is significantly more difficult.

In order to take pictures of the night sky for reference is it useful to include some of the horizon features. Thus, it is best to photograph target parts of the sky while rising or setting. For example, to capture Orion in December in the northern hemisphere, it is easiest to capture it when it rises a couple of hours after sunset.

For taking images of the stars in addition a tripod and a cable release are needed in addition to the camera. With digital cameras, a good image can be taking in about 40 seconds. For film cameras, it takes several minutes. The cable release allows the researcher to take images without jostling the camera. Most cable releases can be used with the open shutter function called "bulb." The earth continues to rotate while pictures are exposing, if longer exposures are necessary a clock drive tripod will be needed. Having a clock drive tripod will prevent star trails because it compensates for the earth's rotation.

Photographing daily life and people's faces at your research site will provide context for your research. You will use these photos in presentations, articles, and books which will enable you to better convey what life is like for the people from whom you are learning about the sky. Also, it is important to record what technology is available at your field site and how such technology effects sky knowledge. For example, is there lighting outside at night that may contribute to less stars being visible? Or are printed calendars available that compete with the traditional sky calendar. A picture of these will allow you to show these technologies to audiences.

Photographing the night sky is difficult and requires a lot of equipment. As a researcher, you may not want to take expensive equipment with you. Disposable cameras can be substituted for more expensive ones for daytime photography, but not for night photography. In certain countries, there are restrictions as to what kind of information can be recorded and taken out of the country. Nonetheless, nights of photographing the sky can be interspersed with nights working with informants identifying objects. Doing both on the same night is usually not possible and makes for a long night.

Sketching

When photographing the night sky is not an option, a sketch of the horizon, the relative positions of stars and familiar constellations may be helpful. In some instances, it may be easier to make a quick drawing than to set up camera equipment. On a drawing, a researcher can label familiar stars and constellations and mark unfamiliar ones for later identification. It is also useful to have informants make sketches of what they are talking about. You may need to instruct the informant to put in familiar horizon features. Such sketches may be useful for identifying stars and constellations by comparing to a star chart or planisphere.

Data Content

Names

In order to begin to talk with local informants about the sky, you must learn basic terminology such as the works for sky, star, moon, and sun. This is part of creating a common language for communicating with local informants. Other important terms are the times of the day, seasons, months or moons, years, and the names of individual celestial bodies and phenomenon. It is possible that a dictionary of the local language contains many celestial terms, it is worth checking. But, terms such as the names of individual planets and less bright stars are often not recorded. Thus, cultural astronomy researchers often record names for celestial bodies for the very first time. Creating a star chart of local names is equally significant. However, recording the names is usually just the first step of more sophisticated cultural astronomy research projects.

Myths and Legends

Oftentimes, people have myths or legends associated with celestial bodies. These two should be recorded with the names of individual celestial bodies. Most people have an accepted origin myth or cosmogony that may also be connected with the sky. Sometimes, these myths and legends include factual information about the physical properties of celestial bodies, or factual information about migration from one place to another. The latter falls in ethnohistory. Other myths of powerful figures or elites may claim a celestial origin or a connection to temporary celestial events such as comets or eclipses [15, 16, 17, 18]. One area of naming and myths and legends that is understudied is meteor showers [19]. Meteor showers occur when the Earth enters the path of a comet. As comets travel the solar system, they leave behind bits of dust and ice particles. It is these small particles that burn up in the Earth's atmosphere during meteor showers. There are five major meteor showers a year in the Northern Hemisphere: The Lyrids, Perseids, Orionids, Geminids, and the Ursids. There are four major Southern Hemisphere meteor showers and the Orionids can be seen in the Southern Hemisphere as well. A researcher can strategically choose to do research during a meteor shower or around another major celestial event such as a solstice or eclipse. Researchers can ask about celestial events, but being there during a celestial event can result in much deeper explanations and stimulate more recollections.

Light and Shadows

Cultural astronomy research in the United States has revealed that Native Americans created petroglyphs in locations such that shadows and spears of light fell onto the patterns only on certain days of the year. A film that shows the phenomena is "The Sun Dagger" [20]. Thus far, no researcher has studied the combination of rock art and light and shadow interactions in Africa. Given the extensive rock art sites in East, South, and North Africa, there are plenty of places for researchers to begin studying. The creation of such sites required much though about both the placement of the glyph and the possible modification of surrounding rocks and earth to create the desired pointing effect on specific days. The NASA Sun Earth Connection provides resource on the web that shows the serpent shadow descending along the central temple on the spring equinox in the Mayan town of Chichen Itza in the Yucatan Pennisula, Mexico, among other light and shadow phenomena see http://www.traditionsofthesun.org/ and http://sunearthday.nasa.gov/2005/index.htm. The Sun Dagger is an example of a natural environment being modified for marking a celestial event, while Chitchen Itza is an entirely built complex aligned for making a celestial event. Examples of these types have not been explored in Africa.

Deeper Questions

After gathering the basics of names, myths and legends, usually a researcher moves on to the core of their research. The core question is usually researcher specific. Some projects have looked at navigation by the stars, architecture and alignments, archaeological sites, rock art, contemporary tribal art, symbolism in literature, and ritual. However, some standard issues should be a part of every study just like learning celestial names, myths and legends. These include gender, acquisition and transmission of sky knowledge, lost knowledge, and social status. Gender begins with which celestial bodies are male, female, both or neither, to what do men or women know about the sky and how they use the sky. For example, many women around the world use the moon to keep track of their menses and fertility. Or when are women or men initiation ceremonies. The acquisition and transmission of sky knowledge answers the question of how people learn about the sky and who is being taught about the sky and why. Lost knowledge reminds the researcher to ask about what people think that their grandparents knew about the sky that they don't know now [21]. What is the social status of the people who know about the sky? Is certain knowledge commonplace and other parts only known by a few elites or non-elites? Is sky knowledge being used to maintain a social caste system [22, 23]?

Conclusions

This paper explores the naked-eye astronomy that needs to be mastered by cultural astronomy researchers but includes field data collection methods and areas of inquiry that should always be considered. To summarize, the cultural astronomy researcher needs to know the constellations, many of the brightest stars, the Sun and its annual apparent motion, the Moon and its phases, and how to measure angles in the sky and along the horizon. Once in the field, a common language for discussing the night sky needs to be established through learning the local names for celestial bodies, angles, and the cardinal directions. Only then can deeper questions and the core of the research project be approached. This paper should help the cultural astronomy researcher, but ultimately each person should design their own unique project with core issues to explore. Thus, this paper is not meant to be exhaustive in scope but merely suggestive.

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Leadership

Shawna Holbrook

The first African cultural astronomy conference was held in Cape Coast Ghana in March 2006. This event was scheduled to coincide with the first total solar eclipse in Ghana since 1947. The intention was to highlight the importance of such astral events for individuals, communities and cultures as well as bring international attention to the fledgling field of cultural astronomy.

> "Cultural astronomy: the study of the use of astronomical knowledge, beliefs or theories to inspire, inform or influence social forms and ideologies, or any aspect of human behavior. Cultural astronomy also includes the modern disciplines of ethno astronomy and archeoastronomy." (Campion 1997)

The organizer of the conference, Dr Jarita Holbrook, has spent several years focusing on African cultural astronomy and saw a need to bring the few scholars in this small field together to learn, exchange, and network. She also saw an opportunity to collaborate with an African university to potentially develop a major in African Cultural Astronomy in Africa.

The fact that the organizers chose to have the conference in Ghana was an important one. For the students and the scholars it brought the abstract study of a people and a culture to life. Most of the participants who actively study the continent had never traveled there. This gave them the opportunity to put flesh to theory, to bring their academic knowledge and see how it fit into the reality of modern day Africa. For the Ghanaians it showed them that there were some westerners who were trying to do more than merely appropriate their art and culture.

The location was not an easy choice, poor infrastructure, the lack of resources, and an attitude by the local people that "all Americans have lots of dollars" created obstacles that could have been easily avoided by having the conference in any American city. The airfare and long travel time, a myriad of injections plus Malaria Prophylaxis, the water and food precautions made this a trip neither for the faint of heart nor the casual tourist. The group that committed to this conference was looking for more than an experience of professional development, they were also looking to immerse themselves in their field and expand their consciousness.

Shawna Holbrook
International Foundation for Education and Self-Help (IFESH), Benin

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Premise

The conference had three major components. The first workshop series titled “cultural Astronomy research” focused on the assessment and advancement of cultural astronomy research in Africa. The second workshop series’, “future leaders at the intersection of astronomy and culture in Africa”, goal was to “train students in methods used on collecting data on the cultural astronomy of Africa”. The third series of workshops looked at ways to integrate African Cultural Astronomy into the classroom.

The second workshop series was attended by students from the University of Alabama Huntsville, The University of Arizona, The University of Cape Coast, The University of Ghana-Legon, and the University of Nigeria. These students participated in workshops that focused on enhancing their knowledge of the field. These included Cultural anthropology, African History, Geography of Africa, Archeoastronomy and Naked-eye astronomy all presented by the leaders in the field. There were many discussions about the field of African Cultural astronomy, where it was headed and what role these students would play as researchers, leaders and professors. The students had many opportunities to talk to the experts about the practical aspects of a future in this field of study. They networked with these experts and gained invaluable contacts for their future.

The final workshop in this series was on leadership. The premise of this workshop was that the students needed more than information and academic ability to excel in whatever field of study chosen. Most often as students we rarely look at the practical things you need to do outside of the classroom to reach the top. The thought was to have the students explore the idea of leadership from two perspectives:

1. leading a group (research team)
2. leading your field as a scholar

Practice

We started the session with introductions and had each person make a statement about the eclipse that they had witnessed earlier in the week and their overall impression of the conference. All of the students were deeply moved by the astral event and thought that the conference was an amazing and innovative event. Many were overwhelmed by the kindness of the Ghanaian people and the outpouring of hospitality from strangers. We moved into a discussion about leadership. We started off naming some of the great leaders in history and in the present day: Kofi Anon, Robert Kennedy, Martin Luther King, Gandhi, Abraham Lincoln and Bill Gates were some that came up repeatedly. It was then asked what these individuals had in common. What characteristics did they share that made them leaders? This list was put on the board and the students were asked to work in groups to come up with a list of characteristics or qualities that defined a good leader. They were allowed 20 minutes for this activity and there was much debate and enormous lists generated. Interestingly enough there was quite a lot of discrepancy between the African perspective and the American perspective in the area of honest communication or directness. The Africans stressed diplomacy over straight-forwardness and felt that the latter tactic was not always the most effective way to keep the group cohesive and get the job done. It became evident that a leader shared many of the same qualities but based on their culture there could be some significant differences. It was brought up that in Japanese culture American directness is very abrasive and that they tend not to argue. A good leader is one who reports the consensus of the group and/or an elder/senior executive.

In the end each group came to a consensus and reported their list. There was much overlapping of characteristics with each group having at least 5 characteristics found on the personality chart below.

Traits of a Good Leader

Compiled by the Santa Clara University and the Tom Peters Group:

- **Honesty -** Display sincerity, integrity, and candor in all your actions. Deceptive behavior will not inspire trust.
- **Competent -** Your actions should be based on reason and moral principles. Do not make decisions based on childlike emotional desires or feelings.
- **Forward-looking -** Set goals and have a vision of the future. The vision must be owned throughout the organization. Effective leaders envision what they want and how to get it. They habitually pick priorities stemming from their basic values.
- **Inspiring -** Display confidence in all that you do. By showing endurance in mental, physical, and spiritual stamina, you will inspire others to reach for new heights. Take charge when necessary.
- **Intelligent -** Read, study, and seek challenging assignments.
- **Fair-minded -** Show fair treatment to all people. Prejudice is the enemy of justice. Display empathy by being sensitive to the feelings, values, interests, and well-being of others.
- **Broad-minded -** Seek out diversity.
- **Courageous -** Have the perseverance to accomplish a goal, regardless of the seemingly insurmountable obstacles. Display a confident calmness when under stress.
- **Straightforward -** Use sound judgment to make a good decision at the right time.
- **Imaginative -** Make timely and appropriate changes in your thinking, plans, and methods. Show creativity by thinking of new and better goals, ideas, and solutions to problems. Be innovative!

Retreat Hell! We've just got here! – Attributed to several World War I Marine Corps officers, Belleau Wood, June 1918. (Key ideal – take a stand)

This list was then put on the board for the students to compare and discuss their own findings. Most were satisfied but put certain characteristics at a higher priority than others. Most students seemed to be aware of the basics of leadership but had not applied it to themselves. We talked briefly about what would be demanded of them as professors or scholars on a higher academic level and came to the realization that leadership would be one of their primary task and would only grow more so as they matured into their career. They would become the professors researchers and the authorities in their field. Many felt ready for the challenge while others turned green and queasy at the realization.

The second part of this workshop looked at how to become a leader in your field. Definitely the preceding characteristics play a significant role but there are also some concrete steps to ensure success.

First we spoke briefly about being a leader in a field. The students were asked to list the things that you should do to be a leader in your field. Each student took five minutes to compile their list then we put the ideas on a white board. The range of responses was huge. Some responses were very specific and personal such as "establish a non-governmental agency to collaborate with Western countries to establish a sister-school program". To the very general, "Get good grades, study hard". After putting their ideas on the board we looked at the list generated by Dr. Holbrook:

How to be a Leading Scholar in Your Field

1. Read everything that has been printed on what you are interested in researching. Do your homework.
2. Go out and collect your data.
3. Analyze your data and write it up.
4. Publish your writings, present at conferences, write popular articles.

The participants found this list very precise and most of the things that they had brainstormed fit under these categories. Yet, there was a significant amount of information that did not belong to any of the presented headings and still needed to be included. The students were put to the task of grouping this information and coming up with additional categories.

How to be a Leading Scholar In Your Field (addendum)

5. Try to take your field in a new direction.
6. Bring a fresh, original perspective to the field. Originality is key.
7. Network. This requires good communication, persuasiveness, and confidence to develop contacts and key relationships that will assist in your career.
8. Mentoring. Find a food mentor that you work well with and that you trust.

The last one on the list caused some confusion and led to more discussion. Some students were baffled by the concept of a “bad mentor”. Several students volunteered examples of mentors who had stolen/plagiarized their work or did not inform them of scholarship or publishing opportunities. There were tales of mentors giving preferential treatment to other mentees. There were also stories about mentors who were just ineffective because of personal problems or personality incompatibility. The opposition found it hard to believe that such things were possible. These were the few who were lucky to have had good mentoring. Through their discussions it was concluded that mentors were human and fallible and that students should remember this fact and not hesitate to find another mentor if they feel that their needs are not being met. In choosing a mentor one should look for someone who is doing what you want to do. A good mentor monitors the student’s academic progress, meets frequently with the student to provide guidance and advise. A good mentoring relationship may continue beyond the university door and into the workplace. Your mentoring can evolve into a rich, lifelong relationship.

Conclusion

Overall the workshop was a nice break from the other lectures. There was more interaction and the participants were asked to think about something different from the rest of the conference proceedings. Though they may not have wholly agreed with each other or the conclusions made they were presented with a blueprint for guiding their career more than a doctrine. Each student left at least thinking about leadership and how it applies to their life and career. The week in Ghana was full of information and experiences that will be remembered for a lifetime. As we leave Ghana exhausted and exhilarated lets just hope that this glow of inspiration will sustain us until the next conference. Africa-2008?

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Integrating African Cultural Astronomy into the Classroom

Sanlyn Buxner and Shawna Holbrook

Astronomy is the oldest science and from its inception it has been closely tied to culture. The earliest humans were aware of the movements of the Sun, the phases of the moon and the intermittent appearance of a variety of astral events such as meteor showers and comets. They looked to the skies to track time, make calendars and plot the seasons. They depended on this knowledge for agriculture, most obviously, but also used it in religion, mythology, navigation, architecture, and art. Eclipses are the most mysterious and dramatic of astral events, and they have inspired terror and religious ecstasy. The sky played some role in the formation of every human culture and is still playing an active part in everyday life. The science that looks at this relationship between astronomy and culture is called "Cultural Astronomy."

In March of 2006, a group from The University of Arizona participated in a unique conference to celebrate a total solar eclipse, and the astronomy and culture of Africa: the Ghana Eclipse Conference in Cape Coast, Ghana. The Conference was open to students, teachers, researchers, and anyone with an interest in African culture and astronomy. The location in itself was an educational experience for many who had never been to Africa. The conference attracted an eclectic hodgepodge of people from a variety of backgrounds, ages and disciplines. From graduate students to professors, artists to eclipse chasers, they gathered at this event to learn, to exchange knowledge, and to network. The conference consisted of three major parts that integrated together throughout the week for participants. The topics of the scientific lectures ranged from solar astrophysics, integrating African culture into American classrooms, specific African cultures and beliefs, and specific projects related to ongoing research in the area of African cultural astronomy. This paper describes the conference workshop – the teacher workshop – designed for teachers to brainstorm and discuss how to bring their experience from the workshop into K-12 classrooms in Africa, Canada, and the United States.

The teacher's workshop was one of the most innovative aspects of the conference. Many participants commented that they liked the idea of taking the specifics of a conference and trying to develop a community based educational component.

Sanlyn Buxner
University of Arizona

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It shifted the conference from a strictly lecture platform to an activity that would incorporate the new information and potentially disseminate it into the community. It also allowed the participants to apply their expertise, work with a diverse group, and produce something concrete.

Planning

The information about the workshop listed in the conference announcement for participants was as follows:

> *The conference will bring together K – 12 and higher education teachers from Africa, the United States, and the international community. The teacher workshop will commence after the eclipse and will include two days of discussions between teachers and expert researchers about the integration of African cultural astronomy information into classroom lessons.* (http://www.ceao.arizona.edu/eclipse/, 2006)

The astronomy education committee for the conference developed an agenda and activities for up to 100 international teachers expected from mostly the United States, Ghana, and Nigeria. The overall purpose of the workshop was to have teachers develop ideas and/or lessons based on their interests and experiences at the conference that they could take home to their classrooms and use with their students. Each lesson would also incorporate aspects of both science and humanities within the larger context of African cultural astronomy.

The teachers were to work in groups based on the grade level they taught so that they could focus on ideas that would be both relevant and accessible to their students. Experience had shown that trying to make lessons for K-12 classrooms usually results in lessons that do not meet the needs of any of the grade levels or that meets the needs of only one age level but is too hard for younger and too easy for older students. One idea that has been tried extensively is trying to scale lessons for a broader range of ages using extensions for older students but even these are done within the parameters of primary and secondary level classrooms. To address this problem, the teachers were to break up into overall groups according to whether they were teaching in a primary (K-6) or secondary (7–12) classroom. Eventually these groups would break up into working groups for first and second grades, third and fourth grades, fifth and sixth grades, seventh and eighth grades, ninth and tenth grades, and eleventh and twelfth grades. Each group would ideally include at least one science teacher and one humanities teacher as well as teachers from different cultural backgrounds or from different countries.

The resulting plan allowed larger group discussions about the conference that would produce ideas on how to bring this information into the participants' classrooms. Some possible topics for the teachers given the scheduled lectures were Igbo, Muslim, South African, Benin, or Dogon peoples' astronomy or archeoastronomy. After collecting ideas from the first day, the intention was to distill the various ideas into major themes or regional focus and have the teachers come back the next day to sign up for the project they wanted to work on which would determine the working groups for the second day. The goal of the second day was to create tangible and usable lesson plans. In addition to creating lesson plans, teachers were to have access to the African cultural astronomy experts that had been giving lectures throughout the week. These experts were to be present the morning of the second day so that the teachers could get more information and clarifications about their ideas.

The Workshop in Practice

The workshop began with an icebreaker where everyone introduced themselves, talked about what they had found interesting about the conference so far, and talked about what they wanted students to understand about their experience. Each person included their interest in being at the workshop. The participant makeup of the workshop was quite different than expected. On the first day those in attendance included the three workshop facilitators, two female education graduate students and one male science education faculty member who acted as the lead facilitator, all from The University of Arizona, a male cultural anthropology doctoral candidate from The University of Arizona that had experience with Native American cultural astronomy and teaching at the university, a female African American pre-service teacher working in Accra, a female African American retired school nurse, a female African American science center administrator that specialized in hands-on education for mostly African American students, a female African American health and physics radiation specialist/ museum curator, a female African American teacher-trainer working in Benin in a resource center, a male Ghanaian college student that had 15 years experience teaching in a primary classroom in Ghana, and two male Ghanaian physics students studying at the University of Cape Coast. Thus, the workshop was dominated by African American women.

The overall goal of the workshop given to the participants was to help students understand the relationship between astronomy and culture in Africa. This goal was a starting point and was open to change as the group saw fit. The teachers were asked to consider creating lesson plans that could be used by teachers in America, Africa, Europe, etc. In the initial discussion, many ideas were shared including making sure the lessons had a practical aspect so that students would do something. The teacher from Accra suggested that the lessons should be thematic and applicable to specific grade levels. The anthropology student put forth the idea of having long-term projects where students could track the movement of the stars and moon incorporating many ideas including the skill of observation. The American museum curator brought up the topic of some recent programs on African astronomy that had been used in informal science centers in the United States including a planetarium program called "African Skies" which gave folklore of the moon and stars which helped generate interest for students to learn more about different cultures and astronomy. The lead facilitator then asked the group to focus on what each person found personally interesting from the conference. As each person shared their personal stories, it became apparent that the event of the eclipse was very meaningful to people, whether it was the actual occurrence or the social/cultural aspects that accompanied it. People discussed the amazement of people around them during the event that the eclipse had occurred. This local skepticism that the eclipse may not happen reflected that there was a lot of skepticism among Africans about western science in general. According to the Ghanaian students, once the eclipse happened it gave the physics department more credibility with the students at the university because of the powerfulness of the reality of the prediction. Before the eclipse there was a lot of joking and mockery from people but once the eclipse had occurred there was a shift in the mood as everyone was brought together in the shared and humbling experience and there was the general feeling that this was a special event for everyone who witnessed it. It was a shared experience around which something could be built for students and communities. The discussion quickly turned to ways to make this event meaningful beyond the morning of the actual eclipse for those who had experienced it in the local area. One idea that came up was to make a story book about the eclipse to help explain what happened. The museum curator suggested that it would be interesting to find people who had seen the eclipse in Ghana in 1947 and this year and compare their experience with 2006 experiences.

From that idea came one about getting together different departments at the university to make educational products, tying together the science department and the art department to make a product commemorating the eclipse. The idea of collaboration and interdisciplinary approaches is one that ran through the entire meeting. Not only would it be "nice" but it is truly a necessity when working in an environment with such a shortage of teaching resources.

There were many concerns that were brought up around the development of appropriate lesson plans. One concern raised by the anthropology student was that studying other events in astronomy other than the Sun would be difficult because it would require students to do things at night when they needed to be sleeping or doing chores at home. The teacher from Accra explained to the group that most Ghanaian students had many responsibilities at home and did not have time to focus on school work at home. He raised additional concerns regarding science teaching in Ghana: the lack of training for teachers, the fact that many primary teachers found science difficult and shied away from teaching it in school and the severe lack of material resources in most schools that would inhibit many lessons that required any materials, including paper. Also brought up was the importance of developing lessons locally for what students in Ghana had and not around western culture.

This idea of developing something locally for local people started a conversation about how this eclipse needed to be documented for the future. Also discussed was the importance of getting local people interested in the eclipse and convincing them that such events did affect their lives like it did for ancient people albeit for different reasons. The group struggled with the idea of practicality versus personal meaning of the eclipse as well as ways of sharing funds of knowledge with our children so that this important event could be shared with future generations.

Later that day, smaller groups talked about what the participants thought that students needed to understand about astronomy and cultural astronomy. One group consisted of the two education students from The University of Arizona, the teacher from Accra, the teacher from Benin, and the science center administrator. The first issue discussed was the national curriculum resource center. The curriculum of Ghana is centralized and is reviewed every four years. In addition to the national curriculum, teachers can also receive supplementary materials to use in their classrooms. The teacher from Accra discussed how some schools could visit labs but many schools had to use what they had locally which was quite often not that much.

The discussion turned again to the eclipse. Several ideas came up for actual lesson plans in the process. The teacher from Benin suggested again connecting with people who saw the eclipse in 1947 to understand their cultural reality as compared to those that saw it this time. This would involve interviewing, and oral reporting to the class or the creation of a comparison chart of 1947 and 2006, a newsletter format was also suggested. The museum administrator suggested documenting the eclipse for students that had viewed it was important so that they could build personal pride and use it as a stepping stone for studying other aspects of astronomy. Documenting could involve story telling or writing, theatre pieces/skits preformed by small groups or developing a radio show using simple cassette recorders. A student from Arizona discussed a possible science lesson around protecting your eyes from the Sun and creating your own eclipse viewing devices. Also discussed was the different perceptions of the eclipse; a cultural/religious aspect and a science aspect that cannot be separated. The one thing that everyone could agree upon was that there was an eclipse but that everyone had their own meaning for it. There was a meaning for those who saw it and those who did not. From this we decided that one model for an eclipse lesson would involve everyone agreeing that the eclipse had happened and looking at the event from different perspectives; culture/religion, science, and personal meaning.

Conferring with the Experts

Next, all the workshop participants came together with a panel of experts for a rich roundtable discussion. The first question posed to the panel was about the importance of cultural astronomy. The panel answers ranged from using cultural astronomy as practical knowledge to help farmers and sustainable agriculture for the present to a study in diversity that helped people understand other world views and a good vehicle for making people aware of and sympathetic to other cultures. One African scholar commented that the field was important for a revival of African culture for African American students who want to understand their heritage. The middle part of the discussion centered on the meaning of cultural astronomy for the scholars and the participants. There seemed to be a general feeling that it was important for everyone to understand it so that we could understand and appreciate other cultures, their stores of knowledge, and their diverse ways of understanding the universe. The last part of the discussion focused around how to link astronomy and culture. The experts discussed how their field suffered from a lack of appropriate words to describe what they did. It was suggested that the field could more appropriately be called cultural cosmology to better describe how people orient themselves to the cosmos. The whole group discussed how hard it could be to get these ideas into classrooms. Currently there is not a place for cultural astronomy in western classrooms and this is an issue that needs to be explored more by the community. It was concluded that cultural astronomy was an appropriate tool in the classroom and a mode of transmission that creates a context for the transmission of sky science.

The first day ended filled with ideas for what could be accomplished. There seemed to be three major themes that came out of the discussion. The first was that the eclipse was an amazing event that needed to be described and shared. The group wanted to make sure that what came out of the workshop would help share something about the experience of the eclipse with students, whether it was for cultural, historical, scientific, or personal reasons. The second theme to emerge was that astronomical events could be used to bring people together and could be used as a vehicle to examine cultural values. The third theme that emerged what that events such as eclipses or moon phases could be understood in different ways and that they could be used as an avenue for various routes of understanding including history, culture and science.

Developing Working Ideas for Lesson Plans

The participants for the second day of the workshop were slightly different than the first day. The four members from The University of Arizona, the museum administrator, the museum curator, the teacher from Benin, the Ghanaian physics students, and the Ghanaian student/teacher remained. The teacher from Accra was not able to come on the second day but we gained a female western educated teacher who ran the physics outreach program at the University of Cape Coast and a male western educated male who worked in Ghana, both African American.

After reviewing the events of the previous day and introducing the new participants, the discussion turned to the reflections on the previous day's work. There was still concern about the relevance of cultural astronomy for students and whether any of it was part of a fundamental knowledge. One of the experts joined us for the first part of the morning and discussed how the study of cultural astronomy for local students would help raise awareness about their own culture and their own cultural development.

A few more local issues were discussed as a large group. Despite the local skepticism about science, it is something that is in the consciousness and day to day reality of students, in both positive ways (cell phones) and negative ways (war technology). In addition science has practical applications like the prediction of tides. One powerful way to link to the past was to look at how people used science in the past and how science is used presently. One more concern brought up by the anthropology student was pointing out that cultural astronomy is rooted in the language and culture of a place and that those must be preserved. He felt that one way to destroy local culture was to talk about the universality of the sky for people and that this way of thinking would destroy cultural diversity.

After much discussion the group was given the task for the day which was to outline what the students would do during an experience to understand something about the topic based on work from the previous day. The three themes from the previous day were presented as starting points to make groups so that one group would work on using the eclipse as a way to understand different disciplines such as science, one group to talk about ways to make the eclipse meaningful for local people, and one group to talk about the idea of using astronomical events as ways to celebrate culture.

In the small group tasked with making a science lesson, the conversation digressed to concerns about the difficulties of making lessons that would reproduce the power structure of the west. Caution was urged because the project was being carried out by The University of Arizona and was a middle class Anglo endeavor. The University of Cape Coast teacher shared some additional concerns. She suggested that we should have taken tours of schools in Ghana to better understand them and to understand our own cultural assumptions about what schools would look like as opposed to what they do look like. We might be shocked to see, she felt, that instead of talking about making students sky literate they should be generally literate. She concluded that we had gone about it in the wrong way, that there was no way to make something to take away from the experience in a lesson form. She admonished that we should be getting grants for resources and use the local community to help us create lessons. As a result of this line of reasoning, the group further digressed focusing on education in Ghana and cross-cultural collaborations rather than on completing the assigned task. It is interesting to note that this group was the one that the facilitators thought would come up with a lesson plan. Through the interactions of the members, we became very concerned with making a product that was locally relevant and making sure that there were recommendations in place for future work.

The second group was to come up with ways to document and share the experience of the eclipse with local people. One of the major ideas that came out of this session was to have students collect and share experiences of the eclipse. One piece of this would be to interview people that saw the eclipse, an elder, a parent, and a peer, and have students report to the class about what they found out. Other topics for discussion for students would have been "what if I had stayed inside for the eclipse?" or "what is the meaning of the eclipse for the future?" Students could also interview people who had seen the eclipse in 1947 or both eclipses and have a discussion about what they thought and how Ghana had changed in the past 50 years. One question that could be posed to a class for research and discussion was how Ghana is different than it was during the last eclipse and how will Ghana be different in 30 years when the next eclipse comes? These parts of the activity would be best used with students in grades six and above. All students, including younger students, could do theater activities or create stories about where they were during the eclipse. Another idea would be to make a collage of pictures, newspaper articles, and perhaps even a simple pinhole camera that could be used to see the Sun on a continual basis. A second major idea that came out was to have students create their own poems, stories, or pictures of the eclipse. One concern again was the lack of resources in most classrooms. Another idea that was shared with the group is the use of kinesthetic astronomy to demonstrate to students how eclipses occur with the alignment of the Sun, Moon, and Earth by having the students play the role of different objects in the system. This was actually used by The University of Arizona team during the eclipse when they were talking to local college students about why the eclipse could only be seen certain places on the earth. This is something that the team also uses in elementary school classrooms in the United States to explain similar concepts. Overall, it seemed important to this group that the eclipse be documented so that there would be more resources of knowledge for the next eclipse. This would help students make meaning of their own experience and give them more local history to build on with their shared experience.

This group was thought of by the facilitators to be the group that would work on an activity for those who saw the eclipse and respect that it was a valuable outcome as well. Interestingly enough, there were many ideas that came out of this group that were very appropriate to use as lessons in classrooms both in the Unites States and possibly in Ghana.

The third small group was to talk about cultural events that occurred around astronomical events. This group wanted to make a lesson that could be used in Ghana and be used as an example for other locations. They started out trying to understand the nature of local celebrations of astronomical events. They were unable to come up with this information, even from the University library. The focus on the lesson turned to having a classroom make its own festival centered on an astronomical event. As the lesson was developed, the group was concerned about doing it incorrectly or in a way that would be offensive. Within the lesson, the students would choose an astronomical event to celebrate, they would name their festival, would choose food for the event, choose dances to perform, would develop rituals, develop costumes, and a procession for the event. In creating their event they would need to learn about either local or other cultures and their celebrations. One thing that the man working in Ghana considered important was finding some commonalities in the celebration of festivals.

Dissemination Issues

The first group in discussing their assigned topic quickly realized that making lessons to use in Africa would be totally different than making lessons for students in the United States. One thing that was brought up was that for Africa we would need to build a curriculum for students from 3 years old to 80 years old, in the same way that a science center works, so that students would get interested in a topic and want to know more. It was cautioned that you could not make any assumptions about what goes on in classrooms in Ghana, that many people had gone back to school and that you can have a sixty year old student in a sixth grade classroom, many classrooms have as many as a hundred students, and that corporal punishment is commonplace in classrooms. Lack of resources is a constant problem in African classrooms. Using kits and sending them to schools in the local area as a way of sharing resources was suggested. Kits are basically a set of resources needed to support the lesson. This may include paper, scissors, crayons, as well as instructions on how to make learning materials from local resources and is sent from school to school. Other ideas about dissemination included sending curriculum and materials to teachers training colleges, IFESH, the Peace Corps, posting them on the internet, and as well as putting them into kits that could be circulated among rural schools. The collaboration with other Non-governmental agencies would be a great source of funds, resources, and expertise.

Overall, the model for what a lesson would look like would be a single piece of paper with background for the teacher on one side and perhaps images to copy on the other side. There would not be a prescribed lesson but rather background reading, a menu of ideas for a teacher to choose from, and some pedagogical information about how to do the activities. One concern was making the activity adaptable to each individual classroom and making so it could be a local product for those who used it.

At the end of the workshop, each group reported on what they had worked on and produced. One final concern brought up was to make sure that anything sent to Ghana was checked up on for feedback so that those creating lessons could see if the lessons were being effective. It was agreed that any educational work needed to be a two-way street so that information flowed both ways.

Reflection

The original planning for the workshop intended it to have two outcomes: something that the teachers could take home with them to use in their classroom and a set of lessons to use in classrooms in multiple countries. Each participant took something important with them from the workshop even if it was not a tangible lesson. Primarily they took away a greater awareness of doing work in a culture that is not your own, whether it is in Africa or the United States. It became evident that it is important to work with local experts to make educational material that is relevant to the classrooms it is intended for. During the two days, there were varying degrees of awareness and personal reflections and growth that showed that participants were sharing ideas and struggling with issues that are the basis of cultural astronomy and the many issues that are embedded within it. One such example occurred on the first day when we were discussing making lessons about this eclipse for students outside of Ghana. The museum administrator was brainstorming ways to create lessons about the eclipse embedded with local Ghana cultural astronomy for use with students in North America for the next eclipse. As she was talking and thinking, it occurred to her that using lessons from Africa would not be as relevant as having students discover the cultures of their own area, in this case, of the Native Americans who have their own stores of cultural and astronomical knowledge. We witnessed her realization that each group

Fig. 1 Sanlyn Buxner and Sulemana Nuhu during the educator workshop. Picture by A. Baleisis

of people needed to rely on the expertise of their area, their ancestors, and those who added considerable culture to modern society.

The goal of coming up with lessons to publish for use in multiple countries had a few roadblocks. One of the concerns that came up in all three groups was making materials that would either be locally useful or appropriate for classrooms in Ghana. Suggestions included visiting Ghana schools and working with local teachers/experts. These suggestions reinforced our idea that using a mixture of teachers from different cultures can be productive and gave us further reason to recruit local teachers for future workshops. Other roadblocks included an overall lack of time to come up with a finished product. Despite these roadblocks, there are some very

Fig. 2 Sanlyn Buxner and Audra Baleisis during the workshop. Picture by M. Peña

Fig. 3 Workshop participant Olanrewaju Oyewole. Picture by M. Peña

relevant and useful ideas that came out of the working groups, both in ideas about how to go about making lessons as well as ideas that can be made into lessons for students at least in the United States.

Another important part of the workshop was the roundtable discussion with the teachers and the experts. This discussion gave an opportunity for teachers to ask the experts directly about their opinions of the field and gave the experts a chance to share their thoughts on education. Despite the fact that the expert panel was not asked specific questions about what they researched, this discussion was an important one for people to share their global perspectives on the fields of education and cultural astronomy. This discussion helped to clarify why we as a society should study cultural astronomy and how it helps us all make sense and personal meaning of our own lives.

Overall, the workshop was a fascinating experience where a variety of opinions and intellectual resources were shared and collected. Despite the fact that we did not have the makeup of teachers that we had expected, the two days were incredibly rewarding and reinforced the need and value of these types of experiences. It can be said that each participant came away with a new perspective and fresh ideas that will be applied to their professional and personal lives.

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A Contemporary Approach to Teaching Eclipses

Timothy F. Slater

Introduction – Importance of Eclipses in Students' Education

Although no "world-wide" standards of science education actually exist, one might argue that if such a document did exist, the nature and predictable movement of objects in the heavens would be a component of it. In the USA, one of the guiding curriculum documents for science education, the *National Science Education Standards* (which surprisingly are not required to be adopted across the USA as a federal mandate) state that all students should understand, amongst many other ideas, that (i) objects in the sky have patterns of movement. The sun, for example, appears to move across the sky in the same way every day, but its path changes slowly over the seasons. The moon moves across the sky on a daily basis much like the sun. The observable shape of the moon changes from day to day in a cycle that lasts about a month and (ii) most objects in the solar systems are in regular and predictable motion. Those motions explain such phenomena as the day, the year, phases of the moon, and eclipses (Adams and Slater, 2000).

Also in the USA, another guiding document for national guidelines for curriculum (similarly not required for adoption federally), the *American Association for the Advancement of Science's Benchmarks for Science Literacy* state that all students should understand that "our Sun can be seen only in the daytime, but the moon can be seen sometimes at night and sometimes during the day. All sky objects appear to move slowly across the sky. The moon looks a little different every day, but looks the same again about every four weeks." Some readers might be surprised that the Benchmarks also state that "no particular educational value comes from memorizing sky object names or counting stars, although some students will enjoy doing so" (Slater, 2000).

Clearly, from the above, as well as from some sense of the nature of what composes an "educated" person, the nature of objects in the sky is a worthy topic for education. But, what about requiring that students learn about the nature of eclipses of our Sun by the Moon? Do these events, dramatic and spellbinding as they are,

Timothy F. Slater
University of Arizona, 933 N. Cherry Ave., Tucson, AZ 85721 USA
Telephone: (520)621–7096; Fax: (520)621–1532

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merit inclusion in teaching when they can only be observed at a particular location under clear skies on time scales on the order of decades? I would argue that the answer is yes. First of all, from a historical perspective, the phenomena of eclipses have reportedly changed the course of human events. Second, with the advent of modern technology such as live TV and Internet broadcasting, each time these events are observed somewhere in the world, they are often broadcast to all reaches of the world. But, perhaps most importantly, when these events do occur, they are often events so dramatic and revered by those observing them, that they serve as cornerstones of life's memories for the individuals that experience them. The Ghana Eclipse Conference focused on the Cultural Astronomy of Africans offered an opportunity to view a total solar eclipse. Part of the conference was a workshop for K12 educators to develop lesson plans about African Cultural Astronomy. As a clear example of the impact of viewing this celestial event, all the groups decided to focus their lesson plans on the total solar eclipse. As such, I propose that eclipses should definitely be included as at least a small part of every child's curriculum.

This paper provides a history of the research surrounding students' learning astronomy and in particular about the predictable motion of objects in the heavens. In order for students to fully understand eclipses, students first need to have a scientifically accurate understanding of the size and scale of the Earth-Sun-Moon system, then need to have a functional understanding of what causes moon phases, and then, and only then, are students in a position to fully understand the nature of eclipses.

First Steps Toward Understanding Student Reasoning Difficulties and Incorrect Beliefs in Astronomy

The idea that astronomy students actively synthesize and interpret information and experiences into conceptual models that may or may not be scientifically accurate is rooted in the educational reforms known as constructivism (Slater, 1993). This student model-building paradigm has motivated and guided the nature and emphasis of a variety of investigations into student understanding. Certainly the most well known study of understanding in astronomy was publicized by Philip Sadler and is presented in the video *A Private Universe* (Schneps, 1989). The video begins with clips of interviews with several alumni, faculty, and graduating seniors from Harvard University. Of the 23 individuals interviewed, 21 could not give a scientifically acceptable explanation for the cause of the seasons or the phases of the Moon. An explanation for the cause of the seasons that is consistent with a scientifically accurate viewpoint would involve how the amount of sunlight reaching Earth's surface at different latitudes is related to the planet's tilt. However, the most common alternative explanation given was the changing distance between the Sun and Earth (that Earth is closer to the Sun in the summer and farther in the winter). A scientifically accurate description of the lunar phases would explain that, despite half of the Moon being illuminated by the Sun at all times, the portion of that half that can be seen from Earth – what we call the phase – depends upon the relative positions of the Sun, Earth, and Moon. Responders most often incorrectly explained lunar phases by an "eclipse" or "interference" model, where shadows cast by Earth onto the Moon or clouds block some of the light. In addition to members of the targeted Harvard community, local ninth grade students were interviewed about these same concepts. The video shows lengthy portions of one student's interview and related commentary by her teacher. Heather, the student, gave detailed explanations and illustrations of her ideas about these concepts. Although she often used terminology that would imply complete understanding, further probing through an interview showed that this was not the case. Heather had deeply-held alternative conceptions before instruction and, after instruction, integrated newly learned information into these incorrect ideas in complex and subtle ways.

Although the ideas so clearly illustrated by *A Private Universe* were garnered through methods that probably do not conform to the rules of reliability and validity that define educational research, the video's influence cannot be understated. Modeled after this presentation, similar videos exposing the robustness of students' individual ideas about the natural world have been created and distributed in the areas of simple electric circuits, photosynthesis, and geometric optics. These videos are widely used to help teachers and faculty understand the nature of learning.

Not nearly as well known, but more reflective of quantitative research on student understanding, is a multiple-choice instrument, developed by Sadler (1992) as part of his dissertation work, that addresses misconceptions culled from the literature and his interviews with students. Sadler administered the instrument to over 1,400 high school students and found a mean student score of 34% correct. In fact, Sadler found that many misconceptions (19 of 51) were actually preferred by students over the scientifically accurate concepts.

In addition to motivating much of the contemporary effort in astronomy teaching a particular strength of Sadler's work was that it lead to the development of the Project STAR curriculum materials (Gregory, Luzader & Coyle, 1995), initiated the widespread use of an inflatable and portable planetarium (called *STARLAB*), and served as the foundation for much of the activities of Project SPICA (Ball, Coyle, & Shapiro, 1994).

Misconceptions About Size and Scale as a Barrier to Teaching Eclipses

One might guess that if students are to understand eclipses, they need to have an underlying idea of the size and scale of the Earth-Sun-Moon system. Unfortunately, students' pre-existing ideas about the size and scale are well poised to interfere with the most well articulated lectures about eclipses. Most students are quite surprised to learn that the Moon is only one-quarter Earth's diameter and even more surprised to learn that the Moon orbits Earth at an orbital radius of about thirty Earth diameters!

Fanetti (2001) interviewed 50 college students and administered an open-ended survey to more than 700 students to investigate their understanding of lunar phases.

Her main conclusion from these data is that a lack of understanding of the Moon-Earth system's scale is the main reason for student difficulties in understanding the phases of the Moon. Earlier work by Callison and Wright (1993, April) investigated the use of different three-dimensional models to teach about lunar phases, focusing especially on the interaction of the students' spatial ability and reasoning levels in their ability to develop mental models. Barnett and Morran (2002) investigated the use of project-based curriculum from the Challenger Center (URL: http://www.challenger.org) in a 5th grade classroom to teach about the phases of the Moon and eclipses. They incorporated findings from research into student understanding by the sequencing of projects, with the report focusing only on the final two projects (covering the relative Earth-Moon-Sun positions and eclipses). Students had opportunities to research information about the orbital motions of the Moon and Earth, as well as to explore an interactive computer model that displayed the Earth-Moon-Sun system from different three-dimensional perspectives. The researchers found that their students were able to increase their understanding of Moon phases (as defined by having a more scientifically complete understanding) after having experienced this series of lessons.

Misconceptions of Moon Phases Serve as a Barrier to Teaching Eclipses

The deep-seated prevalence of misconceptions about the moon mentioned earlier and demonstrated by *A Private Universe* are not limited to Sadler's work. The overarching misconceptions are grounded in the notion that the changing phases of the Moon must be caused by something being in the way – the Earth's shadow or clouds, for instance. Stahly, Krockover, and Shepardson (1999) furthered research on students' understanding of the changing lunar phases. In their review of the literature, the authors report that previous studies had been mainly quantitative in nature (using questionnaires or multiple-choice surveys), and thus they adopted a qualitative, case-study approach and interviewed four U.S. third-grade students. Additional data were collected in the form of written tasks, classroom observations, and teacher feedback. Comparisons between pre- and post-instruction interviews demonstrated that the students showed a positive conceptual change over an instruction intervention characterized as a three-week, multiple component lesson using three-dimensional models, with post-instructional explanations showing more details and more scientifically accurate ideas.

For older students, Lindell (2001) developed the *Lunar Phases Concept Inventory* (LPCI) from interviews with undergraduate students to measure conceptual change in their understanding of the Moon's phases. Her pretest results confirmed earlier work with younger students and argued that scientifically inaccurate ideas persist into college. The LPCI, a multiple-choice instrument that can be quantitatively analyzed, was used to evaluate the effectiveness of an in-class group activity designed to address these concepts using a constructivist approach. The activity showed statistical success in the way of an unusually large average gain ($g = 0.63$), where *gain* is defined as the ratio of the student's actual increased score to the greatest possible increased score. Lindell and Olsen (2002, August) describe further revision, field-testing, and statistical analysis of the LPCI. More recently, brief Socratic-basic tutorial activities (Adams, Prather, & Slater, 2002) resulted in even larger gains when coupled with interactive lecture techniques (Slater et al., 2006).

Trundle, R. K. Atwood, and Christopher recently investigated the understanding of moon phases held by pre-service elementary teachers (Trundle, Atwood, & Christopher, 2002) and in their report provide a table describing the results of many previous studies on this topic. The researchers collected qualitative data through classroom observation, structured interviews, and document analysis. This triangulation of data through multiple sources is a useful and increasingly common way of checking for valid interpretations. A total of 78 participants were interviewed once or twice to determine their mental models; 63 received inquiry-based instruction on lunar phases during a physics course, while the 15 methods course students received no instruction on the topic. As in most of the earlier studies on this topic, the most common alternative conception about the lunar phases is that they result from eclipses by Earth's shadow. Post-instruction interviews showed that 76% of participants demonstrated scientific understanding after the inquiry unit. A later report (Trundle, Atwood, & Christopher, 2003, March) describes the results of additional post-instruction interviews, 6 and 13 months after the instructional period, with a subset of 12 of the participants receiving instruction in the physics course. None of this subset had scientific understanding before instruction. Three weeks after instruction, eight showed scientific understanding and four demonstrated scientific fragments (in which the participant demonstrated knowledge of some but not all of the four components deemed necessary for complete scientific understanding). Either 6 or 13 months after instruction, seven still held scientific understanding and two demonstrated scientific fragments. The other three reverted to alternative conceptions. The researchers also specified that two common problems seen in the pre-instruction interviews were that the participants often did not know that the Moon orbits Earth, or that the Moon is always half illuminated. Without this knowledge, the researchers speculate, students have no reason to question the common shadow eclipse model. The researchers did not use the LPCI (Lindell, 2001) to further investigate their participants' understanding, perhaps because of the LPCI's still limited dissemination.

Abell and colleagues used a six-week long Moon observation project in their elementary science teaching methods course to emphasize aspects of the nature of science as well as content (Abell, Martini, & George, 2001). The details of the goals, methods, and assessments used in this process are described in a later report (Abell, George, & Martini, 2002). Students recorded daily Moon observations in journals, eventually moving to identifying patterns, making predictions, and offering explanations in the journals as well. While students were able to recognize the importance of observation in science, they were not often able to articulate the different roles observation can play. Students were encouraged to develop their own theories to explain their observations; however, few students transferred this aspect of "invention" to a scientist's work. Finally, both small- and large-group discussions were used to emphasize the social nature of science. Most of the students recognized the importance of social collaboration in their own learning process, but again failed to make the connection between this aspect and the work of scientists. The authors recognize that much of their instruction about the nature of science was more implicit than they perhaps had hoped, and plan to make these aspects more explicit in future instruction.

Instructional Strategies to Circumvent Student Difficulties with Moon Phases

Given the extensive nature of research on student difficulties with moon phases, one might mistakenly assume that all teachers and professors are aware of these issues and successfully help students overcome their misconceptions. However, the more common experience among astronomy educators is that well implemented astronomy instruction on moon phases is lacking far too often. Regardless, some very good models exist.

Classic approaches are eloquently described by Pompea (2000) that are time tested and include using models. Some other ideas, worthy of note, include Hickman's (1993) description of a kinesthetic learning approach to teaching moon phases popularly known as "the moon dance" (Slater & Zeilik, 2003). This has gained significant popularity in the USA and has been extended considerably by Morrow (2000) as part of a series of lessons known as Sky Time.

Adams and Slater (2000) designed a collaborative learning lesson that used a heliocentric perspective for teaching moon phases. This asked students to draw stick figures on a circle that represented Earth and first asked students to indicate where a stick figure would be placed at different times of the day on a spinning Earth. They then scaffolded this idea to how a moon that is always one half lit by the Sun would be viewed from Earth at different times of the day and to the month.

Although most of these efforts described above are not fully evaluated, some do have compelling data as to their effectiveness. Sneider and Ohadi (1998) designed a study to judge the effectiveness of an elementary level instructional unit called *Earth, Moon, and Stars* (Sneider, as cited in Sneider & Ohadi), developed by the Lawrence Hall of Science as part of the Great Expectations in Math and Science (GEMS) series. The *Earth, Moon and Stars* GEMS unit of six activities is designed with constructivist and historical approaches in mind and is aimed at grades four through eight. Using the instrument described in Sneider and Pulos (1983), investigators tested the efficacy of the unit through an experimental-control two-group study design. They found that students in the experimental course who used the GEMS unit scored higher on the instrument than those who were exposed to traditional instruction only. Analyses such as Chi-squared tests found that the differences were statistically significant and allowed the researchers to eliminate maturation and pre-test learning effects as explanations for the increased scores.

Fig. 1 K12 educators: Doris Anderson and Betty Turner

Probably the most successful approach that has been fully evaluated are efforts by Prather (Prather, Slater, Adams, Jones, & Dostal, 2004). This team designed an approach called *Lecture-Tutorials for Introductory Astronomy* (Adams, Prather, & Slater, 2005). In this approach, implementing the Lecture-Tutorials ideally consists of three steps. The first step is to pose a set of conceptually challenging questions – presented to students at the end of an abbreviated lecture on a given topic – to elicit and challenge students' fundamental understanding. If an unsatisfactory percentage of students are able to correctly answer the questions, this suggests that the accompanying Lecture-Tutorial should be used. What will be surprising to most faculty is that, even after conventional instruction, the majority of students will still answer seemingly "easy" questions incorrectly (Hewson & Hewson, 1988; Mazur, 1996; Posner, Strike, Hewson, & Gertzog, 1982). Furthermore, when reading the Lecture-Tutorials themselves, faculty often have the same impression about the conceptual difficulty of the materials; however, our research shows that students do not share this impression.

Fig. 2 University of Arizona undergraduate students observing the total solar eclipse in Ghana, March 29, 2006

The second step, and most central to the core of this project, is to use one of the 15-minute, collaborative-learning Lecture-Tutorials in the lecture classroom. During this time, faculty change roles from lecturer to facilitator, circulating among the student groups, interacting with students, posing guiding questions when needed, and keeping students on task.

The final step of each *Lecture-Tutorial* is to debrief the content covered and to bring closure for the students by eliciting student questions and comments. Another common debriefing approach is to make explicit the reasoning needed to fully understand the concepts and provide students with accurate language to describe the phenomenon under investigation. This is an important meta-cognitive step for both the students and the instructor in that it provides useful insight into how the Lecture-Tutorial experience has impacted student understanding. In addition to extensive implementation notes, an online Instructor's Guide also provides "post-tutorial" questions that can be used to assess the effectiveness of the Lecture-Tutorial before moving on to new material.

As one example of how this is applied to moon phases, students are challenged to consider a heliocentric view of the Earth, the Sun, as well as five different possible positions for the Moon. Students are asked:

1. Which Moon position best corresponds with waxing crescent moon phase?
2. Give a reason why each of the other possible choices is not correct.
3. Shade in each of the four Moons to indicate which portion of the Moon's surface will NOT be illuminated by sunlight.
4. Which Moon position best corresponds with the new moon phase.
5. How much of the entire Moon's surface is illuminated by the Sun during this phase? Choose one: (a) None of the surface is illuminated; (b) Less than half of the surface is illuminated; (c) Half the surface is illuminated; (d) More than half the surface is illuminated; or (e) All of the surface is illuminated.
6. Consider the following debate between two students about the cause of the phases of the Moon. Do you agree or disagree with either or both students? Explain your reasoning for each.

   (i) *Student 1-: The phase of the Moon depends on how the Moon, Sun and Earth are aligned with one another. During some alignments only a small portion of the Moon's surface will receive light from the Sun, in which case we would see a crescent moon.*
   (ii) *Student 2: I disagree. The Moon would always get the same amount of sunlight; it's just that in some alignments Earth casts a larger shadow on the Moon. That's why the Moon isn't always a full moon.*

7. If the Sun sets below your western horizon about 2 hours ago, and the Moon is barely visible on the eastern horizon, is it a waxing or waning Moon that is visible?
8. A friend comments to you that he saw a beautiful, thin sliver of a Moon in the early morning on his way to work just before sunrise. Which phase of the Moon would this be, and in what direction would you look to see this moon phase (in the southern sky, on the eastern horizon, on the western horizon, high in the sky, etc.)?

A more recent approach has been to design questions and challenges for students that can be delivered via interactive computer programs (Jones & Slater, 2004). Their research project explored the effectiveness of Learner-Centered Education (LCE) principles and practices on student learning and student attitudes in an on-line, interactive, introductory astronomy course for non-science majors based on the principles of Learner-Centered Education. To do this, the team created a hypermedia learning experience for introductory astronomy that matches Internet technology with how people learn. This course weaved multimedia visualizations into a structured learning environment by dividing complex concepts into bite-sized pieces. Each cognitive piece contains hyperlinks explaining all terms as well as illustrations using high-resolution images, animations, and videos which students manipulate to answer questions. Each module helped students engage in the pursuit of learning astronomy by providing activities where students use astronomical data. Learners were required to answer pre-module questions, not as multiple-choice questions, but as written narratives, about the concept under study to make their knowledge explicit. At the conclusion stage, students compare new ideas with their initial answers and evaluate various alternative explanations.

Just in the last year, members of the University of Arizona's Conceptual Astronomy and Physics Education Research Team have been exploring how automatically computer graded tasks can improve student learning. In one application, students are asked to sort a list of events into one of two categories uncovering their understanding about when and where different moon phases are visible. As a specific example, students sort the list: "(A) is visible near the western horizon about an hour after sunset; (B) rises at about the time the Sun sets; (C) occurs 14 days after the new moon; (D) sets 2–3 hours after the Sun sets; (E) is visible near the eastern horizon just before sunrise; (F) is closest to being blocked by Earth's shadow; and (G) is visible about three days before new moon phase" into one of three categories: (1) Waxing Crescent Moon; (2) Waning Crescent Moon; or (3) Full Moon.

Instructional Strategies to Circumvent Student Difficulties with Eclipses

One approach to improving student learning for eclipses is to test their ability to use the vocabulary of eclipses in the correct physical context. As one example, members of the University of Arizona's Conceptual Astronomy and Physics Education Research Team have been exploring how automatically computer graded tasks can improve student learning. In one application, students are given six eclipse vocabulary words: "(A) node; (B) umbra; (C) penumbra; (D) total lunar eclipse; (E) total solar eclipse; and (F) annular eclipse" and asked them to correctly place them in one of the following sentences.

1. A solar eclipse that occurs when the new moon is too close to Earth to completely cover the Sun can be either a partial eclipse or a(n) __________.
2. During some lunar eclipses, the Moon's appearance changes only slightly, because it passes only through the part of Earth's shadow called the __________.

3. Anyone looking from the night side of Earth can, in principle, see a(n) __________.
4. A partial lunar eclipse begins when the Moon passes into Earth's __________.
5. A(n) __________ can occur only when the Moon is new and has an angular size larger than the Sun in the sky.
6. A point at which the Moon crosses Earth's orbital plane is called a(n)__________.

The importance of vocabulary not withstanding, a much more involved approach to teaching eclipses asks students to fully engage in both the social and scientific aspects of eclipses. This can be done only if the essential questions students need to be able to answer are established at the onset of the lesson and considerable time is allocated to the lesson. I propose that a lesson that takes advantage of what we now understand about student misconceptions and challenges to learning would include the following three essential questions: (i) Do we need solar eclipses? (ii) How much trouble would you go through in order to observe a total solar eclipse? And (iii) What "magic" occurs during a total solar eclipse?

To approach such overarching questions, the student learning goals would need to be that students will understand that:

1. The Moon casts an umbral shadow and penumbral shadow
2. The sky's appearance, animal behaviors, and human perspective often change during a total solar eclipse
3. Ancient peoples had such strong reactions to solar eclipses because of the importance of the Sun in daily life
4. Scientists use the opportunity of a total solar eclipse to study the faint outer atmosphere of the Sun, called the solar corona
5. Scientists and non-scientists use the opportunity of a total solar eclipse for self-reflection and personal enrichment
6. People spend so much time, energy, and money to travel to view total solar eclipses
7. Solar eclipses occur because of a particular alignment of the Sun-Earth-Moon system
8. The size and scale of the Sun-Earth-Moon system impacts the apparent size of Sun and Moon and size of shadows
9. Total solar eclipses can only be observed from certain locations on Earth

And, students would need to be able to explain how total solar eclipses occur, explain why total solar eclipses do not occur with every New Moon phase, and use a diagram of the Earth and Moon's orbit around the Sun to describe the necessary conditions for eclipses to occur.

The beginning of such a lesson would involve students observing a video of people watching an eclipse as invitation to learn are asked to individually write a short description of the behaviors and emotions of the people they are watching and provide evidence to infer what they are experiencing or observing. They then get into small groups to come up with a list of questions they "could" ask the people in the interview about what they are observing and what they are feeling if they could chat with them online or "instant message" them. (An extension activity for the overachieving teacher would be to actually find a friend online to role play as one of the people in the video that would respond to appropriate and well formulated student questions, but answers should be vague and suggest the person was not formally trained in science.)

The next phase would be that students would be challenged to take a series of print images of a solar eclipse withOUT time stamps and asked to arrange them in a possible sequence and asked to relate the images to what they observed in the video of people watching an eclipse and provide evidence for their inferences. Students would then use models previously used for learning about moon phases to reproduce conditions necessary for eclipses. Next, students would look at satellite images showing eclipse shadows on Earth.

For the final concluding activity, students would be challenged to create a culturally relevant celebration that would surround a predicted eclipse. This idea emerged directly from the K12 educators workshop at the Ghana Eclipse Conference. The celebration design would need to include a created song, chant or poem; an original piece of artwork, either as a t-shirt design, a patch, or a flag; a feast with foods that represent different aspects of the eclipse phenomena; and a timeline for which this all would occur around an eclipse prediction.

This final piece of the learning sequence is critical and should not be omitted. This is because students need to have a conceptual understanding of eclipses tied directly to their personal experience. If such a direct connection is not made, then the newly learned concepts will quickly fade from memory. The next total solar eclipse to pass over Ghana is more than twenty-years in the future, which is certainly long enough that many students will have forgotten the scientific concepts surrounding how eclipses occur. This exceedingly long time horizon makes it even more imperative that teachers help students remember the nature of eclipses over the long term. The next dramatic total solar eclipse for Africa will be August 02, 2027 when the Moon's shadow will skim the northern tier of Africa along the coastline. More similar to 2006, the total solar eclipse occurring March 20, 2034 will follow nearly the same path as the 2006 pathway, but slightly more southern passing through Nigeria, Chad, and Sudan. This 2034 eclipse will go straight over the top of Accra, Ghana as well. Given that eclipses will pass over any location quite infrequently, but because total solar eclipses often happen somewhere in the world each year, solar eclipse pathways do give teachers an opportunity to study the specific customs and cultures of countries whose' residents are experiencing a total solar eclipse. Thus, following total solar eclipse events around the world give teachers an opportunity to pick a country very different from their own to introduce to students.

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Teaching Cultural Astronomy: On the Development and Evolution of the Syllabus at Bath Spa University and the University of Wales, Lampeter

Nick Campion

Abstract The Master of Arts in Cultural Astronomy and Astrology at the University of Wales, Lampeter, formerly taught at Bath Spa University in England, is the first degree of its kind in the world. (I shall refer to the discipline as Cultural Astronomy, with initial letters as upper case, and the phenomena which it studies as cultural astronomy, all lower case). My definition combines both the discipline and the phenomenon; 'Cultural astronomy: the use of astronomical knowledge, beliefs or theories to inspire, inform or influence social forms and ideologies, or any aspect of human behaviour. Cultural astronomy also includes the modern disciplines of ethnoastronomy and archaeoastronomy' (Campion 1997: 2).

The MA program in Cultural Astronomy and Astrology was launched at Bath Spa University in October 2002 and relocated to the University of Wales, Lampeter in September 2007, although teaching continued at Bath Spa until June 2008.

There are just two previous reports on the Bath Spa MA, by Michael York, my predecessor as course director, and that focused on the astrological side of the Cultural Astronomy-Astrology question (York 2004, 2007). Other academics have set up individual classes as part of their teaching programmes but the Lampeter programme remains the only full degree programme. In 2005 Bath Spa University decided to close the programme rather than develop the distance learning programme which the Centre regarded as an essential part of its work. The program then transferred to the University of Wales, Lampeter, where teaching will be primarily on-line. I mention this because it illustrates the problems of running a programme in what is essentially an emerging discipline. That is, before we actually consider pedagogical issues, particularly what Cultural Astronomy as an academic discipline, which studies cultural astronomy as a human phenomenon, should consist of. What should the syllabus contain, and are there appropriate theoretical models which can provide a suitable framework?

Nick Campion
Director of the Sophia Centre for the Study of Cosmology in Culture, and Senior Lecturer in Archaeology and Anthropology, University of Wales, Lampeter, UK (www.lamp.ac.uk/sophia)
E-mail: n.campion@lamp.ac.uk

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Navigating academic politics is only one part of developing cultural astronomy as a discipline. The politics of knowledge are also crucial. The most obvious problems in this respect are likely to arise in two areas, especially when the words astronomy and astrology are combined in the same degree title. First is the well-known antipathy, ranging from bemusement to deep hostility, that characterizes many astronomers' attitude to astrology. Second is the question of whether astronomy, as a science, is itself subject to cultural pressures. In cultural studies the view is that, necessarily, even in terms of the scientific questions it asks and the manner in which data is interpreted, astronomy is cultural. As Michael Hoskin (1996: 887), editor of the *Journal for the History of Astronomy*, wrote, 'What astronomy is not an astronomy in a culture?' I do not believe that Professor Hoskin was taking the extreme post-modern view that science is itself absolutely culturally conditioned but, as an historian, he is aware that the kinds of questions that astronomers ask must condition the results they achieve (see, for example, Hoskin 1999).

The history of Cultural Astronomy as a discipline stretches back to the 1960s and the furor created amongst archaeologists by Alexander Thom's work on megalithic sites in north western Europe in general, and Gerald Hawkins studies of Stonehenge in particular, and the effective foundation of the modern study of archaeoastronomy (see Campion 2004). The first and, to date, only substantial manifesto of Cultural Astronomy's scope and methodologies was published by Clive Ruggles and Nicholas Saunders (1993). The essential problem Ruggles and Saunders identified was that archaeoastronomical methodologies lacked certainty. First, the decision about which points and criteria to use as a basis for measurement, especially when stones may have moved over time, as well as the interpretation of results, are both highly subjective. Second, while such problems might be partly overcome by using statistical methods (the authors suggested Bayesian analysis), ethnographic evidence is also necessary. This solution had been suggested by Elizabeth Chesley Baity (1973), in her early use of the term 'ethnoastronomy'.

As the study of archeaoastronomy spread from a focus on European megaliths to include the Americas in the late sixties and early seventies, American astronomers discovered their own version of ancient astronomy in Mesoamerican ruins and, to a lesser extent, in Native North American sites. This focus had its consequences; due to Cultural Astronomy's origins in Archaeastronomy its subject focus has remained narrow. Of the nine papers in the 1993 Ruggles and Saunders volume, all were on pre-modern and non-western topics. This emphasis pervades the literature, particularly the publications which result from the 'Oxford' conferences on Archaeoastronomy and the meetings organized by the European Society for the Study of Astronomy in Culture (SEAC) conferences, *Archaeastronomy* journal and the now defunct *Archaeoastronomy* supplement to *The Journal for the History of Astronomy*. The focus is almost exclusively pre-modern and non-western. Only the Inspiration on Astronomical Phenomena (INSAP) conferences have extended the remit to consider modern art and literature. It is clear then, that the subject area of Cultural Astronomy needs to be extended. To exclude modern and western culture is not possible if the discipline is to develop. Here again, we may refer to Ruggles and Saunders who, in their introduction to *Astronomies and Cultures*, cited approvingly

Tristan Platt's suggestion that we are in need of an 'anthropology of astronomy'. Platt's words are somewhat more radical than this quote would suggest. He wrote that,

> an historical anthropology of astronomy must emphasise the interaction between different cultural perspectives on history and time, rather than subsuming them within what is still a predominantly North Atlantic 'World' perspective. Hence the need to deconstruct the universalising discourse of modern professional astronomy itself (still with an inbuilt tendency to appeal to a historicist account of its own past) if we are to arrive at an approach to the subject at once sociological and ethnoscientific, which recognises the recreation of different cultural histories as a more significant and viable prospect than an absolute (and inevitably ethnocentric) Universal History (1991: S83).

The implication of Platt's perspective is that contemporary astronomers must be able to reflect on and understand their own beliefs, practices and mythologies. Can they follow Immanuel Kant, who famously wrote that 'two things fill the mind with ever new and increasing admiration and awe, the oftener and the more steadily we reflect on them: *the starry heavens above and the moral law within* (1952: 360)'. It was on the basis of the need to understand one's own culture that I formulated a definition of Cultural Astronomy in the first issues of *Culture and Cosmos*, the journal on the history of astrology and cultural astronomy. I had read neither Ruggles and Saunders nor Platt at the time, but my perspective was informed by my background as an historian, so we were all moving in the same direction. My historical work in *Culture and Cosmos* became the foundation of the MA in Cultural Astronomy and Astrology, which was the main teaching focus of Bath Spa University's Sophia Centre. We developed the syllabus specifically to include contemporary western cosmologies, including literature and the arts. For example, one student is current preparing a dissertation on cinema as an alternative cosmology, drawing on studies of the cosmological nature of Renaissance theatre (Yates 1978). The Sophia Centre's academic remit was defined in specific and general ways as follows:

a. to undertake the academic and critical examination of astrology and its practice;
b. to pursue research, scholarship and teaching in the relationship between astrological, astronomical and cosmological beliefs and theories, and society, politics, religion and the arts, past and present.

To complement the definition of Cultural Astronomy I used a definition of astrology which seemed sufficiently neutral and broad: 'the practice of relating the heavenly bodies to lives and events on earth, and the tradition that has thus been generated' (Curry 1999). I have defined three major forms of contemporary cultural astronomy, all of which have featured to a greater or lesser degree in the syllabus. First and most important is astrology. Second are the mystical, theosophical and New Age cosmologies, from Immanuel Swedenborg to Rudolf Steiner, which provide a philosophical context for contemporary astrology. Third and, least important in the current syllabus are UFO cults and related theories concerning extraterrestrial life. The MA's emphasis has remained predominantly western, mainly due to the limitations of staff expertise but also because, with a student body of under thirty, there is a limit to the amount of material one can cover while retaining a coherent syllabus; with the exception of a seminar on the religious context of Indian astrology there has been no coverage of astrology in non-western cultures. Only the launch of a distance learning programme, which is an aspiration, would make this possible in the future. It would also be necessary to bring visiting professors together. The result of the western focus, though, has been unexpected. With each year's revisions of the syllabus one philosopher assumed an increasing importance: Plato. It became clear that Plato, though he flourished in fourth century BCE Athens, is the pivotal figure in western cosmology, including astronomy and astrology. He brought together knowledge and wisdom from the entire Eastern Mediterranean and Near East, including Greece, Egypt and Babylon, and formulated the belief in celestial meaning which still underpins astrology and New Age cosmology, the notion of a mathematical order which underlies modern science, including astronomy, and the concept of an underlying 'order' which influences twenty first century mathematics. As an illustration of Plato's enduring influence, let me quote Roger Penrose: 'The mental images that each one has, when making this Platonic contact, might be rather different in each case, but communication is possible because each is directly in contact with the *same* externally existing Platonic world!' (1991: 554–5). As Plato himself said, 'And so the heaven, revolving these very objects for many nights and many days, never ceases to teach men one and two, until even the most unintelligent have learnt sufficiently to number' (1929: 978D).

My own background is originally in political history and I welcome the approach taken by those who are examining such problems as the politics of the space race (for example www.astropolitics.org). However, for the simple reason that we cannot cover everything, I have taken a slightly different direction. My syllabus' emphasis is contemporary, but with a strong historical component designed to trace the development of relevant beliefs, ideas and practices; for example, it is argued that contemporary alternative spirituality needs to be understood in the context of classical Gnosticism. There is a strong anthropological and sociological component but also a strong interdisciplinary element, in that historical and the Study of Religions approaches are also applied.

The first core module (Introduction) examines cultural astronomy, magic, astrology and divination in a post-modern context.

The second core module (Research Methods) requires students to undertake qualitative research using interviews or questionnaires, with a strong reflexive emphasis, where appropriate.

The optional modules explore the background to the ideas investigated in the core modules, from a generally philosophical perspective.

The history module examines the development of cosmological ideas in the west, particularly astrology, with strong reference to Plato and requires familiarity with approaches to the study of history.

The stellar religion module explores New Age theories concerning the relationship between the soul and the stars, examining origins in the ancient and classical worlds, and requires an understanding of main currents in the sociology of religion.

The psychology module examines psychological approaches, including Freud's attitudes and the sources, nature and implications of C.G. Jung's work in astrology, as well as that of post-Jungians such as James Hillman, and its penetration in contemporary thought.

The science module examines scientific sources and critiques of astrology, particularly in relation to theorists such as Paul Feyarabend, and the intellectual basis of critical skepticism.

The New Age module investigates the phenomenon of New Age belief within the context of theories on millenarianism and the work of sociologists such as Paul Heelas, Michael York and Wouter Hanegraaff.

The sacred geography module investigates theories concerning the construction of sacred space, with reference to such theorists as Ernst Cassirer, Mircea Eliade and Christopher Tilley, and with attention to contemporary spiritualities. I hope that our new location at Lampeter will enable us to develop studies in archaeoastronomy.

Changes in the MA were prompted partly by my examination of whether Cultural Astronomy is a subject area (i.e. astronomy *and* literature, astronomy *and* architectural alignment, astronomy *and* the arts and so on) or a discipline with a coherent methodology. As a subject area the emphasis has tended to emphasize such areas as magic, divination, religion, science and psychology, a fairly broad swathe. There is a strong contextual emphasis on the historical lineage of New Age culture and the western esoteric tradition, in which key texts include Faivre (1994, 2000), Faivre and Needleman (1992), Heelas (1996), Hanegraaff (1996) and York (1995). That is the simple part of constructing a syllabus. The issue, though of Cultural Astronomy as a discipline was one which Ruggles and Saunders had implicitly raised in 1993. It's also an issue addressed, from his sociological perspective, by Jim Pass (2004). We have incorporated some sociological perspectives. For example from Max Weber (1991), we have taken the debate on disenchantment, pulling astrology's contemporary appeal into perspective as an example of the push for 're-enchantment'. The key, for me, though, was the use of the word cultural; the study is neither of astronomy, nor astrology, nor of UFOs, but of culture. And that opens up huge problems, as well as possible solutions. 'Culture', Terry Eagleton wrote, is said to be one of the two or three most complex words in the English language, and the term which is sometimes considered to be its opposite – nature – is commonly awarded the accolade of being the most complex of all' (2000: 1). He continued,

> It is hard to resist the conclusion that the world 'culture' is both too broad and too narrow to be greatly useful. Its anthropological meaning covers everything from hairstyles and drinking habits to how to address your husband's second cousin, while the aesthetic sense of the word includes Igor Stravinsky but not science fiction. Science fiction belongs to 'mass' or popular culture, a category which floats nebulously between the anthropological and the aesthetic (2000: 32).

Eagleton's pessimism aside I began to look at questions such as whether the MA was examining astrology/astronomy *in* culture – i.e. as part of culture – or *as a* culture – i.e. as a culture in itself. Then, of course there are sub-cultures within cultures. We have touched on cultural theory, including ideas such as hegemony, which can be useful for understanding the tense relationship between astronomy and astrology (see for example Hall 1998: 442–53). This may well be understood to be a matter of scientific truth versus fantasy. But, if we consider that ninety percent of the people at an astronomical gathering will be men, and ninety percent at an astrological meeting women, we might begin to suspect that something more complex is going on, even if only a matter of gender relations. Then there is the question of astronomers and religious belief. The dominant discourse in astronomy is atheist, but there are notable exceptions, a recent one being Owen Gingerich the distinguished historian of astronomy. The publicity for his book, *God's Universe* (2006), is an open challenge to the atheist consensus as well as, in a larger scientific context, Darwinianism:

> Owen Gingerich believes in a universe of intention and purpose. We can at least conjecture that we are part of that purpose and have just enough freedom that conscience and responsibility may be part of the mix. They may even be the reason that pain and suffering are present in the world. The universe might actually be comprehensible. Taking Johannes Kepler as his guide, Gingerich argues that an individual can be both a creative scientist and a believer in divine design – that indeed the very motivation for scientific research can derive from a desire to trace God's handiwork (*www.amazon.co.uk* accessed 21 August 2006).

Such questions are an essential area of inquiry for the Cultural Astronomer. Neville Brown (2006) has also recently inquired into issues arising from the interface between astronomy and faith. In an atmosphere such as that in the USA, in which Christian evangelicals use of Intelligent Design is used to promote Creationist cosmology, work such as Gingerich's is potentially seriously damaging for the anti-Creationist case. The inquiry then into the religious culture of astronomers, whether Creationist, atheist or in-between is one which we have touched on at Bath Spa, but a full inquiry has been left for the future.

While there is a strong historical component in the Bath Spa MA, in the traditional sense of examining past cultures mainly through literary research, the contemporary elements of the course have drawn on current developments in oral history, but more

Fig. 1 Dr Tim Slater (left) and Dr Nick Campion (right)

Fig. 2 Mary Wehunt, Bath Spa University graduate (left) and Wendy Slater (right)

so, on the basis of influences from the study of religions, current developments in sociology and anthropology (see for example, Bryman 2001, Silverman 1997), especially work of relevance for the investigation of contemporary astrology (Greenwood 2000). We have, for example, placed a strong emphasis on grounded theory, in which theory arises out of data, instead of, as all too often, data being arranged to suit theory (Glaser 1978, Glaser and Strauss 1967).

In particular phenomenological perspectives have been influential (see for example Ferguson 2006, Sokolowski 2000). The phenomenological approach may be simply defined as one 'in which differing belief systems are examined as perceived in their own terms, rather than by adopting a reductionist stance' (Caird and Law 1982: 153). As I developed the idea within the context of Cultural Astronomy, the assumption is that the scholar can never be divorced from the scholarly process. Phenomenological principles were first set out in 1913 by Edmund Husserl who argued that it was essential that all inquiries into any area of human endeavour touching on consciousness paid due respect to the 'I' (Husserl 1972: 7), the individual's subjective experience, rather than attempt to explain it away or reduce it to quantitative measurement. This doesn't mean that subjectivity undermines rigor. Quite the reverse, the scholar can no longer pretend that their own conditioning, bias and unconscious responses, have no impact on their inquiry. Phenomenology was imported into religious studies by Ninian Smart in the 1970s. He had realized that the entire field had been distorted by the privileged position afforded to Christianity and the subsequent misunderstandings that were imposed on other religions (Smart 1973). The simple aim is the 'qualitative understanding of the forms of life of a religious tradition from that tradition's standpoint' (Twiss and Conser 1992: 27). Over the course of the twentieth century Phenomenology has diversified into different forms. It can suggest that there is an underlying essence underpinning the material world, and in this sense is itself Platonic. However, Post-modern perspectives, including the understanding of narratives, discourse and text, have also come into play. These approaches are particularly appropriate in view of Babylonian notions of astrology as the gods' writing in the sky, Biblical belief in celestial signs and modern claims that astrology is a symbolic language (see Best and Kellner 1991, Jencks 1992). Postmodernity rejects metanarratives, universal explanations and so can not accept Phenomenology's assumption of an essential order. Instead I took three ideas from Phenomenology. First, and very importantly if one is examining astrology, UFO cults, New Age ideas or any other contemporary idea which is often subject to ridicule, one needs to adopt a position best defined as methodological neutrality, the purpose being to penetrate and understand the cultural phenomenon under investigation. There are substantial political issues to be aware of in this regard, which are often highly complex and nuanced. For example, a western astronomer who may be angry at, or contemptuous of, western astrology, would probably not dare express the same sentiments regarding, say Native American cosmology or sub-Saharan celestial divination. It is sometimes more difficult to look dispassionately at one's own culture, even more so at one's self. The second idea I took from Phenomenology, one that many would say lies at the heart of all academically sound qualitative research, is reflexivity; the researcher needs to be constantly aware of his or her own position in order to avoid projecting assumptions on to other people, and listen clearly (see for example Davies 1999). An understanding of insider-outsider questions is essential (McCutcheon 1999). A researcher who is interviewing a creationist on Biblical cosmology, or a channeller who communicates with beings on the Pleiades has to be able to listen clearly and non-judgmentally. Again, issues of truth or validity are less important than understanding the cultural phenomenon.

The third idea I borrowed from Phenomenology was the notion that one should attempt to place one's self inside the phenomenon. Again, I turn to Clive Ruggles who argued that, 'by walking in the modern landscape we can try to appreciate patterns of relationship between monuments and the topographic elements of the landscape as experienced by people living in that landscape in prehistoric times' (Ruggles 1999: 151). He conceded that we can never exactly know that we experience the same feelings when watching an especially bright full moon as did a prehistoric observer, but he does argue that 'the idea deserves serious consideration in contextual interpretations'. The idea is a radical one: at what point does the scholar require a genuine experience of what is being studied. This is a problem which has plagued anthropologists who realized, during the course of the twentieth century, that they could not understand the beliefs and practices they were studying unless they participated. But how far should that participation go (see Evans-Pritchard 1967). Indeed, how far can it go if the anthropologist comes from an alien culture? But the question needs to be asked whether one can truly understand astronomy's cultural impact if one has never had the experience of numinous awe at the sight of a brilliant night sky. Recently Patrick Curry suggested that it is impossible to understand the history of astrology unless one has not just studied astrology, which has been part of the medieval and Renaissance history of astrology at London University's Warburg Institute, but had an experience of it working (Curry 2005). Similarly, on the experience of the solstice at Stonehenge, Ed Krupp wrote

> One should make a point of being there. Celestial events take place in context. When you see what actually happens in the landscape, you learn a great deal more about it. It is, of course, possible to determine the alignment of a building with instruments, but nuances of light and shadow details of the horizon, difficulties in practical observation, and many more subjective aspects of a site can only be appreciated in person (cited in Ruggles 1999: 151).

Can such approaches be genuinely helpful? I have made the argument that they can elsewhere (Campion 2005b). Standard views of the origins of astronomy dwell on the supposed superstitious fear and insecurity of Stone Age people. A typical example is from Pannekoek's *A History of Astronomy*. Talking of a hypothetical cave-dweller, he wrote,

> To maintain himself he had to fight for his existence incessantly against the hostile forces of nature. The struggle for life occupied his thoughts and feelings entirely, and in this struggle he had to acquire such knowledge of the natural phenomena as influenced his life and determined his work; the better he knew them, the more secure his life became (1961: 19).

However, if we actually ask what modern astronomers – or anyone who is moved by the sight of a brilliant full moon or bright starry sky – experience, it may be astonishment, wonder, delight, inspiration, enlightenment and pleasure. This is also a question I have begun to explore elsewhere (Campion, 2005a, 2006). As Peter Haworth pointed out in 2001, 'How do most people react to seeing a star-studded night sky? With startled surprise' (2001: 10). But all such experiences are embodied and a self-reflexive phenomenological approach might reveal a quickening of the pulse, a feeling of physical elation. So, did Stone Age people feel the same? Is Pannekoek's view, though typical, fanciful? Can we, as Ed Krupp suggested, project our present experience back to the past, using ourselves and our own experience as historical data? This, at least, is one question which we raised at Bath Spa University.

The study of Cultural Astronomy is in its infancy but there are now sufficient scholars involved to generate increasing awareness and understanding of the complexities and importance of social and cultural relationships with the stars. As more scholars become involved in the discipline, or subject area, issues of syllabus and curriculum development will become more important. Chief among these developments should be a new international focus, with scholars from Africa, the Far East, South Asia and the Americas involved in seminars, conferences and teaching. I hope that the Sophia Centre and the University of Wales, Lampeter, can help facilitate such developments.

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Evidence of Ancient African Beliefs in Celestial Bodies

Felix A. Chami

Introduction

This paper aims to present some evidence which suggests that ancient Africans believed that the celestial bodies, mainly the sun and the moon, were gods (for conspectus see Chami 2006). Such evidence is not new to scholarship since in some parts of Africa, such as the Nile Valley and North Africa there are ancient records that clearly suggest so that God was represented by sun-discs with radiating rays (see Casson 1966; Bolliger et al. 2006: 330–331). It is when it pertains to Africa South of Sahara that such evidence becomes controversial (see Figs 1–6; Willcox 1972). It will be shown for instance that scholars object to ideas on rock paintings and in ancient records that points to Sub-Saharan Africa having a solastic religion or some knowledge of astronomy.

By the concept "ancient" I mean the period from 3000 BCE to 500 CE. In the early part of this period, 3000–1000 BCE, Egyptian Dynastic culture was operating linked with the Neolithic sub-Saharan Africa. In the later period, and particularly after 600 BCE some parts of Sub-Saharan Africa developed polities which were either trading or interacting with new non-African Egyptian powers such as Carthaginians/Phoenicians, Persians and Graeco-Romans. It should be noted at this juncture that from about 600 BCE Egypt was invaded by non-African forces from Asia and Europe. These new rulers assumed the powers of Pharaoh and like the previous African Pharaohs attempted to interact and trade with the rest of Africa. Records of such intercourses are discussed elsewhere (Chami 2006).

I should also present the focus of this paper at this onset. The paper wants to provide direct and circumstantial evidence which suggests that Africans of the ancient time revered some celestial bodies. This is more of religious matter than astronomy or astrology. Clive Ruggles (2005) has discussed these two concepts in detail. It will however be suggested that the ancient people of Sub-Saharan Africa had some astronomical knowledge of which some evidence exists in historical records. Astrological practice is also indicated.

Felix A. Chami
History/Archaeology Department, University of Dares Salam
E-mail: fchami@udsm.ac.tz

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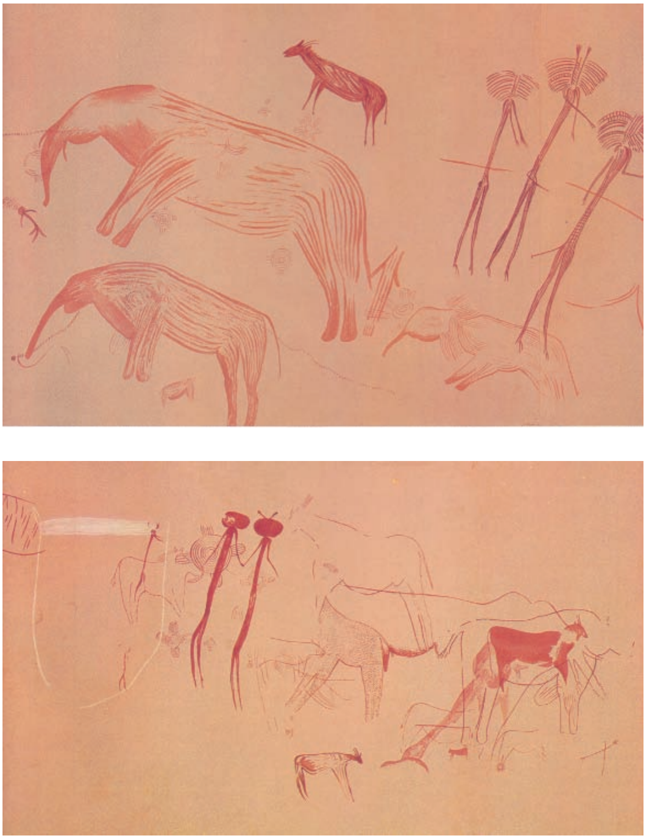

Fig. 1 Kondoa rock paintings with sun discs with rays. Top are rayed discs around elephants and below are human beings superimposed on a big disc (After Leakey 1983: 53)

In modern day ethnography the sun and moon have been used by Africans to regulate their monthly and annual activities sometimes more unconsciously than consciously. Probably the Musi of Ethiopia are presented as one example of African groups who are quite conscious of that aspect (Ruggles and Turton 2005). The Muslim communities of the Swahili people are another group known to have used the celestial bodies as calendar for religious, sailing and other economic purposes. The Mwaka Kogwa festival, termed by Chittick (1975:4) as Nairuz in order to link it with Persian festival, heralding the beginning of the New Year, is one of those activities related to calender. I participated in one of the festival in July 2007.

Problem

Africa south of Sahara has been viewed to have people without sophisticated religious belief system. Putting aside areas which had adopted Islam, the rest of Africa is mapped as belonging to animism (Getis et al. 2004: 258):

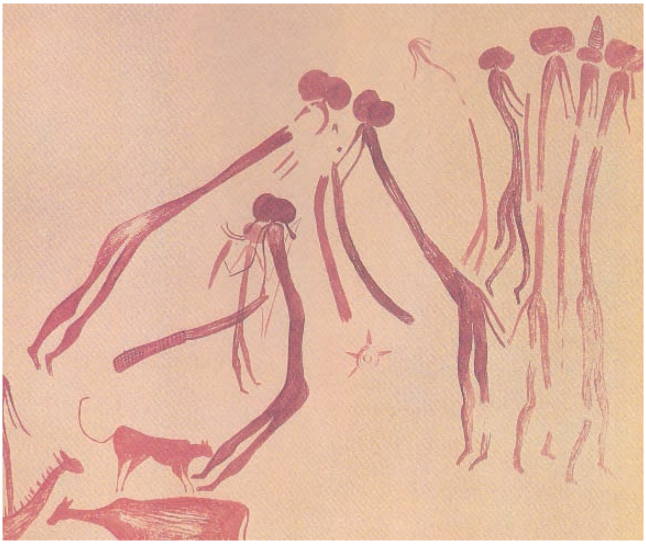

Fig. 2 Kondoa rock paintings with sun with rays at the middle space (After Leakey 1983: 59)

> Animism is the name given to their belief that life exists in all objects, from rocks and trees to lakes and mountains, or that such objects are the abode of the dead, of spirits, and of gods.

It should be noted at this juncture that a belief in one god who cuts across traditions is conceptualized as universalizing religion (Getis et al. 2004: 257). So the Egyptian belief in Amun Ra, which became a hidden god with the rays of the sun (Casson 1966: 74), was accepted as a universalizing religion, believed beyond the borders of Egypt to the rest of Africa, Asia and Europe (Casson 1966: 74) and probably elsewhere (see Jairazbhoy 1974).

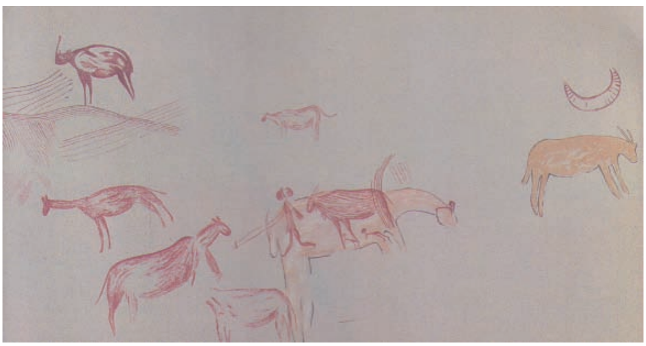

Fig. 3 Kondoa rock paintings with the moon crescent or sun eclipse crescent (After Leakey 1983: 63)

Fig. 4 Muleba, Lake Victoria paintings with sun and rays at the upper middle space (Photo by the Author)

Whether linked to Egypt or not, Eastern and Southern Africa was recognized by some scholars before 1970 to have had a belief in the sun-god. The region has a widespread painting/engraving of sun/moon discs. Collinson (1970) studied such a phenomenon on western Tanzania and compared them with those found in central Tanzania and southern Africa. He argued that:

> The worship of cosmic bodies has probably had the widest following of any religious cult in the world. Africa has been no exception, where the sun has been thought of extensively as the source of life, or high god, and where there is often a directional symbolism incorporating the movement through life, from birth to death, in a process from east, the point of the sun to west, the point of the moon and death. (Collinson 1970: 60).

However, this view, which is well entrenched in the work of Mary Leakey (1983), is refused by some scholars. They view the widespread painted and engraved circles as childish work or doodling.

Fig. 5 Mawe Matatn (tree stones) at Kiwangwa, Bagamoyo in Tanzania revered by the local people

Fig. 6 Muleba, Lake Victoria paintings showing stars (Photo by the Author)

> Collinson accuses me of rejecting diffusion as the explanation of the similarity of the circle-based designs found as far apart as Patagonia, Ireland and South Africa, without my suggesting another explanation. But I did suggest another, which has been ignored, that Jung's theory of archetypes is correct at least in the respect that certain forms rise spontaneously and universally from the unconscious mind, and that one of these is the mandala-the circular design. (Willcox 1972:168).

This paper is in support of Collinson's diffussionist idea as already elucidated elsewhere (Chami 2007). The sun god religion and other beliefs in celestial bodies had existed in Africa for several millennia. Egyptians have a record of it from about 3000 BCE suggesting that it must have been in Africa or spread from there to other continents by then or before (Jairazbhoy 1974)

Some More Evidence

As noted earlier, most of the evidence I discuss below is not new. Only that a new perspective has to be thrown on it countering the recent developments which tend to deny ancient belief in sun-god in Africa.

Megalithic Sites

One aspect which is universally accepted as evidence of sun-god worship is the ancient practise of erecting stones, sometimes in circles, in the position where the sun or the moon was probably worshipped or properly observed. As Ruggles (2005) has already presented about this, the stone circles are sometimes associated with burial places. These appear in good numbers in western Sahara (see Africa 2009: 20).

In Africa south of Sahara only one place is known and other possible sites remain to be discovered or confirmed. The site is Namoratunga stone circles in Turkana region of Kenya studied by Lynch and Robbins (1978). The stones were described to have had astronomical alignment and among other aspects associated included burials and geometric rock engravings. The stones were not regarded as a worshipping place, but to calculate the annual calendar (see Soper 1982).

The denial that this site had nothing at all to do with celestial bodies either in worshipping or calendar was raised by Soper (1982). He argued that the astronomical function raised by Lynch was based on "faulty survey data and must be rejected" (Soper 1982: 156). Most stones measured by Soper were found not to have any alignment to stars. Lynch (See Soper 1982: 168) rebutted arguing that while he could have been wrong in some aspects raised by Soper he keeps to his position:

> At this point I am not prepared completely to reject the calendric reckoning hypothesis... although I will agree that their argument is weakened by the non-alignment of two stones (Lynch and Sopher 1982: 158).

The circles are thought to date to late pre-Christian era extending probably to early Christian era. You need to add the more recent work by Doyle and Frank which remeasures the stones and shows the alignments (1997).

Another region with a number of megalithic sites stone circles is that of Bouar of western Central African Republic. The monuments are identified as Tazunu. "Today most monuments appear as low earthen mounds littered with granite blocks and slabs of various sizes, very few of which are more or less erect." (David 1982: 43). The purpose of these monuments is unknown and astronomy is not hypothesized by Nicholas David (1982). However, given the popular scholarly conception of associating megalithic sites with sun-god religion I would not hesitate driving such an hypothesis here. The date of the Central African monuments is like those from other parts of the world of Late Stone Age with pottery. David has dates ranging from the 7th century to the 6th century BCE.

It is likely that Africa has several other megalithic features which are either man-made or non-man-made used for purpose of worshipping. By non-man-made structures I mean a natural occurrence of arranged stones erected towards stars or just standing or creating a passages or shadows as one of the example below suggests. Johnson Urama (this volume) presents about one man-made site in Nigeria used to worship sun-god. One nom-man-made site also exists at Kiwangwa, in the hinterland of Bagamoyo, Tanzania with several standing megaliths which could have occurred naturally due to gully erosion which is associated with an escarpment. The residents revere the place which they identify as *mawe matatu* (three stones) (see Fig. 5) and it is not clear how long these stones have existed in the area. The stones are however in an archaeological site with aceramic Late Stone Age materials. One charcoal sample was collected and dated back to 10,000 BP. (see Chami 1996). This date is probably too early for an aceramic site, although not impossible. Sites with such dates have been accepted in Turkana, Kenya (Barthelme 1985) and Far-east Asia (Yasuda 2002). However more work is needed in the Bagamoyo site to collect more dating materials.

Sites with Drawings of the Celestial Bodies

It was suggested earlier that paintings/engravings of sun-like discs are widespread in Eastern and Southern Africa (Willcox 1984: 242–243). Most discs have rays suggesting the sun or moon. It was shown earlier that Willcox who presents the majority of these discs does not belief that these were made to represent the sun or the moon. But other scholars such as Collinson (1970) and Leakey (1983) view them that way.

However, it is my opinion that not all drawn discs or circles with inside marks would represent sun or moon. It has been noted that the Schematic/Geometric/Amorphous (SGA) paintings/engravings of the region of Africa and elsewhere encompassed circular figures which like the accompanying drawings represented a type of script (see Fell 1975; Chami 2006). It seems that what Willcox (1984: 242) presents as petroglyphs of Redan include what would qualify as sun/moon symbols which appear in central Tanzania (Figs. 1 and 2). Collinson (1970) figures from Makalo in western Tanzania also represent suns. It is also very obvious that Leakey (1983: 63) (see Fig. 3) has a picture of the moon crescent or an eclipse of sun in which the sun is in crescent shape. The Lake Victoria region is abundant of SGA paintings. The paintings are rarely associated with figures which could be considered to be sun or moon. One such symbol has however been observed (Fig. 4). Many circles associated with SGA paintings either have internal divisions or are filled with dots (Fig. 5) suggesting literary symbols. At one place in Muleba star symbols (Fig. 5) appear clearly suggesting celestial bodies (Fig. 6).

The dates for the drawings of sun like discs and other circular figures in Africa remain controversial. However, a few dates can be presented here. Collinson (1970), also quoting Fosbrooke, argues that:

> It would seem safe to say that some of our Tanganyika paintings probably date back for thousands rather than hundreds of years. A claim to "thousands" can not be made for Makalo on the evidence available, but a correlation of these two writers' ideas when applied to Makalo suggests an age of a thousand or more years (Collinson 1970: 59)

It should be noted that most of Leakey's Kondoa drawings were painted with red colour. Leakey (1983: 124) proposed a date before 1500 BP for this kind of painting and beyond to 29,000 years ago. It is my opinion that the sun-god religion dates back to the Neolithic or before when it can be shown to be practiced in Egypt and the rest of North Africa by cultural groups which worshipped the sun-god. In the language of these cultural groups the etymon "t", which represented sun-god, is profuse in the names of the people, towns and physical features such as mountains. To reiterate what is published elsewhere (see Chami 2006) mountains of North Africa include Atlas, Tassili and Tibest, people such as Tuareg, Tibu, Atlantes and Atarantians and towns such as Tripoli and Tunis. I have suggested that "t" is profusely used in some parts of Africa suggesting the spread of it probably from North Africa in about 700 BE and afterwards.

It is actually appropriate to mention here the profuse use in Meso-America of "t" word in the same manner as Africa and in the same time period, from about 1000 BCE. One prominent example are the names of nearly all the Mesoamerican monumental settlements including Teotihuacan, Tenochtitlan (see more in Forte and Siliotti 1997: 265) and even in the names of people such as Aztec. Scholars such as Jairazbhoy (1974) have argued for the ancient spread of sun-god culture from Africa to Americas.

In Lake Victoria the dates from charcoal samples associated with ochre pencils used to paint/produce painting colour is between 500 BCE–200 CE. (Kwekason and Chami 2003). Phillipson (1976) dates similar paints to the same period.

Historical Records

There are few ancient records which suggest that Africa south of Sahara had communities which *either* venerated cosmic bodies or had a knowledge of them or what we could view as astrology. These documents were believed to not have referred to the region south of Sahara because of academic biases already discussed elsewhere (Chami 2006). Probably the earliest one was by Herodutus who narrated of Cambyses, the Persian King of Egypt, sending troops to the long living Ethiopians in about 525 BCE to look for the "table of the sun"-probably referring to a calendric device. Most scholars think the land of long lived Ethiopians to which the mission was sent was Nubia (Cary and Warmington 1963: 206; Adams 1984: 294). However, Herodutus clearly suggested that the concept Ethiopian stood for Black people of Africa and not to the modern Ethiopia. He also described the location of the Ethiopian territory in which the mission was sent in the following manner:

> After this Cambyses took counsel with himself and planned three expeditions, one way — and a third against the long-lived Ethiopians, who dwelt in that part of Libya which borders upon the Southern Sea (Rawlinson 1964: 218).

It is apparent that the part of Africa (Libya) that borders the Southern Sea would have been the region along the waters of Indian and Atlantic Oceans of Sub-Saharan Africa as indicated by Herodutus on his own map of the world (see Riad 1981: 196). For him the southern part of Africa had a semi-circular curvature with the Indian and Atlantic Oceans forming the Southern Sea.

In about 300 BCE, or a bit later, a number of Greeks seem to have visited the coast of East Africa and were aware of the location of the islands and interior. The documents discussing Panchea, the land visited, or the island of the sun are again not believed by scholars to be Eastern Africa. The documents themselves are not believed by scholars. Cary and Warmington (1963: 236) have classified those documents under the title: wonderlands and Utopias. Despite that entitlement the two authors would still speculate that the location of Panchea or the islands of that territory could have been on the Horn of Africa and Sokotra. These speculations have been countered by this author elsewhere suggesting that Panchea was in East Africa (Chami 2006).

According to Euhemerus in the land of Panchea there was near the temple of the priests the river with the name "water of the sun" (Oldfather 1961, Vol. 3: 219). And according to Iambulus, in the island of the sun, supposedly Panchea, the people "sung in honor of the gods hymns and spoken laudations, and especially in honor of the sun, after whom they name both the islands and themselves" (Oldfather 1963, Vol. 2: 81). Elsewhere the people of the island of the sun are reported to "give attention to every branch of learning and especially to astrology (Oldfather 1963, Vol. 2)". It should also be mentioned that the Pancheans are reported to have written from up to down or vertically. At the Namuratunga stone circles the erected stones are engraved with SGA symbols vertically. The dates given to the stone circles and that of Panchea is the same as noted earlier, 300 BCE or earlier.

Oral Traditions

In this volume some papers from Nigeria can offer some ethnographic and literacy works suggesting that Africa still has aspects of sun and moon worship. It is redundant to go through each ethnic group of sub-Saharan Africa for the sake of showing the obvious: that the sun is believed to have ruled and created the world. And, the moon has always been viewed as the sun's concert. The Chaga of Kilimanjaro still holds their sun-god-Iruwa as the highest god-Mungu. Pronounciation of their Mungu-Iruwa/Iriwa is reminiscence of the Egyptian Amung-ria. The Bible has been translated into Kichaga language among the Lutherans. The "God" in the Bible is directly translated as Iruwa-the sun-god of the Chaga people. This god is also seen to belong to water pools (see Chami 2006)

Conclusion

The purpose of this paper was to provide more evidence on the ancient African belief in deified celestial bodies and the possible use of celestial calendars and astrology. It has been demonstrated with a small data sample that such phenomenon existed in ancient times. It was shown that the larger part of Africa had already adopted a universalizing religion notwithstanding the degree of animism that may have continued to coexist with the new faith. Indeed until today both Christianity and Islam, the new universalizing religions, continue to coexist with traditional African belief systems forming a kind of syncretism.

For instance all caves on the islands of eastern Africa are worshipped by Muslims who believe that the caves or panga (belonging to god or spirit) are invested with ancestral sprit. They are either shrines or revered places. This is the same with ancestral shrines, water pools and forest grooves which are associated with either benevolent or malevolent spirits all over Christian and Muslim Africa. Most of what was raised above is probably already known, but not discussed before with contextualizing the problem. This paper is rather a reaction against denials raised in the problem section and ignorance of data.

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Astronomy of Nabta Playa

J. McKim Malville, Romauld Schild, Fred Wendorf and Robert Brenmer

Introduction

The Southwestern desert of Egypt, now one of the driest areas on the Earth, was not always so inhospitable. Beginning about 9000 BC the summer monsoon rains moved northward from central Africa and created a landscape where nomadic pastoralists with their cattle could survive (Wendorf et al. 1992–1993; Wendorf et al. 2001; Wendorf and Schild 1998; Schild and Wendorf 2004). Even with rains it was still a dry environment with an annual rainfall no more than 100–150 mm. Rain was unpredictable and the climate was punctuated with numerous droughts, some of which caused the desert to be abandoned for long periods of time. Game was scarce, consisting of small gazelles and hares. Cattle were walking larders of milk, blood, and meat, used in a manner similar to those of modern Masai. Cattle allowed people to live in the desert, thereby controlling their lives and dominating much of their ceremonialism.

Located 100 km west of Abu Simbel, Nabta Playa is a large internally drained basin. During the early Holocene (ca 9000–6100 BC), the playa was seasonally flooded attracting nomads to bring settle intermittently on its shores (Figure 1) The first settlements at Nabta were small seasonal camps of cattle-herding and ceramic-using people. These people probably came into the desert after the summer rains from either farther south or the adjacent Nile, in search of pasture for their cattle. Each fall, when the water in the playas dried up, they had to return to the Nile or to better watered areas in the south.

The depression of Nabta Playa was covered with potential fodder grasses following the summer rains and would have been a very attractive area for grazing by wild and domesticated animals. In addition to grasses and seeds of other plants. Boerhavia has edible seeds and leaves which are grazed today by sheep and goats. Seeds of Schouwia were also found at Nabta. That plant has palatable leaves for human consumption and is good fodder for cattle. Eating its leaves reduces the need

J. McKim Malville
University of Colorado, (303) 492-8766
E-mail: kim.malville@colorado.edu

J. Holbrook et al. (eds.), *African Cultural Astronomy – Current Archaeoastronomy and Ethnoastronomy Research in Africa.*

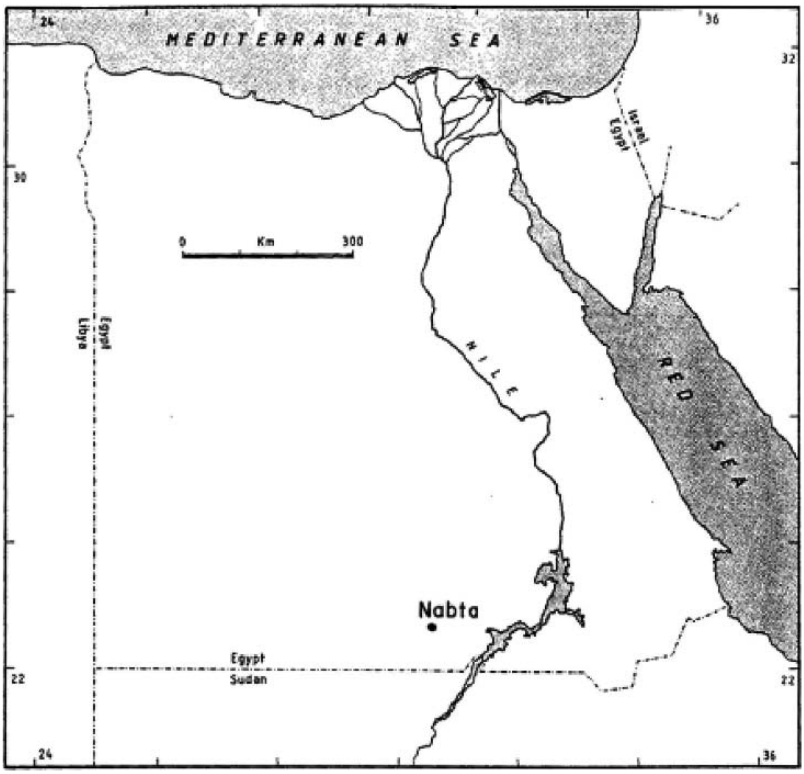

Fig. 1 Location of Nabta Playa

for water. Large stands of Schouwia often develop in depressions after monsoon rain, growing so high that camels can not be seen within them. Animals could also feed upon parts of shrubs and trees such as Acacia (Wasylikowa 2001).

By 7000 BC settlements became larger, and their inhabitants survived in the desert throughout the year by digging large deep wells. They lived in organized villages consisting of small huts arranged in straight lines. By 6800 BC they began to make local pottery. A few hundred years later around 6100 BC sheep and goats appear for the first time, which were almost certainly introduced from southwest Asia.

Ceremonial Center

Nabta probably began to function as a regional ceremonial center during the Middle Neolithic (6100–5500 BC) during the summer wet season. By a regional ceremonial center we mean a place where related but geographically separated people gather periodically to conduct ceremonies and to reaffirm their social and political identity. The center at Nabta gives evidence of a complex ideology, centered on themes of death, earth, water, skies, and cattle. These gatherings occurred along a dune on the northwestern shore of the basin where there are hundreds of hearths, extensive cultural debris, and many bones of cattle. While present at most other sites, bones of cattle are elsewhere never very numerous, which is good evidence that they were kept primarily for their milk and blood, rather than for meat. This pattern resembles the role of cattle among modern African pastoralists, such as the Masai, for whom cattle represent wealth and political power. They are rarely killed except on important ceremonial or social occasions such as death of a leader or marriage.

Following a major drought which drove earlier groups from the desert, the Late Neolithic began around 5500 BC with a new group that had a complex social system expressed in a degree of organization and control not previously seen. These new people, the Cattle Herders (also known as the Ru'at El Baqar people), appear to have been responsible for first establishing the ceremonial center at Nabta Playa. The newcomers had a complex social system that displayed a degree of organization and control not previously seen in Egypt. They sacrificed young cows and buried them in clay-lined and roofed chambers covered by rough stone tumuli and constructed many tumuli having both surface and subterranean features.

The Valley of Sacrifices and the Calendar Circle

Along the western rocky bank of a shallow valley entering Nabta Playa from the north, which we have called the Valley of Sacrifices, there are about ten identifiable mounds of broken sandstone blocks. These mounds contained offerings of large articulated pieces of butchered cattle, goats, and sheep. The largest and perhaps the oldest tumulus contained an entire young cow, the most precious offering that a herder can make, contained in an elaborate chamber covered by a tamarisk roof (Figure 2). A piece of wood from its roof yielded a radio carbon date of about 5500 years BC. Probably a female just entering adulthood, the animal, lying on its left side, was oriented approximately north-south, with its head in the west. This wadi brought water to the playa after the first rains at the beginning of summer, and thus would have been an appropriate spot to have performed cattle sacrifices, asking the gods for rain.

The wadi ends in a small a stone circle on top of a small sandy knoll (Malville et al. 1998; Applegate, 2001) (Figures 3, 4 & 5). The circle contains sets of upright, narrow slabs. Two pairs of slabs aim the eye approximately to the north and to the position of the rising sun at summer solstice, which would have been near the start of the rainy season. A radiocarbon date from a hearth adjacent to the circle yielded a date of around 4900 years BC. Its center contains six upright slabs arranged in two lines, for which the astronomical functions, if any, are not clear. One of our Bedouin workers reported that it was not uncommon in the desert to set similar stones the sand and watch their moving shadows as time keepers. Another well-known stone circle was discovered by Bagnold (1931) in the Libyan Desert. It is larger, 8.5 meters, but seems to be made up of the same kind of thin stone slabs as at Nabta. No evidence of astronomical orientations has been reported, and none is readily discernable in photographs of the circle.

Fig. 2 Skeleton of a Young Cow

The Complex Structures

To the south of the Valley of Sacrifices are a series of knolls carved in the ancient lake clays by the desert winds. The area contains several dozen complex megalithic structures built during the Final Neolithic by the Megalith Builders (Bunat El Asnam

Fig. 3 Calendar Circle

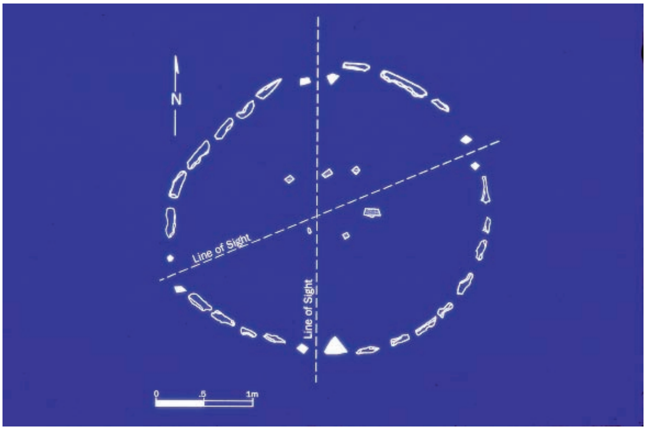

Fig. 4 Reconstruction of Calendar Circle

people). The Final Neolithic at Nabta Playa extended from 4600 BC to abandonment of the area in approximately 3400 BC. The complex structures are identifiable on the surface by groups of sandstone blocks, which were originally set in silt deposited during the final part of the Early Neolithic.

The groups of shaped sandstone blocks consist of megaliths ranging in weight from several tons to less than 50 kg (Schild and Wendorf 2004). A few upright, and other broken bases were found still embedded in the clays, suggest that originally the had been set up vertically, facing north. The dynamics of collapse involved the prevailing northerly winds that carved holes in front of the megaliths and caused their collapse. These depressions can be found underneath the collapsed large blocks, indicating that the individual stones generally faced north. Many are sculptured in a manner similar to the blocks of the alignments, with anthropomorphic shoulders

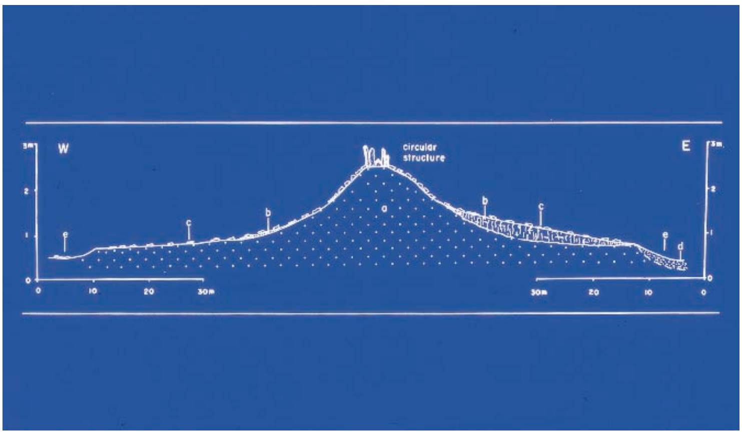

Fig. 5 Profile of Calendar Circle

suggesting that they represented the dead. Groups of these shaped stones may represent souls of departed members of clans or extended families.

The largest of the complex structures, A, appears to play a major role in the symbolism that overlies the ceremonial center in the Final Neolithic (Wendorf and Krolik 2001). We originally thought the structure might contain elite graves, but excavation has failed to disclose any human remains. It is the focus of the five radiating megalithic alignments. The builders of the structure had dug a pit through playa sediments to expose a table rock at a depth of 2.6 m. The rock is quartzitic sandstone that remained after the surrounding softer sediments had been removed by erosion. A similar rock was found under the second and the third complex structure that were excavated a fourth rock was located under a cluster of slabs by a probe. The table rocks were probably formed during the initial deflation of the Nabta basin by wind, long before the deposition of the playa sediments. In the case of Complex Structure A, the northern and western sides of the table rock were shaped and its top was probably worked and smoothed. After shaping the oval rock measured 3.3 m by 2.3 m with its long axis aligned north-south.

The pit was partially refilled and a large secondary stone, weighing 2–3 tons, was placed above the center of the table rock. This secondary stone was also slightly shaped with a large head-like projection facing slightly west of north. It was held upright by two large slabs set against the structure at its north end. One side had clearly been smoothed by pecking. The stone has a vague resemblance to a cow and may have represented a surrogate sacrifice. What is clear is that considerable effort was expended in quarrying the stone, shaping, transporting, and placing it on top of the table rock.

Alignments

After reanalysis of our previous measurements and a new campaign of mapping the sandstone blocks of the area, we identify five alignments of megaliths that radiate outward from Complex Structure A (Figures 6, 7 & 8). We also have likely dates for the placement of these stones in the sediments of the playa based on carbon dates from the nearby quarry. Approximately 100 m east of the quarry is a storage area where dozens of additional sandstone blocks are resting for use. Five radio carbon dates from the quarry are 4500 BC to 4200 BC. Since we also have a carbon date for complex structure E at 3600 BC, we estimate that the megalith period lasted for approximately 800–900 years from 4500 BC to 3600 BC. A closer inspection of the stones reveals most were worked, shaped into apparently anthropomorphic shapes, and many were set in the sand approximately facing north.

Our original measurements of the megaliths (Wendorf and Malville 2001) have been complemented by satellite imagery by the Quickbird satellite in 2002 and additional GPS measurements by Brophy and Rosen (2005). We are gratified that there is good agreement with regard to the locations of the megaliths by these independent measurements. In our analysis we combine the two sets of GPS data and the satellite results.

Fig. 6 Tilted megalith in northern alignment; tents of field camp in background

Alignments at Nabta Playa

For our calculations of precession we have used the formulae of Bretagon et al. (1997). Because of the movement of the dunes over 6–7 millennia, it is difficult to estimate the actual horizon, and we assume a level horizon. Many of the slabs are scattered and fragmented, and in estimating the dates when these alignments may have been oriented to certain stars, we include an uncertainty of $\pm 0.6^{\circ}$. While we had originally considered Dubhe, the brightest star in Ursa Major, to be a possible candidate for the three northernmost alignments, Arcturus now appears to be a much more likely choice during the period of megaliths (4500–3600 BC). It is the

Fig. 7 Top of buried megalith

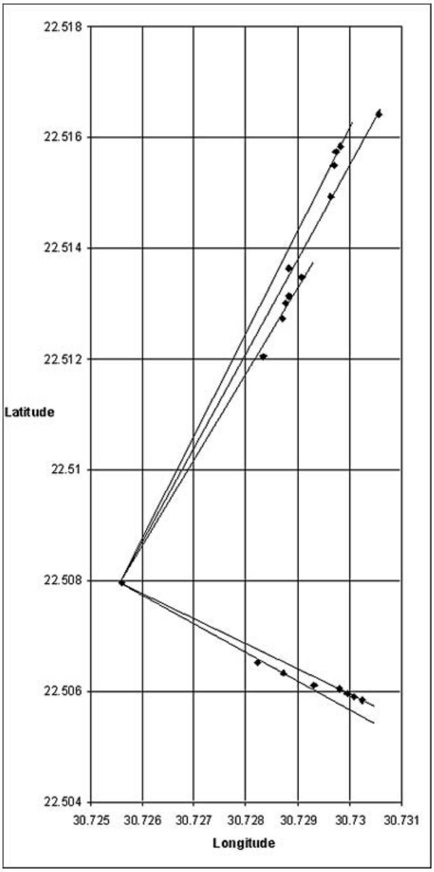

Fig. 8 Alignments at Nabta Playa

brightest star in northern celestial hemisphere, and there were three occasions when alignments A1, A2, and A3 were oriented to the rising positions that star in that span of time. Each of these three alignments may have been to account to the changing location of the star due to precession.

A fourth alignment, B1, would have lined up with Sirius, which is the brightest star in the night sky and α Centauri, which is the third brightest, in the period 4600–4300 BC. The final alignment, B2, may have been lined up with Alnilam in the belt of Orion between approximately 4400–4200 BC and/or with winter solstice sunrise. A close inspection of the southernmost alignment, which we had initially designated as C, indicates that it consists of stones resting on the slopes and tops of erosional silt hillocks and may not represent an original set of aligned slabs.

Stellar Associations of the Megalithic Alignments

With the exception of Canopus, these alignments might have been associated with the brightest stars in the night sky of Nabta. (Figure 9; Table 1) In 4500 BC Canopus

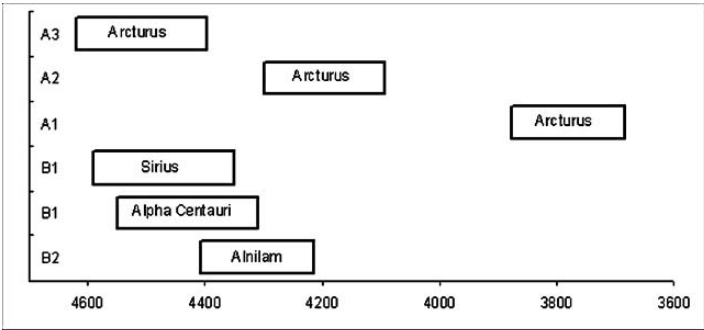

Fig. 9 Orientations of Alignments

would have risen with an azimuth of 159° and would have reached a maximum altitude of approximately 8° above the southern horizon. It is conceivable that the slight rotation of some of the megalithic slabs away from north-south was due to an attempted alignment with the rising position of that star. Another possible geometry of the site involves the approximate right angles between A3/B2 and A1/B1, which possibility has a certain credibility because of the interest the nomads in the cardinal directions.

In their analysis of the positions of the alignments Brophy and Rosen (2005) propose that the southernmost alignment, C, (which we consider to be problematic because of migration of the stones) was associated with Sirius in 6088 BC and that the other alignments are associated with Vega and stars of Orion in 6270 BC. Their suggested dates are about 1500 years earlier than our best estimates for the establishment of a ceremonial center. Brophy (2002) has also suggested that the table rock of Complex Structure A is a map of the Milky Way galaxy dating from 17,500 BC, showing spiral arms and a neighboring dwarf galaxy. He also proposed that the stones of the stone circle represent a map of the stars of Orion as early as 16,500 BC. These extremely early dates are not consistent with the archaeological record. Before about 9000 BC, the Saharan desert had no settlements beyond the Nile valley. With the arrival of monsoon rains, the hyper-arid desert was replaced by savannahs and occupied by nomadic pastoralists (Kuper and Kropelin 2006; Wendorf and Schild 2001). After about 5000 BC human settlements became well established, including the ceremonial center at Nabta Playa. There is no archaeological evidence whatsoever supporting the idea that a high culture was present in the Eastern Sahara as early as 17,000 BC. The likelihood of a culture interested in establishing the alignments in the playa in 6000 BC is also very slight. Inference in

Table 1 Orientations and Identification of the Alignments

Alignment	Azimuth(degrees)	
A3	26.3	Arcturus
A2	28.3	Arcturus
A1	30.6	Arcturus
B2	116.6	Alinlam Winter solstice
B1	120.1	Sirius α Centauri

archaeoastronomy must always be guided and informed by archaeology, especially when substantial field work has been performed in the region.

Prehistoric Herdsmen

Judging from the elaborate burials at the nearby cemeteries at Gebel Ramlah, the nomads associated with the ceremonial center were prosperous, healthy, possessing a strong aesthetic sense, and interested in preserving and honoring their dead (Kobusiewicz and Schild 2005). These cemeteries are some 20 km from Nabta Playa and are most likely part of the extended community that established the ceremonial center and alignments. Since it is a rare opportunity to learn about people associated with such an early ceremonial center, it seems worthwhile to describe these prehistoric herdsmen in some detail. The most reliable carbon dates are from bone collagen giving almost 4400 years BC. The cemeteries contained 67 individuals in both primary and secondary inhumations. Inspection of dental features indicates that there were two different populations of Mediterranean and sub-Saharan peoples represented in the cemeteries.

The exceptional wealth of grave goods is notable. Many were buried with ceramic pots, some of which were elaborately decorated. Vessels known as tulip beakers were apparently produced exclusively as grave goods and usually placed on the chest or near the head. They were accompanied by sets of cosmetic artifacts consisting of stone pallets, stones for grinding color-bearing minerals, and containers made of ivory, bovine horn, stone, or ceramic. Many of the graves contained large sheets of mica, more than 10 cm across and 1 cm thick. They must have been highly prized since they were frequently buried in the vicinity of the head. One sheet was shaped in the form a tilapia, a fish frequently encountered in the Nile. This is the oldest known sculpture to be discovered in Egypt.

This was a healthy and prosperous community. The lack of dental enamel hyperplasia, an indicator of growth disruption during early childhood, also indicates that children must have been healthy and well-fed. The tall stature of the burials suggests good health and nutrition. Secondary inhumations may have been of individuals who died while traveling. All 7 primary inhumations were in flexed position, oriented to west, facing south (Figure 10).

The cemeteries indicate that there was a keen interested in preserving the remains of the dead. There were two skulls in which some of the upper teeth were replanted in the lower jaw and vice versa. The forearm of one woman was found with four bracelets, which had been fastened to the skeleton. Other skulls were found with 18 teeth placed an eye socket and three placed in the nasal aperture. Many of the burials were sprinkled with large amounts of red hematite dust, which in many cultures is associated with blood, the life force, and high status.

An important conclusion we can draw from these burials, is that the people living near or visiting the playas of Gebel Ramlah and Nabta participated in a wide trading network, which could bring them into contact with ideas as well as trade goods. Their contacts stretched far as evidenced by a turquoise nose plug, of which the closest known source is 1000 km to the north on the Sinai Peninsula. Shells were

Fig. 10 Adult burial facing south

brought in from the Nile; mica came from the distant mountains along the seacoast; ivory came from elephants further south.

Each of the three cemeteries contains the graves of individuals who seem to have belonged to single clans. The individual graves that preserved anatomical order were of people who died at the settlement and were interred there. The secondary graves, in which the skeletons are co-mingled and incomplete, can be interpreted as burials of higher status individuals who died during the distant migrations of the herders. The bodies may have been transported throughout the grazing season until the nomads returned to the vicinity of the ceremonial center. Alternately, they may have been exposed to animals such as Catal Huyuk (Malville N.J. 2005) or buried and subsequently disinterred. The disarticulated remains were placed in the graves at Gebel Ramlah without preserving anatomical order (Kobusiewicz and Schild 2005). It was important to bury them in the clan cemetery at a site that was believed to be the center place for the culture.

Summary and Conclusions

The evidence for astronomical observations by these ancient herdsmen comes in three forms. The repetitive orientation of megaliths, human burials, and cattle burials toward the northern regions of the sky reveals a very early symbolic connection to the northern regions of the sky, and it is the most substantial evidence of astronomy. The groups of shaped stones facing north may have represented spirits of individuals who died either on the trail or locally. The second bit of evidence for astronomy is found in the stone circle with its two well-identified sightlines toward the north the positions of the rising sun at June solstice. Finally, the alignments of sandstone slabs, which are oriented to bright stars in the fifth and fourth millennium, suggest an even more careful attention to the heavens. The dates for possible associations with the brightest stars largely agree with the dates at the quarry and the cemetery.

Interest in the northern part of the heavens does indeed seem pervasive during the Final Neolithic at Nabta Playa and Gebel Ramlah, where we have found orientations to the north. The northern circumpolar region of the sky is that realm where stars never set and later in dynastic Egypt was identified as the realm of eternal life. Survival in the desert may have required an ability to navigate by the stars, as the nomads moved across the sea of sand without trails or major landmarks. There was no bright star at the north celestial pole at that time, but north could easily have been inferred from the circulation of stars around that region in the sky. On a flat northern horizon, the positions of the rising and setting of bright stars could have been marked by cairns and the midway position would have been north. North could have been established during the day by shadow casting of a vertical stick or gnomon.

The complex groups of slabs provide the greatest enigmas of Nabta Playa. Why the buried table rocks were chosen as the buried center piece and how they were located beneath the sands remain a puzzle. It seems unlikely that that the rocks had been found accidentally during excavation for wells, as these were in dunes at the edge of the playa and not in the playa sediments. Perhaps these large table rocks were revered, as in animistic traditions, for possessing supernatural forces or souls (Eliade, 1974). Unusual rocks have been viewed as sources of power and spirit throughout history, and these may have attracted attention earlier than the late Neolithic before they were submerged in the blowing sands. Their presence may have been part of the cultural memory of the community, and their location may have been revealed by slight mounds in the sand. In any case, this grouping of buried stones, water of the playa, human and cattle burials, the solstice sun, and stellar alignments appears to identify powerful and evocative symbols of these ancient herdsmen.

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Romans, Astronomy and the *Qibla*: Urban Form and Orientation of Islamic Cities of Tunisia

M. E. Bonine

This paper examines the role of the *qibla* (direction to Mecca) for the orientation and structure of traditional Islamic cities in Tunisia. First, the various ways in which the qibla direction may have been calculated in the medieval Islamic world are discussed. Then several of the principal Tunisian cities are examined to show the relationship between the qibla and urban structure, indicating in these cases that not only were astronomical phenomena perhaps significant, but also that the earlier extensive Roman presence may have had a profound effect on the Islamic settlement orientation – and, hence, the direction of the qibla as well.

The influence of the qibla for the orientation of religious architecture is due to the Qur'anic injunction for Muslims to face in prayer the Ka'ba, the cubic structure in Mecca that becomes a central focus in Islam. In most cases a mosque is a rectangular building which has one of its walls facing in the direction of Mecca, this being the qibla wall which contains the *mihrab* or prayer-niche that indicates this sacred direction for prayer. In some situations there may be internal skewing of the qibla wall – or even of the entire interior, although this pattern is not common. A number of mosques in Cairo, for instance, do have this characteristic and hence the street direction will not be aligned with any walls of the interior (Kessler, 1984). Also, when a church or other religious building is converted into a mosque there may be a new skewed qibla wall constructed within the existing structure – or in other instances, the wall closest to the perceived direction of the qibla might be used without any internal adjustment. When Mehmet II conquered the Byzantine capital of Constantinople in 1453, one of his first acts was to convert the great church of Hagia Sophia into a mosque. The mihrab within the existing building was established some 10 degrees south of the main axis of the church.

The usual situation, however, is that a rectangular mosque (or other Islamic building) will be surrounded by streets – and housing or other buildings – which are parallel with the axis of the mosque. Hence there will be a rectangular grid system which will be in the same orientation as the qibla. If the mosque were built first, as was often done in newly established Islamic cities, then the street pattern

M. E. Bonine
University of Arizona

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may have evolved around the structure, orthogonal to the qibla axis. In fact, a great many traditional Islamic cities in the Middle East and North Africa have a rather regular rectangular or orthogonal morphology. In some cases, as in Damascus, the Islamic city evolved upon an earlier Roman or Greco-Roman grid system. And even if there were a deterioration of the extremely regular grid (as shown in the classic study of Damascus by Sauvaget, 1934), the basic orthogonal system still remains. In other cases, as in many traditional Iranian cities supplied by *qanat*s, an orthogonal morphology results principally from rectangular irrigation and field systems, and the slope characteristics play the predominant role in the orientation of those systems (Bonine, 1979).

In many if not most traditional Islamic cities, the direction of the religious structures and the axis of the street systems – and hence the alignment of the cities – all correspond with one another. The significant problem, then, is to explain this relationship and, more importantly, what are the specific influences which determine these patterns and orientations? Do mosques determine the street patterns – or does topography determine street orientations and hence even the direction of the qibla and the alignment of the religious buildings? It is important to understand these relationships because the possibility that newly established Islamic cities were laid out in relation to the direction of Mecca is most significant. It would mean that Islam has played a major role in the actual layout of cities, and that a sacred direction and orientation was important in Islamic city planning. First, however, we need to examine briefly how the qibla was determined in medieval Islam.

The Sacred Direction in Medieval Islam

Within the last several decades David King, a scholar trained in mathematics, Islam, and the history of science and technology, has examined many Arabic manuscripts in order to explain how the qibla was determined by Muslim astronomers and mathematicians in the Medieval Islamic period (King, 1982, 1984, 1985, 1986, 1987, 1995, 1999). At least from the ninth century there were mathematical calculations using trigonometric formulae or geometric constructions for determining the qibla, using the great circle distance from a particular city to Mecca (Fig. 1). There were many astronomical handbooks with tables (*zije*s) which were modeled after Ptolemy's *Geography* and which contained sections on determining the qibla by specific mathematical procedures (King, 1985, 317). However, it appears that "the earliest Muslim qibla determinations were cartographic, in that they can all be derived by considering plane representations of the part of the terrestrial globe between the locality and Mecca" (King, 1986, 89). Such systems often treated the meridians as parallel straight lines as well as the parallels of latitude being parallel straight lines (Fig. 2). Also, it should be mentioned that from the fourteenth century onwards the compass was available for determining the qibla.

Yet, often the mathematically calculated qibla – or the use of a compass later – was not always followed, using instead some other method of determination. What is

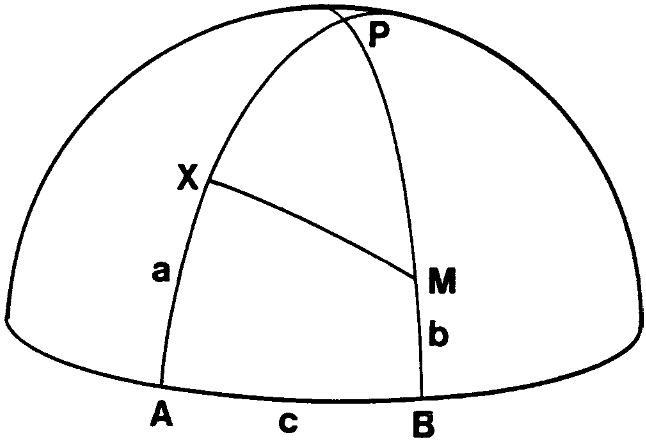


Fig. 1 The Mathematical Calculation for Determining the Qibla
Source: King, 1985, 317

surprising is that evidently there were often a number of accepted qiblas of different directions at the same locality – although these may reflect separate time periods as well. As King (1982, 304) asks, "Why are so many medieval mosques, according to modern historians of Islamic architecture, not properly aligned towards Mecca?"

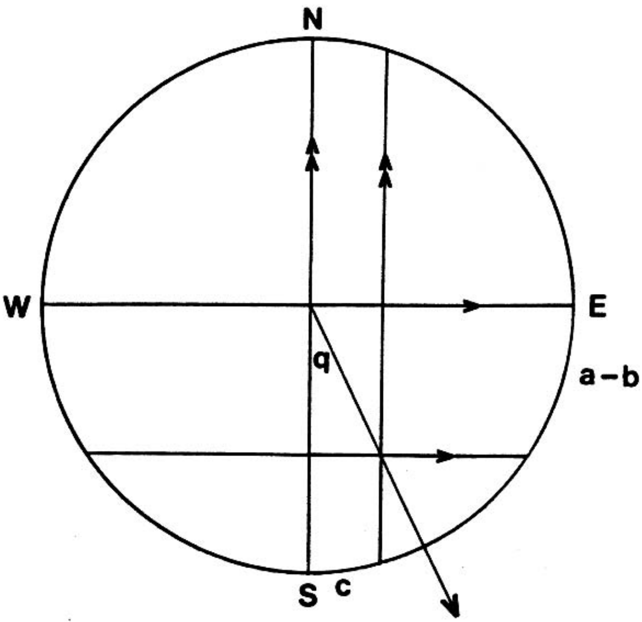


Fig. 2 The Geometric Calculation for Determining the Qibla
Source: King, 1985, 317

The orientation of the earliest mosques in Islam often emulated the practice of Muhammad as well as the Companions of the Prophet. Muhammad (and the Companions) had prayed directly south from Medina to Mecca. Hence, in Palestine and Syria the first qiblas also became due south. King (1985, 319), for example, notes that "in Jerusalem the Aqsa Mosque was built in the year 715 on the rectangular Temple area. Its mihrab was aligned with the major axis of the complex to face roughly due south. This direction was favored as the qibla in Jerusalem in later centuries even though the astronomers had calculated that according to the available geographical data the qibla in Jerusalem was about 45° east of south." Similarly, in Damascus where the Byzantine cathedral was aligned by cardinal directions (along with the grid pattern of the Greco-Roman city), when it was converted into a mosque the southern wall became the qibla wall and "the qibla of due south was favoured over the centuries in spite of the fact that the astronomers had calculated the qibla there at about 30° east of south (King, 1985, 319). Since churches were usually aligned in cardinal directions, when many of them were converted to mosques in Syria or Palestine they therefore already had a south-facing qibla wall.

In other parts of the early Islamic world, mosques were sometimes aligned in cardinal directions with the south wall being the qibla in much of the Middle East and North Africa. This cardinal orientation (with the qibla to the south), for example, occurred even in Islamic Spain, facilitated once again by converting cardinal-oriented churches to mosques. The fact that the eighth century Umayyad Caliphate of Spain had its original roots in Syria – with their qibla directly south – may have influenced a similar practice in the Iberian Peninsula. In areas to the northeast of the Arabian Peninsula, as in Central Asia and areas farther to the east, cardinal directions may also sometimes have constituted the main axes of the religious architecture – but, especially where influenced by the Hanafi legal school, the western side might well be the qibla wall.

However, many, if not most, mosques were not built in cardinal directions. The earliest mosque in Egypt, the Mosque of Amr in Fustat (the predecessor settlement south of the future Cairo), for instance, was built facing the winter sunrise [December 21st], while the earliest mosques in Iraq faced the winter sunset (King, 1985, 319). Both these directions remained popular for later mosque orientations, even after the mathematicians had calculated the "correct" great circle directions. Throughout the Islamic medieval world different orientations began to be used in different regions and even cities. As King (1985, 320) has noted, "the qibla in individual localities (became) defined in terms of an astronomical horizon phenomena, such as the rising or setting of a prominent star or of the sun at the equinoxes or solstices." At least in some of the popular folk astronomical texts, mention is made of even wind directions being used to determine the qibla. It should also be pointed out that according to some legal scholars, it was permissible to pray in any direction which would be within one's field of vision when facing the Ka'ba directly – which is slightly more than one quadrant (Ibid). During the Islamic Middle Ages various Muslim scholars also devised diagrams of the world divided into various sectors about the Ka'ba (Fig. 3a). In many of these schemes each sector was identified with

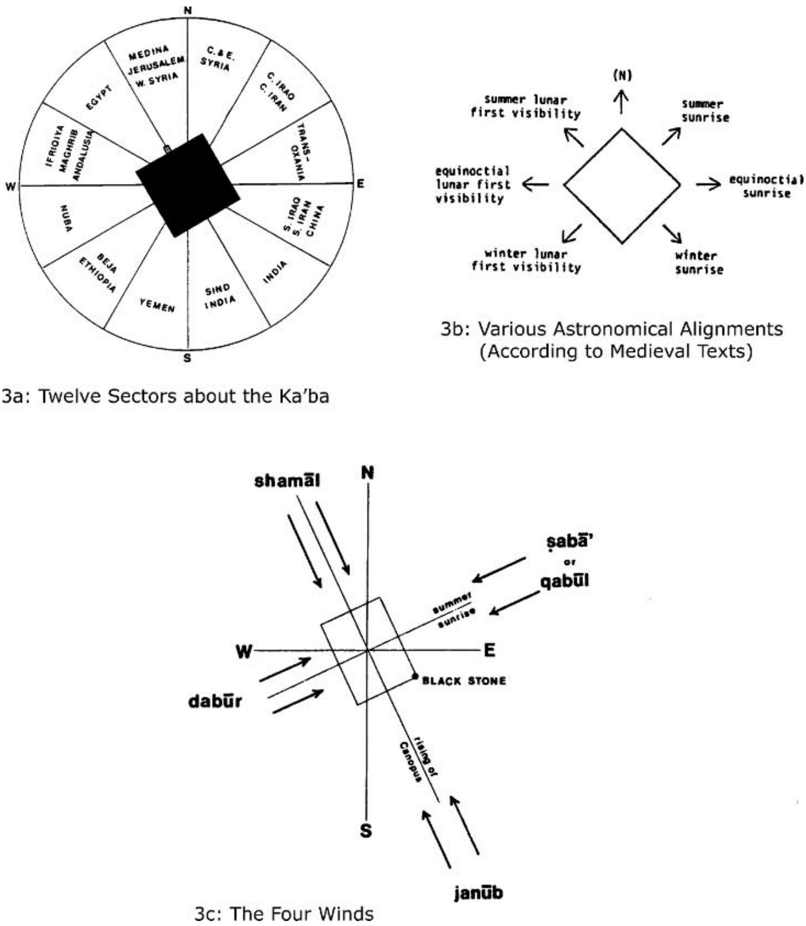


Fig. 3 The Orientation of the Ka'ba
Source: King, 1982, 307; 1985, 324; King and Hawkins, 1982, 105

specific rising or setting of prominent stars or star groups (e.g. the Pleiades), or in terms of the sunrise or sunset at the solstices, the cardinal directions, or specific winds (Ibid).

The orientation of the Ka'ba itself also has influenced the alignment of religious buildings in many parts of the Islamic world. This sacred cube, existing even in pre-Islamic times (but as a much simpler structure) is astronomically aligned at 30°S of E, the major axis facing not only winter sunrise but also the rising point of the star of Canopus (at least according to some Arabic texts (Fig. 3b). With such an orientation the minor axis points towards the rising point of the sun at midsummer. Certain lunar sightings at the solstices are also mentioned by the Arabic texts (Fig. 3b), although the accuracy of these astronomical determinations of the Ka'ba varies. And, according to folk astronomical traditions each of the four major winds also blow so that they strike one of the sides of the Ka'ba (Fig. 3c).

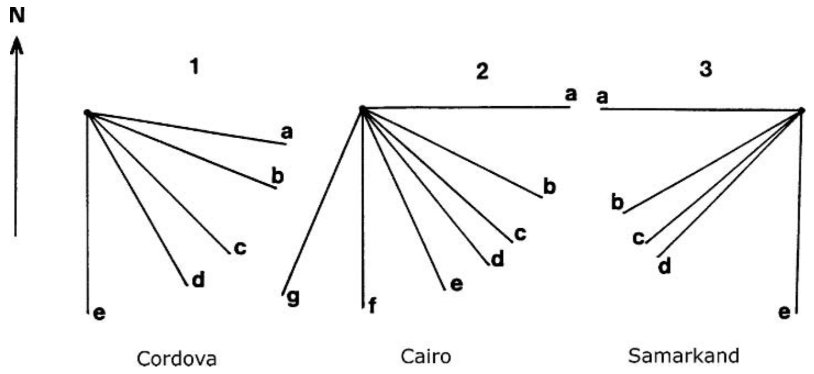


Fig. 4 Accepted Qiblas for Cordova, Cairo and Samarkand
Source: From Arabic Texts, in King, 1985, 325

The significance of the Ka'ba for the orientation of mosques is noted by Hawkins and King (1982, 102): "The *qibla* walls on some medieval mosques were intended to be "parallel" to one wall of the Ka'ba, this "parallelism" being achieved by facing the mosque towards the same astronomical horizon phenomena as one would be facing when standing in front of the appropriate wall of the Ka'ba." Therefore, alignments could be used to orient a mosque anywhere in the Islamic world in order for the building to have the same axes as the Ka'ba itself. Hence, the first Muslims "knew that, when facing a particular wall or corner of the Ka'ba in Mecca, one was facing a particular solar or stellar rising or setting point; they assumed that away from Mecca, if one faced in that same astronomical direction one would still be facing the same wall or corner of the Ka'ba" (King, 1982, 309–310).

There developed, therefore, during the Islamic medieval period a number of "accepted" qibla directions within most cities which were based upon either certain important astronomical directions or various other determinations. King (1985, 324–325) has examined, for example, the main qibla directions from certain Arabic texts for Cordova, Cairo and Samarkand (Fig. 4). In Cordova, according to a probable twelfth century work on the astrolabe, the qiblas were: a) the direction computed by the mathematicians using the standard formula based upon the latitude and longitude for Cordova and Mecca; b) the direction of winter sunrise; c) directly southeast; d) the direction of the Great Mosque of Cordova – being perpendicular to the northwest wall of the Ka'ba; and e) due south (taken from other texts).

In Cairo, according to the fifteenth century Arab historian al-Maqrizi, the qiblas were: a) due east b) the direction of winter sunrise – which was the qibla of the Companions of the Prophet in Cairo [i.e. based upon the Mosque of Amr in Fustat, built in 641–42]; c) the mathematicians' qibla computed by the standard formula; d) the orientation of the Mosque of Ibn Tulun; e & g) any direction between the rising and setting of the star of Canopus, including directly south (f). Finally, in Samarkand, according to the eleventh century legal scholar al-Bazdawi, the qiblas were: a) due west – used by the Hanafi legal school and corresponding to the direction in which the main road to Mecca left Samarkand; b) the direction of winter sunset – which was used for the Great Mosque; c) directly southwest; d) the mathematicians qibla computed by the standard formula; e) due south – used by the Shafi legal school (King, 1982).

Each major city, hence, often had a number of accepted qiblas, although it is probable that only certain directions (or even just one) were deemed "correct" during specific periods, or by certain individuals, such as the *ulema*. Over time, however, there would develop several standard ways to determine the qibla in a particular city (even if they were not necessarily all considered "correct"). But what was the correlation between the sacred direction – or various qiblas – and the alignment of the streets and the built form of the city? That is the subject of the next section.

The Qibla and City Structure

King (1982), besides examining many of the Arabic texts discussing the detmination of the qibla, also recognized that many Islamic cities had orthogonal street patterns and were laid out in one of the accepted qibla directions of a specific city. The mosques and other Islamic buildings would be oriented in these directions as well. For instance, the earliest section of Cairo was laid out in a more or less orthogonal system after 969, based upon the qibla of the Companions of the Prophet (which was about 27° south of east) – but which also was at a right angle to a major canal which linked the Nile to the Red Sea. However, the Fatimids favored the mathematically computed qibla of 37° south of east (= azimuth of 127°), and so most mosques, such as the Fatimid Mosque of al-Hakim and al-Azhar Mosque, became skewed about 10° to the city plan. In fact, the skewing of the religious buildings within a pre-existing street pattern in Cairo has led John Williams (1984, 39) to state "that in no other Islamic city were so many adjustments of monument to site necessary; it is one of the distinctive features of Cairo architecture."

In 1990 I published an article in *Muqarnas* in which I have reported on my survey of major cities in Morocco that examined the relationships between religious architecture orientation and the city structure, evaluating the role of the qibla as well as slope and topography in determining the alignment of streets and the city orientation. Morocco provided an excellent case for such a study because the region had a great number of cities which were newly established in early and medieval Islam. Equally significant, is the fact that many of the old medinas are still existing in Morocco.

The contemporary determination of the correct qibla is that it is the direction of the great circle route (i.e. the shortest distance) from each specific location to Mecca. In Morocco this ranges from an azimuth of 97 ° in the northern city of Tangier to 91° (i.e. almost directly east) in the southern city of Marrakesh. Yet, considering only the principal mosques and shrines of each city (usually the Jama' or Great Mosque [to use the translation of the commonly used French term, Grande Mosquée]) there are a great variety in the qibla directions (taken from compass readings by the author

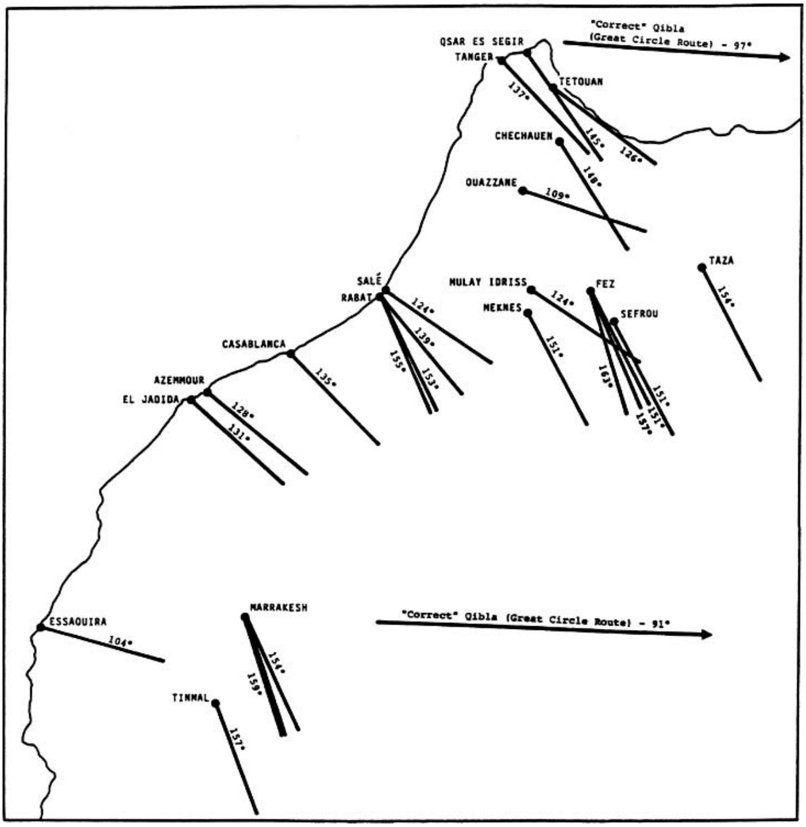


Fig. 5 Qiblas of Major Moroccan Religious Architecture
Source: Field Data, in Bonine, 1990

in the field and adjusted to true north), and, hence, the orientations of these religious building (Fig. 5). There is particularly a concentration of alignments in the mid-to-late 150°, which may be due to establishing a similar axis as the Ka'ba, as previously explained. Most of these alignments also belong to religious structures built during the Almohad dynasty in the twelfth century. Another cluster of readings occur in the 120° and 130°, and these may be based upon the mathematical calculations and tables of the astronomers, on the winter sunrise, or even simply a mid-point in the southwest quadrant. Only in the more recent Alawite period (mid-seventeenth century) do the directions begin to approach the contemporary "correct" readings of the great circle routes.

When the evidence for all the cities of Morocco are examined, it appears that the topography often was the predominant determinant of the street pattern and city structure. Streets (and housing) follow the slope, and if there is a change, even slight, in the gradient the morphology of the city is altered as well. Yet, a very significant finding about the city axes and street orientations in Morocco is that with the exception of the extremely hilly city of Fez, all of the medinas' main axes are in a roughly southwest – northeast alignment, instead of being in roughly in cardinal directions. When the predominant qiblas of the specific cities are examined, there is the close correspondence of the qiblas with the street patterns – and hence the main axes – in most cases. And, when the slope characteristics (where known) are considered, these are often the same direction. Examples of the southern part of Marrakesh (as well as the general axis of the entire city), Rabat, Salé, and particularly Taza, confirm this correlation (see Bonine, 1990, for details). One of my principal conclusions for the Moroccan cities was that perhaps slopes in the appropriate qibla direction(s) were being selected for the location of many of these medieval Islamic cities. The qibla, therefore, determined the street pattern and city axis in many of the traditional Moroccan medinas only if the slope conditions allowed.

Tunisia: Qayrawan, the Aghlabids and City Structure

In the year 670 Qayrawan was founded in what is present-day Tunisia by the Arab general, ‘Uqba ibn Nafi, the first Islamic city to be established in the conquest of Ifriqiyya – or what is called today the Maghreb or Northwest Africa. Similar to the other earliest Islamic settlements, such as Kufa, Basra, and Fustat, the mosque was the first building to be constructed. This Great Mosque of Qayrawan, still known as the Sidi ‘Uqba Mosque, was originally built of sun-dried bricks mixed with ashes and was extremely modest (Hill and Golvin, 1976, 91–92). It was rebuilt in 695 and then in the period of 724–743, during the reign of Caliph Hisham, it was enlarged to its present dimensions. Restored once again in 774, it was then completely demolished except for the minaret and mihrab, and rebuilt by 862 in its basic present plan and form (Fig. 6, Fig. 7) by the Aghlabid soverign, Ziyadat Allah (Hill and Golvin, 1976, 91–92).

It is perhaps possible that the Great Mosque of Qayrawan provided the model for the alignment of the other major mosques in this region – and that this axis influenced the orientation of the early Islamic cities of Tunisia. This might manifest itself particularly in the Aghlabid period (800–909), when in fact many of the other major Islamic Tunisian cities and Great Mosques were founded.

The axis of the Great Mosque of Qarawan is aligned at an azimuth of 147°. Since the currently accepted qibla (the great circle route) for the city of Qayrawan is 110°43’, the reason for the orientation of 147° must be explained – as will be detailed below. As already mentioned, the Great Mosque was rebuilt several times in its early history, even being completely demolished except for the mihrab and the base of the minaret. And even if there had been slight changes in the alignment (which may reflect why parts of the building seem not to be so perfectly rectangular – note Fig. 6), these early changes would appear to have been minor. The last major reconstruction was by the Aghlabids in the mid-ninth Century, and so we know that the axis of 147° was being used at least by that century. The fact that the Sidi ‘Uqba Mosque was the earliest mosque in the Maghreb perhaps would have given it special reverence, and, hence, that may have precluded any attempt to

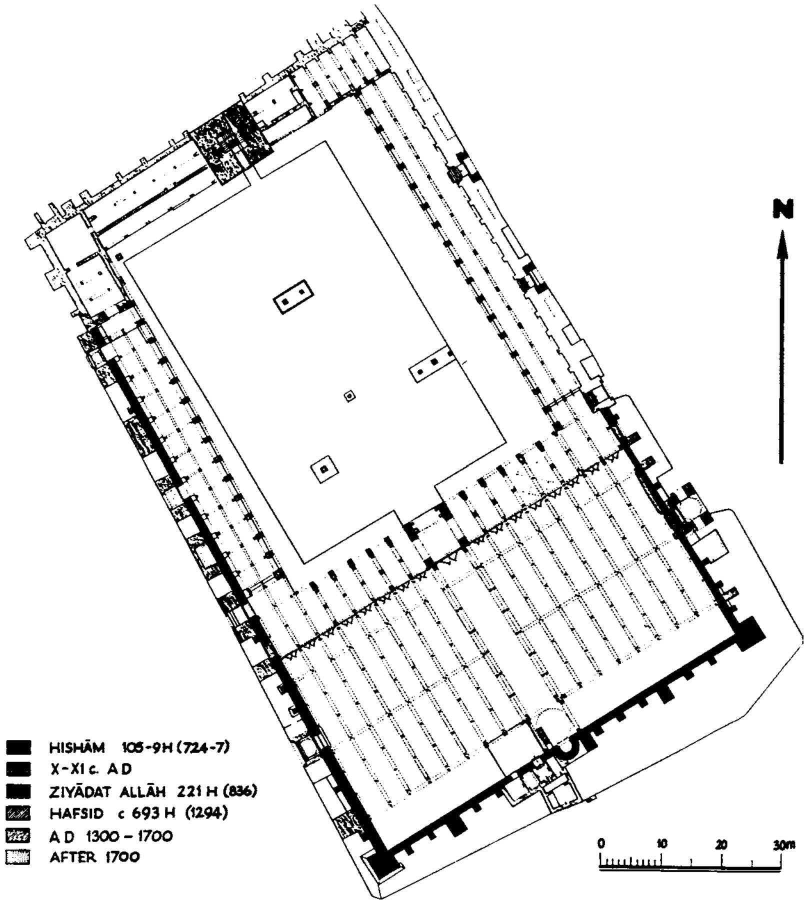


Fig. 6 Plan of the Great Mosque of Qayrawan
Source: Creswell and Allan, 1989, 318

change the qibla direction. However, even if there were a change in the qibla of the Great Mosque, we know that at least with the reconstruction by the Aghlabids that the qibla was 147°, and so it is feasible that this mosque in Qayrawan still might have served as the model for the orientation of other mosques in Tunisia.

The Aghlabids undertook a major program of urbanism, even founding a number of new cities in the ninth century. Most of the major mosques of Tunisia, in fact, date from this period – although in the case of Qayrawan, some mosques were reconstructions of buildings from earlier periods. For instance, the Great Mosques of Sfax, Monastir, and Sousse were founded and the Great Mosque of Tunis (and Qayrawan) were extensively rebuilt by the Aghlabids. As shown in Table 1 and Fig. 8, except for Sousse's qibla of 163°, the other four mosques' orientations are almost exactly the same as Qayrawan's qibla of 147°. This similar sacred direction appears to have continued to take precedence in the Tunisian region in later periods

Fig. 7 The Great Mosque of Qayrawan
Source: Photo by the Author

as well, as evidenced by the qibla of the Great Mosque of Mahdia (this mosque being built by the Fatimids in 916), and even Hammamet (the city and the Great Mosque being built in the fifteenth century).

Similar to the qibla's influence in Moroccan cities, the sacred direction to Mecca appears to be significant for the orientation of many of the traditional Tunisian cities. Yet, it is more difficult to analyze the Tunisian patterns because, unlike the Morocco study, detailed city plans, contour maps, and aerial photographs were not made available to the author. Nevertheless, some preliminary observations and conclusions can be made. Each of the major cities will be discussed in detail in the next section.

Qayrawan: Since the Great Mosque of Qayrawan has been postulated as the possible model for the direction of the qibla in the Tunisian region, this city must first be examined. Unfortunately, the medina of Qayrawan shows little close relationship to

Table 1 Qiblas of Great Mosques in Tunisia

City	Building	Period	Qibla	"Correct Qibla"
Qayrawan	Great Mosque (Sidi 'Uqba)	670/rebuilt by Aghlabids 862	147°	110°43'
Tunis	Great Mosque (Zaytuna)	Umayyada 732/rebuilt by Aghlabids 856–863	145°	112°37'
Sfax	Great Mosque	Aghlabids 849	147°	109°50'
Sousse	Great Mosque	Aghlabids 9th c.	163°	111°31'
Monastir	Great Mosque	Aghlabids 9th c.	147°	111°41'
Mahdia	Great Mosque	Fatimids 916/921	146°	111°28'
Hammamet	Great Mosque	Hafsids? 15th c.	147°	112°28'

Source: Qibla directions are azimuths taken with a Suunto optical reading compass in the field. Magnetic declination in Tunisia in summer 1985 was approximately 1° west of true north, and true north readings have been drived by subtracting 1° from the compass reading. Directions are expressed in azimuths from true north. The "correct" Qibla is the great circle route to Mecca.

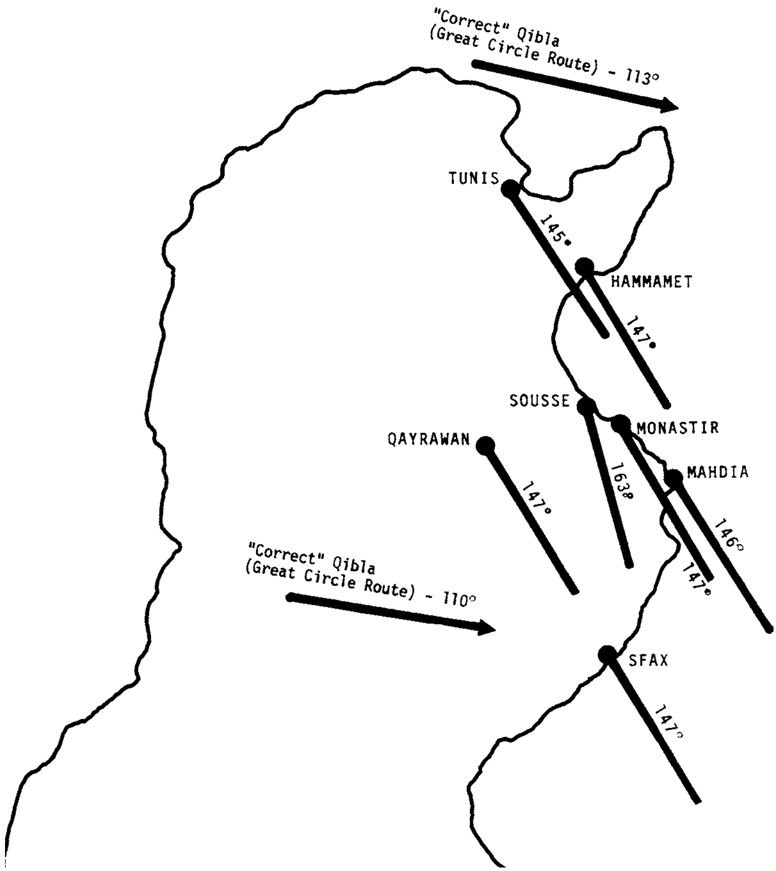


Fig. 8 Qiblas of Great Mosques in Tunisia
Source: Compass Readings in Field Survey by the Author, 1985

the orientation of the mosque (Fig. 9). The building is located at one end of the Old City and even though there are a number of major streets that are somewhat orthogonal to the axis of the mosque, a major section of the city also is oriented at about 45° to that structure. It is known that the Hillalian invasions of the eleventh century destroyed many cities in North Africa, and when "great towns such as Qayrawan were reduced to the status of villages" (Hutt, 1977, 19). It may be that a more orthogonal morphology and street pattern were lost at that time, or as Donati (1989, 42) has speculated, the city east of the mosque may have been swept away by the annual floods of the *wadi*s there. In any case, today there is little relationship of the orientation of the Great Mosque and the pattern of the urban structure in Qayrawan.

Tunis: The medina of Tunis shows considerably more correlation of the qibla with the orientation of the city. The Aghlabids built – or rebuilt – in 856–863 the Great Mosque in Tunis, known as the Zaytuna Mosque (Mosque of the Olive Tree), maybe upon the foundations of an earlier monument which probably was a church or a *ribat* (fortified convent or sanctuary). The Zaytuna Mosque has a qibla measured at 145°, although similar to the Qayrawan Great Mosque, parts of the structure also are not exactly rectangular to one another (Fig. 10), which means probably that in reconstructions there might have been some minor adjustments in alignment. However, in Tunis the major streets are parallel or at right angles to the main qibla of the Zaytuna Mosque, especially around the mosque itself (see Fig. 10). And, except for a few sections, the entire medina of Tunis is basically this same orientation (Fig. 11). The qibla of other religious buildings are basically aligned as well in the same direction as the Zaytuna Mosque – and as the orientation of the orthogonal street network. Such a pattern also means that there are many rather straight streets in the historic medina (Fig. 12).

Sfax: The city of Sfax presents one of the most intriguing cases. This medina and the Great Mosque were built in the ninth century by the Aghlabids. Although the Great Mosque was restored in the tenth and eleventh Centuries and reduced in size, it was enlarged again to its original size in the eighteenth century (Hill and Golvin, 1976, 106). The qibla of the Great Mosque is the familiar 147° and the orientation of the city is in the same direction (Fig. 13).

Fig. 9 Plan of the Medina of Qayrawan
Source: Jeridi, 1984, Frontispiece

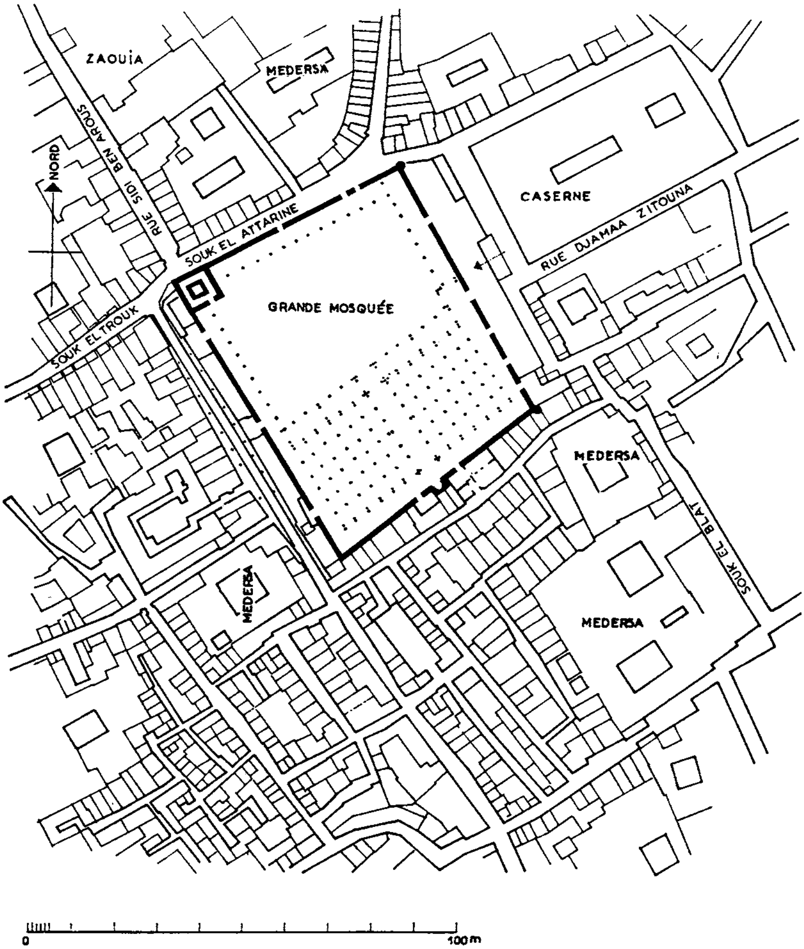


Fig. 10 The Great Mosque of Tunis in its Setting
Source: Lezine, 1971, 156

The rather extreme orthogonal street pattern of Sfax, in fact, is so regular (for an Islamic city), that some scholars assume that Islamic Sfax was built on the exact site of the Roman city of Tapurura (e.g. see Van der Meerschen, 1972, 6, 23). Although it is certainly known that Sfax is at least near that ancient Roman city, so far there has been no definitive archaeological evidence to verify absolutely that Sfax is built on the same location of that city.

However, the main axis of Sfax is the same – almost exact – direction as the qibla of its Great Mosque – which, as already stressed, is the same direction as the qiblas of the Great Mosques of Qayrawan, Tunis, and many other Tunisian cities. Although Sfax might have been built upon ancient Taparura because the ancient town (or its main avenues) just happened to be aligned exactly in that direction (of the qibla), this great coincidence still must be explained (see below). Was Islamic

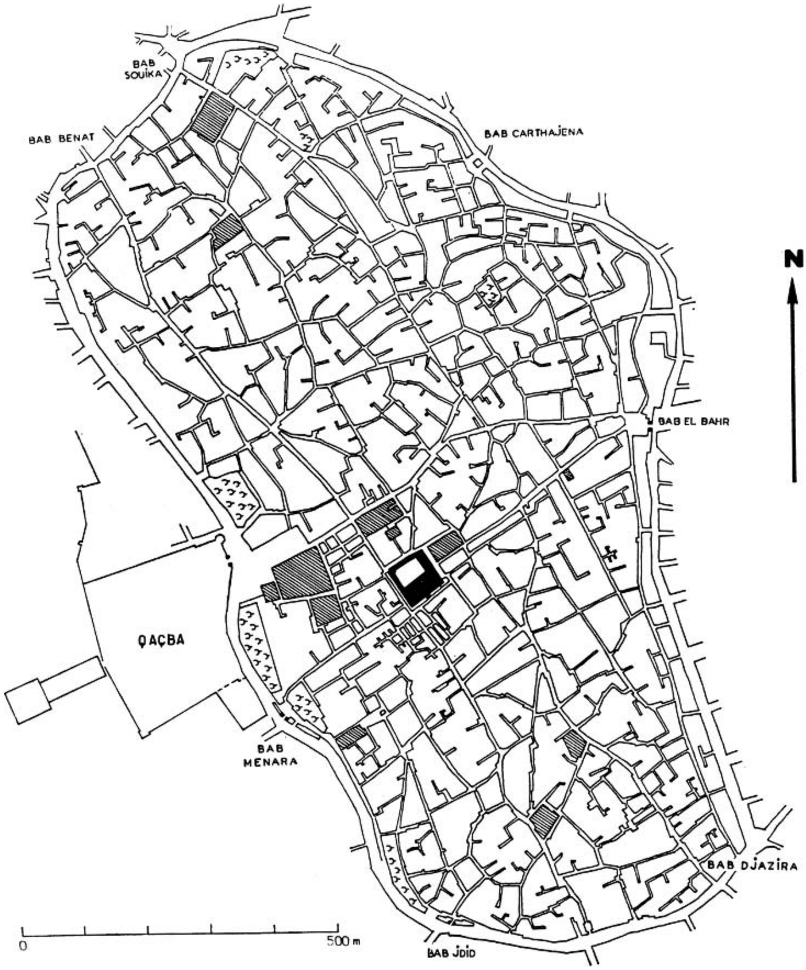


Fig. 11 Plan of the Medina of Tunis
Source: Lezine, 1971, 144

Sfax established anew by the Aghlabids as an Islamic city, and was the alignment of the orthogonal system of streets and housing determined by the accepted direction of the qibla – that direction which was first used or at least had become accepted by the Aghlabid period in Qayrawan? The fact that the topography of Sfax is quite flat would also lend itself to the evolution of a rather regular and orthogonal morphology and with many straight streets (Fig. 14), analogous to some of the cities in Morocco or Iran (Bonine, 1979, 1990).

Sousse: Although by the mid-ninth century Sousse was fortified and the Great Mosque built by the Alghabids, the town had long been an important port – of the Romans and then of the Byzantines. The qibla of Sousse's main mosque (163°) is the only Great Mosque (of those surveyed in Tunisia) which was not basically the same

Fig. 12 A Medina Street in Tunis
Source: Photo by the Author

direction as the Great Mosque of Qayrawan (i.e. 147°). Also, several other mosques and the small ribat in Sousse had qibla's of almost exactly south (180°), including one building (Bu Fatata) with a qibla of 188° – i.e. slightly towards the west!

Although a number of major streets in Sousse are approximately at a right angle to the Great Mosque, part of the city, and especially the southern section, is aligned almost north to south (or slightly to the southwest) (Fig. 15). The irregularity of the orientation of the smaller religious buildings in this case may have evolved in a pre-existing (Punic or Roman?) city structure, part of which was in cardinal directions. A somewhat irregular topography in Sousse, similar to the situation in Fez, also may have contributed to the irregularity in streets and qiblas – and, hence, in the building alignments (Fig. 16).

Monastir: Originally founded as a rabat in 796, Monastir was a Punic and Roman town earlier – although perhaps not at the exact same location. The Great Mosque was built next to the rabat in the ninth century by the Aghlabids. The qibla of the Great Mosque is, once again, the familiar 147°, and most of the other smaller mosques (and the rabat) were quite close to that direction as well. Although the relationship of qiblas and the street orientations were not examined in detail, the general street pattern of Monastir is rather orthogonal and mostly in the same alignment as the qibla of the Great Mosque(Fig. 17).

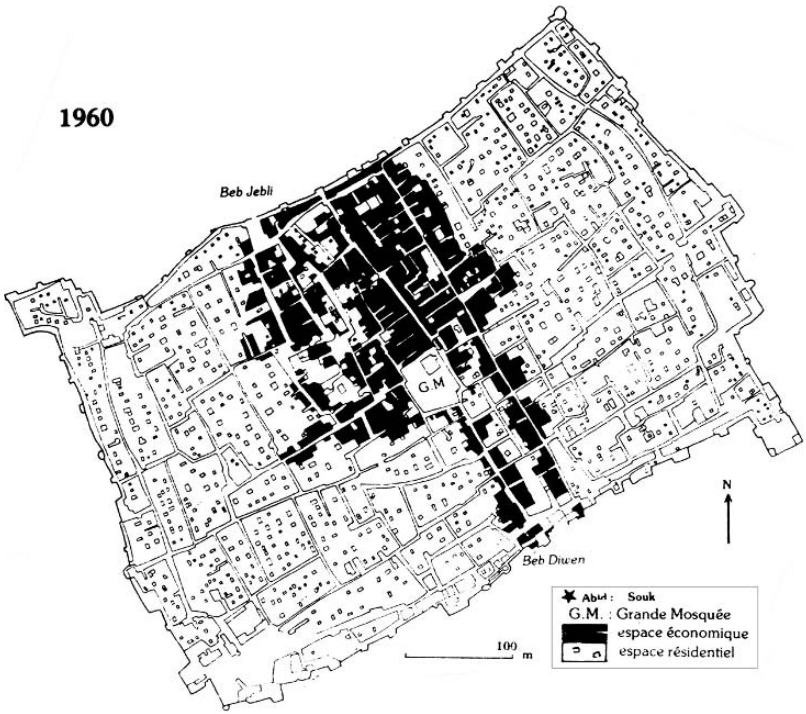


Fig. 13 Plan of the Medina of Sfax

Mahdia: Mahdia was founded in 913 by the Fatimid ruler ‘Ubaid Allah as the first major capital in North Africa. The Great Mosque (Fig. 18) was built in 916 and the qibla measured as 146°. The city was built on a small strategic peninsula which was fortified (and which had been used earlier by the Phoenicians and Romans). Although only in one corner of the peninsula, originally an avenue went from the mosque to several palaces (Fig. 19a). This is a natural axis along the peninsula, and so later streets and housing follow the same orientation (Fig. 19b). Although the streets are approximately at a right angle to the axis of the Great Mosque, it is more reasonable in this instance to see the pattern as perhaps a response to the orientation and topography of the peninsula (Fig. 19c) rather than as any influence of the alignment of the mosque.

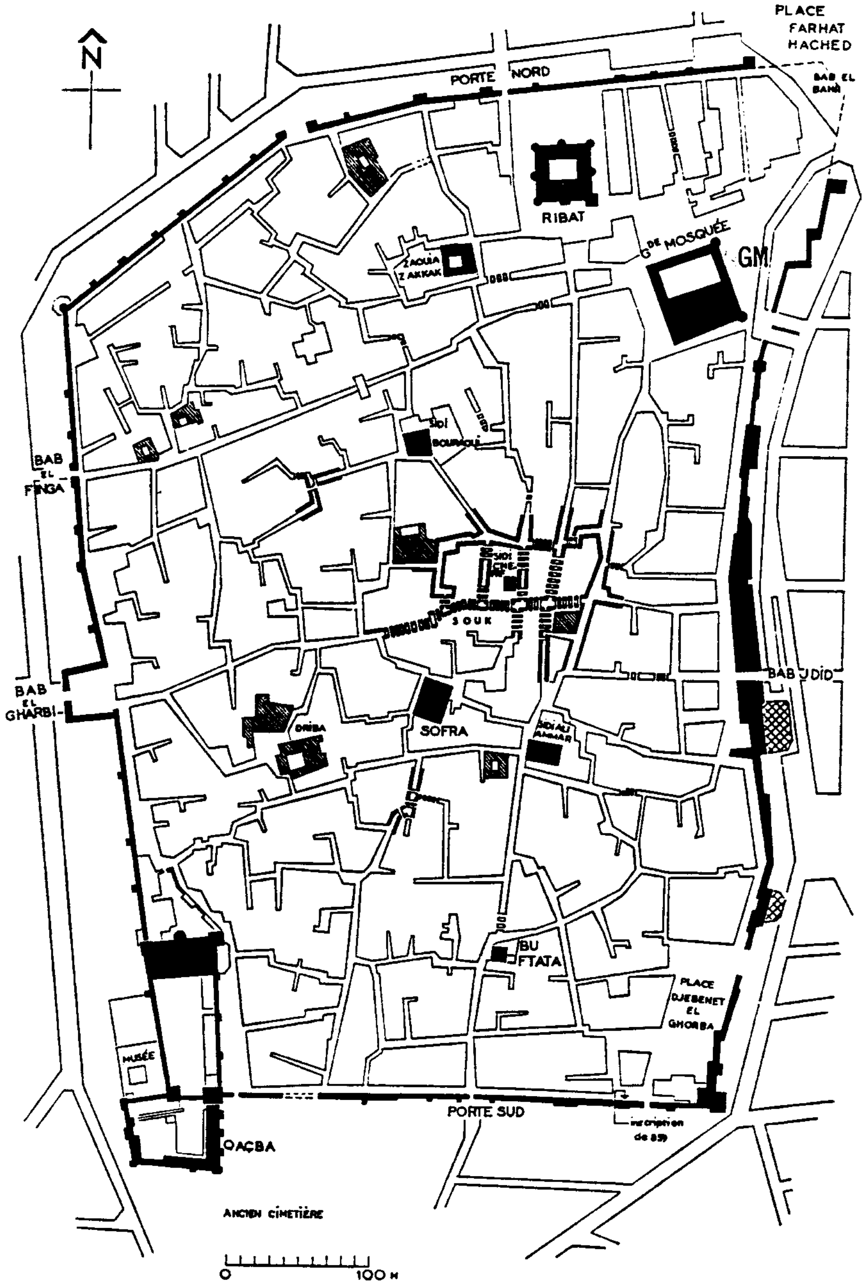
Hammamet: Finally, it is interesting to note that Hammamet, which was built in the fifteenth century, has a qibla also of 147° for the Great Mosque (Fig. 20) (which was built in the fifteenth century as well). And, in this case the entire city is not only extremely orthogonal (Fig. 21, Fig. 22), but also it is aligned in the direction of the qibla of the Great Mosque (and other religious buildings). Hence, even at this later date the direction to Mecca used by Qayrawan and the Aghlabids was still influencing the qibla and hence the alignment and structure of Tunisian cities. Yet, we still have not explained that orientation – to which we now turn.

Fig. 14 A Medina Street in Sfax
Source: Photo by the Author

Tunisian Qiblas and Islamic Urban Structure: A Roman Legacy?

Tunisia has long been a crossroads, at the juncture of the western and eastern Mediterranean basins and close to Sicily and Italy. Before the coming of Islam, this region was part of the Punic, Roman, and then Byzantine empires, as well as being influenced by Vandals, Berber kingdoms and various other political units and coalitions over the centuries and millennia. Carthage was once one of the great cities of the Mediterranean world, and numerous other towns, especially port cities, were part of these empires. Although a pre-Islamic town in some instances may lay underneath an Islamic city, and, hence, influence the structure and orientation, as in Sousse (Roman Hadrumetum) and perhaps Sfax or even Tunis, there is another possible influence which may have been more significant in determining the orientation of these Tunisian Islamic cities – and hence also the direction of the qibla. This factor is the rural survey of the landscape by the Romans, called the Roman centuriation system.

As the Roman Empire expanded, in many frontier areas an extensive land survey was conducted to establish colonies as agricultural settlements, and for the division of their allocated cultivated lands. Such surveys often divided the land into squares with a side of 2,400 Roman feet (705.10 meters) and containing an area of 200 *iugera* (c. 50.4 hectares), which were called *coloniae* or *centuriae* (centuries),



GM = Great Mosque

Fig. 15 Plan of the Medina of Sousse
Source: Lezine, 1971, 14

Fig. 16 The Medina of Sousse
Source: Photo by the Author

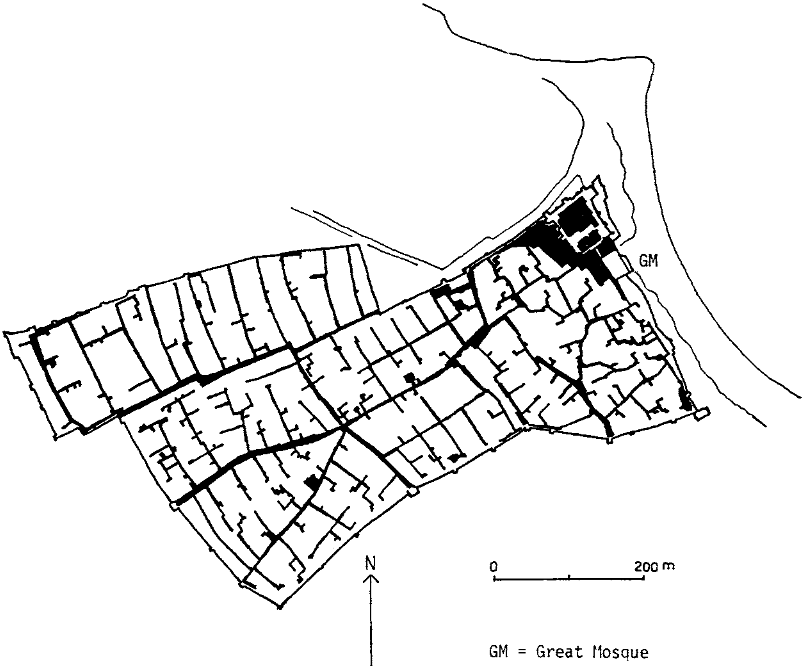


Fig. 17 Plan of the Medina of Monastir
Source: Lezine, 1971, 130

Fig. 18 The Great Mosque of Mahdia
Source: Photo by the Author

because they theoretically contained 100 *heredia* ("inherited areas"), consisting of two *iugera* ("yoke areas") each, which was the size of the plot usually given to the colonists. It is this cadastral survey of land into these squares which is known as centuriation (Dilke, 1971).

Evidence of centuriation has been found in northern Italy, France, Netherlands, Great Britain, and a few other areas. In North Africa it appears that mainly Tunisia (and part of eastern Algeria) were subjected to these surveys. In fact, the centuriation in Tunisia was rather vast (Fig. 23), and has been the focus of extensive research for many decades, mainly by French scholars. Such work has included the detailed *Atlas des Centuriations Romaines de Tunisie*, published in the early 1950s and showing the centuriation system (identified in aerial photographs) overprinted on existing 1:50,000 maps. What is apparent is that there are large areas with the same orientation, although the directions sometime vary from region to region. Either squares or rectangles will comprise a particular system (e.g. Fig. 24, Fig. 25). The original Roman province of Africa began in 146 BC, when Carthage was conquered and razed to the ground, and centuriation began in Tunisia soon after that time. By the late second century BCE about 15,000 sq. km. had been divided into regular squares (Dilke, 1971, 156). Extensive new centuriation occurred in AD 29–30, including central Tunisia, carried out by the third legion of Augusta.

The orientations of the centuriation systems are not in cardinal directions, but, instead, the main axis, the *decumanus maximus*, is oriented to the southwest, with the *cardo maximus* at a right angle to the decumanus (although these two axes get switched in some instances) (Fig. 26). There are slight variations to the directions of the main systems, and one, the centuriation centered on Acholla, has a rather different orientation (Note Fig. 26). Several French scholars have examined the Tunisian centuriation, particularly Chevallier (1954) and Trousset (1977, 1978, 1997). Some of the coastal centuriation has been explained as evolving at a right angle to the coast, although a number of the main systems are oriented to face either sunrise at the summer solstice

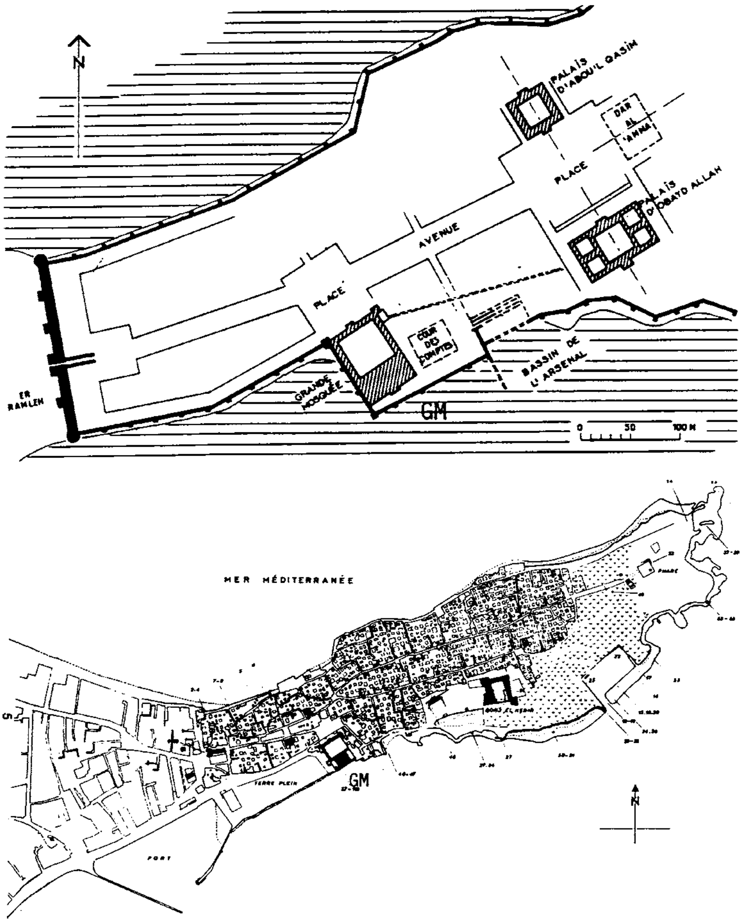


Fig. 19 Plans of the Medina of Mahdia
Source: Lezine, 1968, 5, 6, 47

or sunrise at the winter solstice (this latter orientation often being the direction of the cardo maximus, and so the decumanus maximus would be 90° to that direction). The centuriation at Acholla, for instance, is oriented to the summer solstice (119°), as Trousset, 1977, notes – although that system is also at right angles to the sea coast, which may be the main reason for the orientation. For many of the major systems, such as the one which begins at Jabel Bou el Hanech (Fig. 26), the cardo maximus is oriented to the sunrise at the winter solstice (60° at about latitude 37° [Tunis, Carthage] to 61° at about latitude 35° [Sfax]). Hence, the direction of the other axis, the decumanus maximus, will be 150° to 151° for these latitudes.

Now, let us return to the directions of the qibla of the major mosques of specific cities, as previously discussed. While assuming a level horizon, Qayrawan, located at 35°41', will have sunrise at winter solstice at about 60.7°, giving the right angle

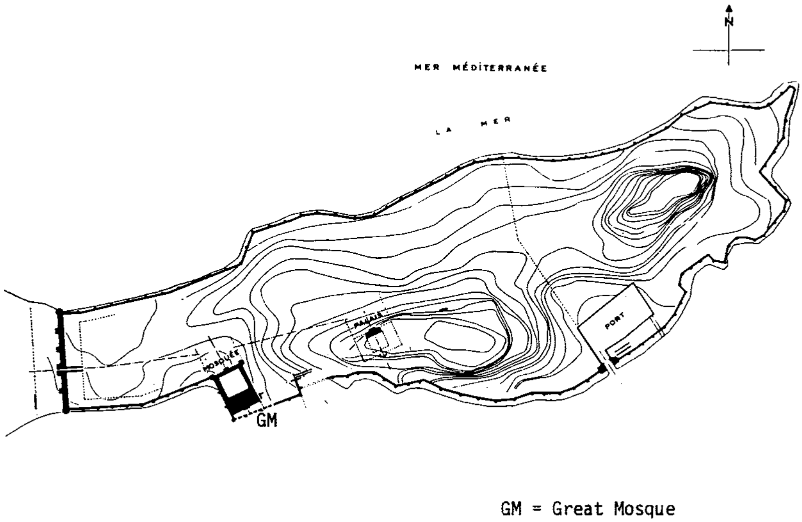


Fig. 19 (continued)

direction as 150.7°, and as noted above, the qibla of the Great Mosque in Qayrawan was measured at 147°. Sfax, located at 34°44’ N, will have the winter sunrise at about 61.1° and the other axis 151.1° (and the qibla measured 147°), while Tunis at 36°48’ N will have winter sunrise at about 60.4° and 150.4° at the right angle (and the qibla measured 145°). Similar close correlations of the winter sunrise axis and the qibla occur for Mahdia, Monastir, and Hammamet, with only Sousse being rather different, as previously mentioned.

As previously mentioned, King has noted that according to the medieval Arabic sources mosques were often laid out toward the winter sunrise, because it was thought

Fig. 20 The Grand Mosque of Hammamet
Source: Photo by the Author

Fig. 21 Plan of the Medina of Hammamet

Fig. 22 The Medina of Hammamet
Source: Photo by the Author

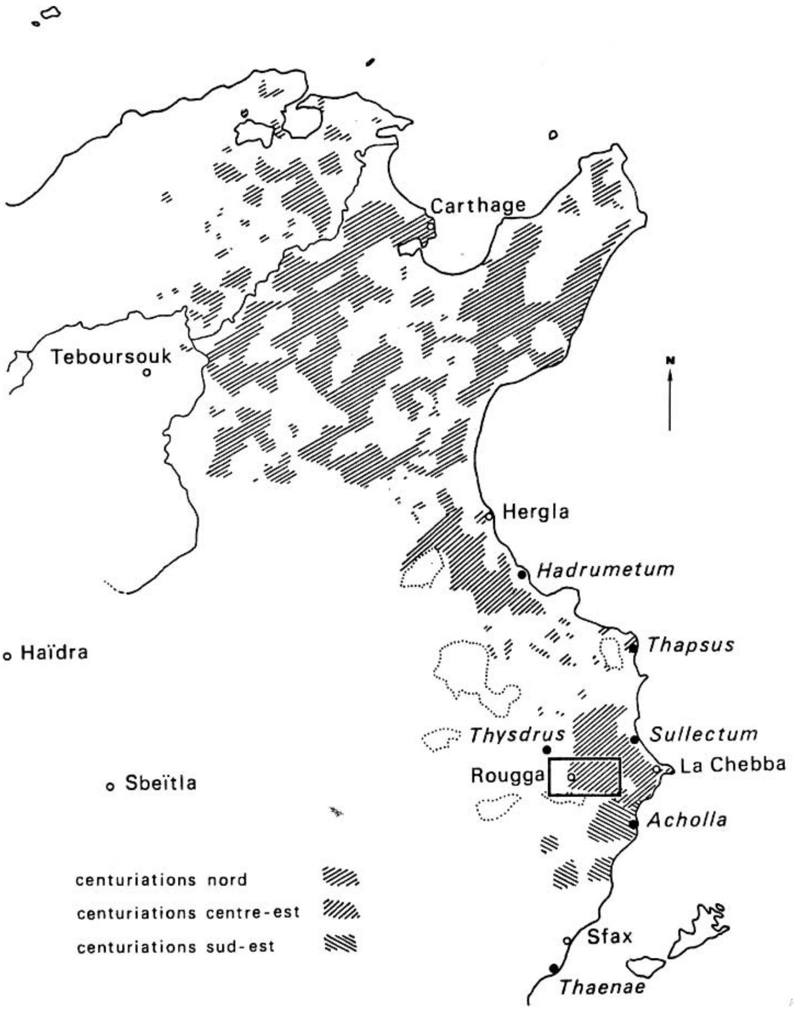


Fig. 23 The Roman Centuriation System in Tunisia
Source: Caillsemer and Chevallier, 1954

that this would make their qibla walls parallel to the north west wall of the Ka'ba (i.e. facing the northwest wall of the Ka'ba). Mecca at 21°29' N would have a winter sunrise of 115.3° with an even horizon (although actually it is quite mountainous around the holy city). Hence, even though in Tunisia the winter solstice is at a rather different angle than at the Ka'ba, for the faithful attempting to follow this particular prescription (i.e. direction), the winter solstice might still be considered a proper orientation. However, the 60°–61° direction of the winter solstice is to the northeast quadrant and not to the southeast, which would mean that it would be the wrong quadrant in any case. So, why would the mosques in Tunisia be at a right

Fig. 24 The Roman Centuriation System at Acholla
Source: Caillsemer and Chevallier, 1954

angle to this winter solstice direction? Since many of the Roman centuriation systems are also in the axis direction of the sunrise of the winter solstice, could this mean that these Roman cadasters might have been significant as well? The fact that the directions of the qiblas of the major religious structures are so consistent and follow the centuriation direction, also might lend some credence to the role of centuriation. However, is centuriation determining the qibla? – or is it determining the settlement pattern and orientation, within which a later mosque would be built and hence have a particular direction for the qibla? Now we turn to an examination of the relationship of the Roman centuriation with the settlement morphology and orientation.

The connection between centuriation and settlement form certainly has been recognized by several scholars. For instance, Soyer (1976) has shown how the

Fig. 25 The Roman Centuriation System near Tunis and Carthage
Source: Caillsemer and Chevllier, 1954

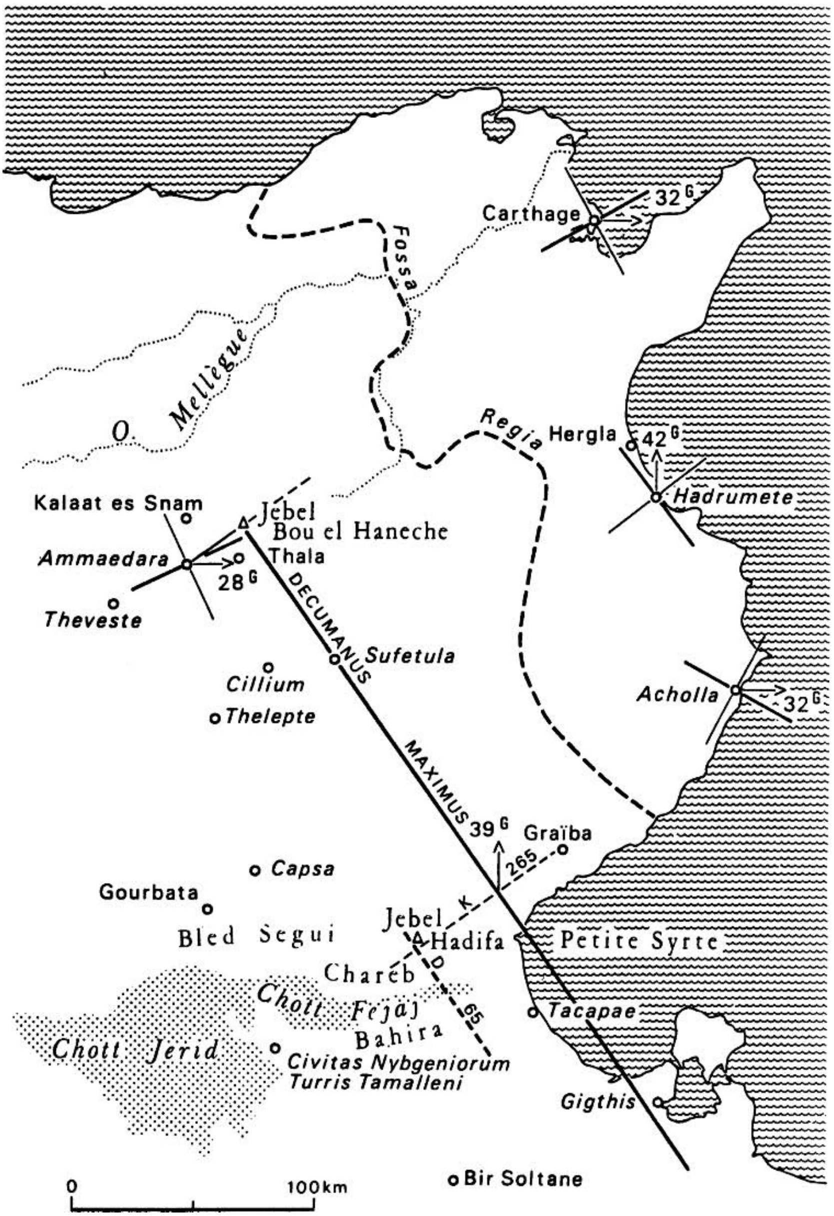


Fig. 26 Axes of the Major Centuriation Systems in Tunisia
Source: Trousset, 1978, Fig. 6

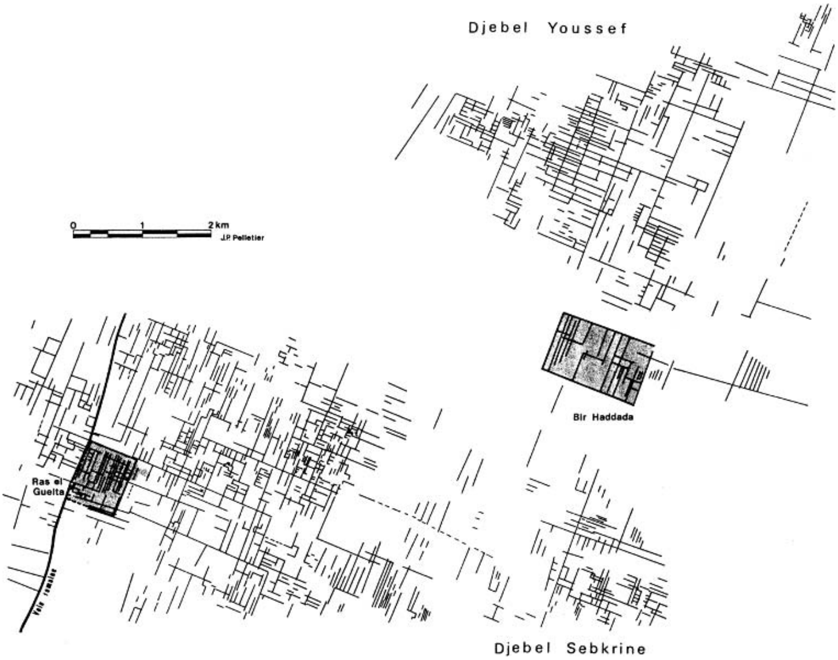


Fig. 27 Centuriation and Settlement Morphology in Western Algeria
Source: Soyer, 1976, Fig. 23

morphology and orientation of some settlements in eastern Algeria have been determined by the Roman cadastres (Fig. 27). Within Tunisia the first consideration is to examine Qayrawan itself. Unfortunately, we are again disappointed with the lack of evidence for the earliest major Islamic city in the Maghreb. At least according to the *Atlas des Centuriations Romaines de Tunisie*, centuriation has not been found in the immediate vicinity of Qayrawan. However, since some systems have been identified in other areas of Tunisia which do not appear in the atlas, it still may be possible that centuriation had been present and influenced the layout of Qayrawan – and the orientation of the Great Mosque. (But until such evidence is forthcoming, Qayrawan will remain the model city which cannot be properly explained.)

Tunis, on the other hand, provides an interesting and most relevant case study for this papr. Woodford (1990), for instance, discusses the evolution of Tunis, which includes an examination of the centuriation system and Roman Tunis. He remarks that "in the 1920's, the French noted the correspondence of street axes in the Tunis medina with those of the rural colonia, but undertook no studies to determine whether they related only to the rural colonia, or whether they could have formed part of an urban layout" (1990, 56). He then shows that the present street orientations are aligned along the decumanus and the cardo, and that the present street intervals correspond to intervals of 240 Roman feet (Fig. 28). He also shows that the Zaytuna Mosque fits into a square which is 240 by 240 Roman feet (Fig. 29).

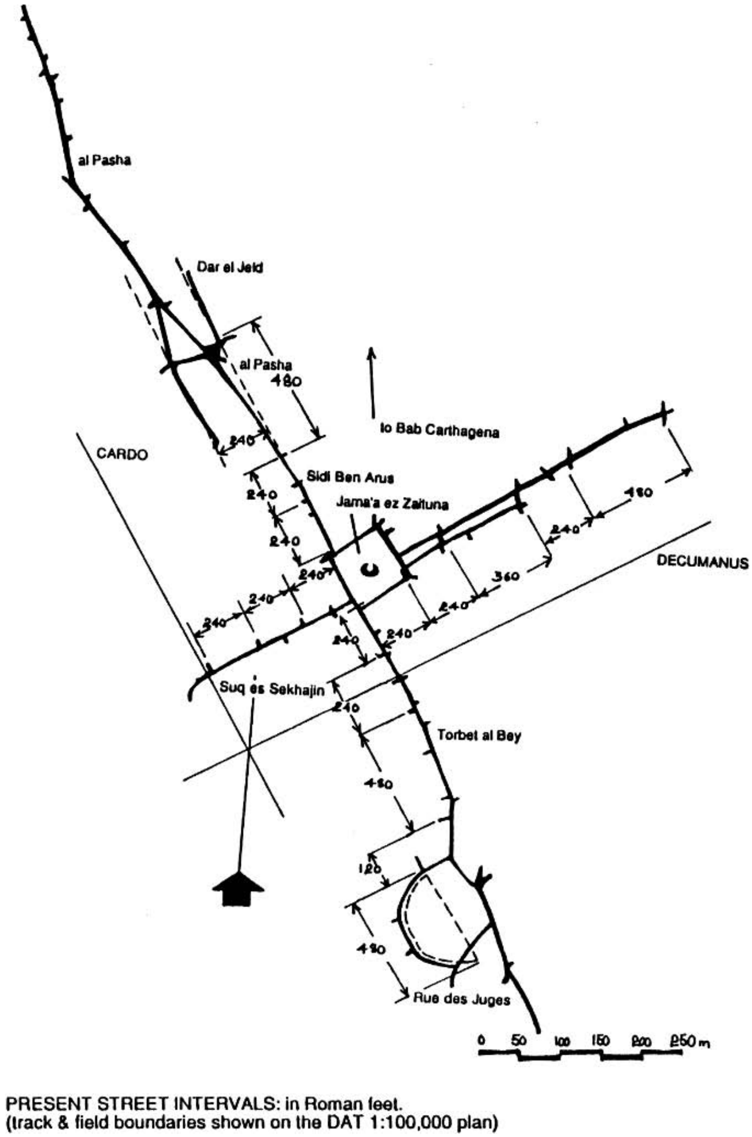


Fig. 28 Roman Street Intervals in Tunis
Source: Woodford, 1990, Fig. 18

Woodford postulates that Islamic Tunis was built over a Roman city and not just the rural cadastre system. This reasoning is due to the continued existence of the earlier Roman rectangular modules, which measure 1,440 by 1,752 Roman feet. These are then divided into *insulae* or street blocks of 96 by 240 feet, with the long side in the direction of the decumanus (Fig. 30) (1990, 56–61). Although Woodford notes that the Zaytuna Mosque (the Mosque of the Olive Tree) was probably built

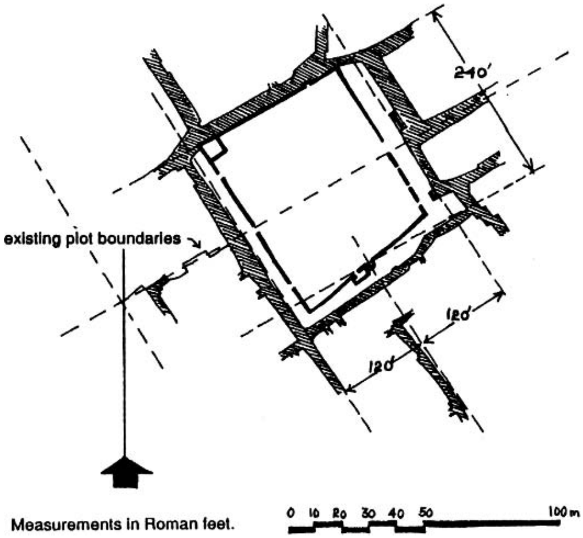


Fig. 29 The Grand Mosque of Tunis and the Roman Block
Source: Woodford, 1990, Fig. 19

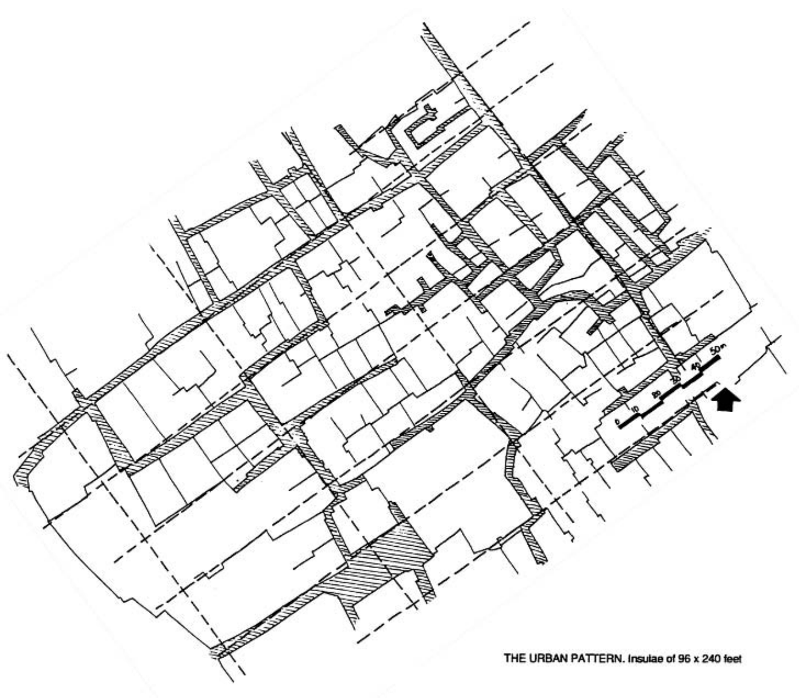
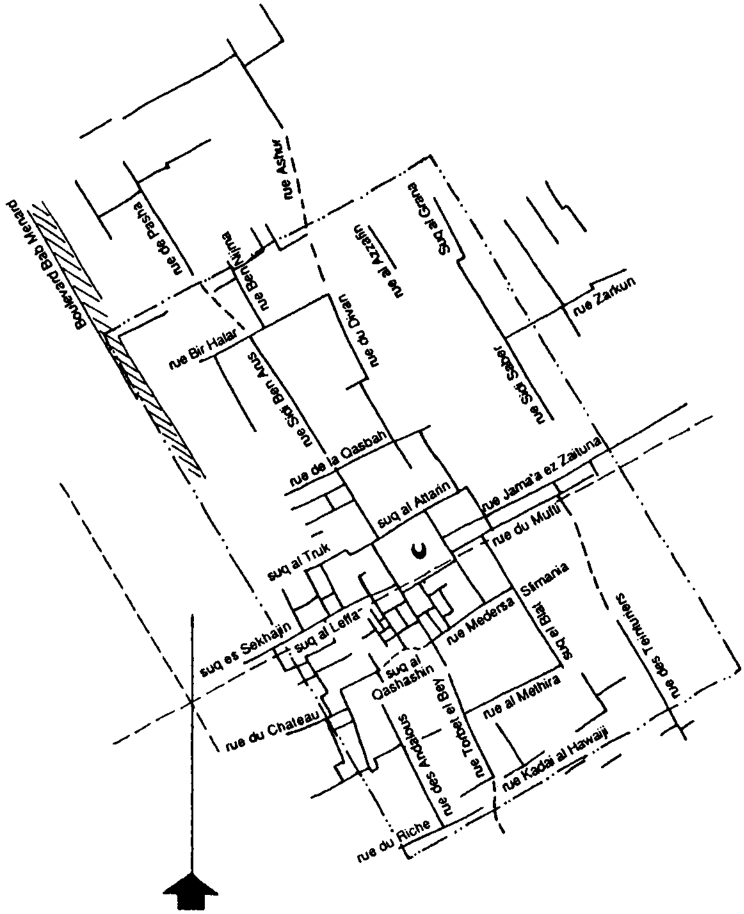


Fig. 30 The Morphology of Tunis and the Roman Blocks
Source: Woodford, 1990, Fig. 21



MEDINA STREETS FOLLOWING THE COLONIA.

Fig. 31 Tunis and the Legacy of the Roman Street System
Source: Woodford, 1990, Fig. 20

upon an earlier church which had been dedicated to St. Olive, he does not ever comment upon the qibla orientation which has resulted from this Roman cadastre system. The alignment of the Zeytuna Mosque as well as its dimensions seem to confirm the influence of the Roman cadastre (and even though the mosque is not exactly orthogonal, it is only slightly askew and the qibla actually closely parallels the direction of the Roman decumanus and the main streets (see Fig. 10). In fact, the major streets of the medina are all basically orthogonal and follow the centuriation, as Woodford has noted (Fig. 31). Daoulatli (1976, 31), on the other hand, attempts to explain the orientation of the major streets in the medina as a consequence of the direction of the principal external roads (but, actually, whose orientation would have been highly influenced by the Roman centuriation). The orthogonal alignment of fields and roads near the medina, as near Sebkhet Es Sedjoumi, for instance, also seems to indicate a pre-existing Roman cadastre, although the orientation does change slightly in certain areas, probably due to the slope.

The medina of Sfax is also quite orthogonal, as previously discussed. The Islamic city is certainly built upon a Roman cadastre, although whether it is built upon a rural centuriation or upon the Roman city of Tapurura (and hence similar to the situation of Tunis as postulated by Woodford), remains to be determined. Sfax actually does not appear as part of the *Atlas des Centuriations Romaines de Tunisie*, being just south of the most southern centuriation system shown. Yet, it is relevant to note that the land divisions around Sfax are very orthogonal, and are oriented in the same direction as the medina itself. And, similar to Tunis, the orientation of the Great Mosque of Sfax also appears to have been determined by a pre-existing Roman cadastral survey (and/or perhaps Roman city).

As a last example, Hammamet not only shows the same orientation and extreme regularity, as previously mentioned, but also it has many blocks of housing which are the exact same widths (Fig. 21). If Hammamet was indeed founded only in the fifteenth century as a new city, it nevertheless must have been built upon the legacy of a Roman centuriation. Hence, once again the orientation of the mosque (and hence the qibla) appear to have been determined by the earlier Roman system.

Conclusion

The patterns which have manifested themselves in this brief examination are intriguing indeed. We have seen that the qibla for the Great Mosques of a number of Tunisian cities are basically the same direction (except for Sousse), and that this direction is 90° of sunrise at the winter solstice. Sunrise at the winter solstice is also the orientation of the axes of many of the earlier Roman centuriation systems. When the evidence of a Roman cadastral survey is found associated with these cities, it then appears that the qibla and the Islamic city structure has therefore been determined by the pre-existing Roman system.

Yet, there needs to be more investigations to confirm some of these notions and patterns. One needs to look for evidence of centuriation in the vicinity of Qayrawan. Careful measurements of Sfax and other cities need to be done to determine what Roman system (centuriation or Roman city) might have influenced the later urban structure and orientation. More settlements – and qiblas – need to be examined in other areas of Tunisia (and eastern Algeria). The role of the Aghlabids, who built so many of the main Islamic Tunisian cities (and the Great Mosques) needs to be better understood. In any case, it does appear that, unlike Morocco and many other areas of the Islamic Middle East, the ancient Roman centuriation system indeed may have determined the qibla and the orientation of mosques, as well as the structure and alignment of the traditional cities themselves in Tunisia. And the centuriation systems were often laid out based upon astronomical calculations. Further work is needed to confirm and elaborate upon these intriguing patterns and relationships.

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The Timbuktu Astronomy Project

A Scientific Exploration of the Secrets of the Archives of Timbuktu

Rodney Thebe Medupe, Brian Warner, Shamil Jeppie, Salikou Sanogo, Mohammed Maiga, Ahmed Maiga, Mamadou Dembele, Drissa Diakite, Laya Tembely, Mamadou Kanoute, Sibiri Traore, Bernard Sodio and Sharron Hawkes

Abstract The ancient city of Timbuktu was the main centre for commerce and scholarship in West Africa from the 13th century until the 17th century. Books were bought from North Africa and other centres of Islamic learning, and local scholars also wrote many books on astronomy, medicine, mathematics, literature, law and islam. Scholarship peaked during the 16th and 17th century but declined gradually until the 19th century. Our project aims to study the ancient manuscripts from Timbuktu in order to search for astronomy in them. The main aim of the project is to document our research and use it to attract African youth into science and technology by appealing to their heritage. This paper outlines progress made since the inception of the project in 2006.

Introduction

The city of Timbuktu was the major commercial and intellectual centre of the Mali and Songhay empires. Scholarship in Timbuktu peaked in the 15th and 16th centuries due to the tremendous support from the Songhay emperor Askia Mohammed, and its increased link with North Africa and Egypt in particular. Fabulously wealthy, Timbuktu's commercial success created fertile ground for an important African centre of learning where scholars of religion, arts and sciences flourished. During this period, thousands of manuscripts were commissioned and meticulously executed by Timbuktu academics. A thriving book trade existed with other parts of the Islamic world. This resulted in various manuscripts being imported, including exclusive copies of the Koran for wealthy families.

Rodney Thebe Medupe
Astronomy Department, University of Cape Town
E-mail: thebe@saao.ac.za

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For three hundred years, Timbuktu flourished until being invaded by Morocco in the 1590's. Although the culture of scholarship continued until late 19th century, the golden era for Timbuktu scholarship was undoubtedly the 16th century. Fortunately, a treasure trove of hundreds of thousands of manuscripts survived the gradual decline of the city – safeguarded by descendants of the ancient scholars and scribes – many lying untouched in trunks or buried deep in the thick mud walls of mosques for generations. There is one public library, the Ahmed Baba library, and several private libraries in the region of Timbuktu. Only eight of these private libraries are accessible to study. Only one of them, the Mama Haidara library has catalogued its manuscripts. The Ahmed Baba library has a collection of over 20,000 manuscripts, only nine thousand of these are catalogued. The contents of these manuscripts are largely a mystery and the documents are in grave danger of being lost and damaged before their contents are revealed.

The Timbuktu manuscripts are part of a much larger collection of Islamic writings found throughout much of West Africa (Hunwick & O'Fahey 2002). An interest in the study of Islamic writings in West Africa by Western scholars goes as far back as 1900. These early researchers mainly concentrated on the history of the region and literature as written by the region scholars. The Institute for Studies of Islamic Thought in Africa (ISITA) headed by Professor Hunwick, has also used some of the manuscripts to study the history of Timbuktu, and the biographies of some of the remarkable scholars such as Ahmed Baba and his mentor, Muhammad Baghayogho (Hunwick 2001). Hunwick (1999) translates the works of one of the early Timbuktu historians, Abd al-Rahman al-Sa'di (died. 1655). His historical writings cover the history of Timbuktu and Jenne from the twelfth and mid-seventeenth century. More recently, one of our research team members, Shamil Jeppie, has initiated a study into the law content of the Timbuktu manuscripts.

As far as we know, no studies have been made on the science content of the manuscripts from Timbuktu or any other part of Africa where ancient manuscripts are found. For example, Hunwick & O'Fahey 2002 mentions the thirty two astronomy manuscripts that have been identified in the libraries of the Al-Furqan foundation in the Republic of Ghana, but they make no mention of any detailed studies of them. We therefore proposed a pilot project titled "*The Project into the Scientific Contents of the Timbuktu Manuscripts*" to initiate the first ever research by scholars (scientists and historians) into the science content of the Timbuktu manuscripts. Initially we will focus on the astronomy content, but as we develop and optimize research techniques and methodology we hope to expand our area of research to cover other areas of science.

The primary goals of this research are to investigate the extent of the participation and contribution of African astronomers to Medieval Islamic scientific culture. We are interested in promoting the role played by Africans in Islamic Science in order to encourage young Africans today to pursue careers in the fields of Astronomy, Science and Technology.

Our main objective is to build a complete picture of the status of scientific studies and research during the Mali and Songhay empires so as to document the contribution of Africans to the development of science in the world. This project is multi-disciplinary, therefore the results of the investigation may have bearing on other fields of study such as more illumination on the history and nature of the interaction of Sub-Saharan Africa with the rest of the Islamic world.

The Scientific Investigation

Islamic Astronomy at the Time of the Mali and Songhay Empires

An interesting question to address concerns the possibility of a sharing of scientific ideas between the known centres of medieval Islamic science such as Baghdad and West Africa. Islamic science flourished during the period between the 1200 and the 700 years ago. During that period, it is believed that most research in astronomy in the world took place in the Islamic Spain, North Africa and the Middle East. The knowledge resulting from this era went on to benefit European scientists during the time of European Renaissance (see Saliba 1999). The research involved a combination of the translating ancient Greek science manuscripts, and original works by Medieval Islamic scientists.

In the Islamic world, research in astronomy was driven by two main religious practices; firstly, the requirement for Muslims to pray facing Mecca and to orient their mosques in the direction of Mecca. Secondly, the need to determine proper times for prayers at sunrise, noon, afternoon, sunset and evening. Practical solutions to both of these problems require the use of trigonometry. Ideas on Trigonometry were first used by ancient Egyptians and Babylonians, but was developed into an area of mathematics by ancient Greeks (Adamek et al. 2005). Hipparchus is considered the father of trigonometry (Heath 1981). Ptolemy's trigonometric solutions were correct but his methods were too cumbersome. Muslim astronomers devised easier solutions by presenting trigonometry as is known today. The medieval Islamic astronomers also improved on the astrolabe, an instrument that was used to predict positions of stars and planets (King 1986; Saliba 1991). For further reading: Gingerich (1986) gives a brief but easy to read account of the history of Islamic astronomy.

The Investigations

We are interested in exploring the Timbuktu scientists understanding of several basic astronomy principles. Such as if knew that the earth was round, and whether their view of the universe was heliocentric. We also want to determine if Timbuktu astronomers used any instruments to study the positions of stars, and their perception of transient astronomical events such as comets, eclipses and shooting stars. Finally we want to determine their knowledge of mathematics and whether they used it in their study of astronomy. We plan to search their records of astronomical events for supernovae as well as other transient events mentioned above.

The answers to these questions alone are very interesting, however, the full extent of the information to be found in the thousands of documents lying unexplored and undiscovered can only be guessed at.

Project Feasibility

The possibility of finding information about astronomy in the archives is based on the following points. First, until quite recently, the stars in the night sky dominated many aspects of human life, providing vital information on the time, changing seasons, navigation and complementing spiritual beliefs (Snedegar 2000; Prins 1961). The importance and extent of people's dependence on astronomy and their sky knowledge is quite likely to be contained in the archives of Timbuktu.

Secondly, Timbuktu traded extensively with Muslim traders from North Africa and the Middle East. In the previous sections of this paper, we have shown that from the 8th century until the 13th century, Muslim astronomers took over from the ancient Greeks as some of the most accurate and innovative mathematicians and astronomers in the world. Through the book trade and regular interaction between these cultures it is quite feasible that they shared knowledge about astronomy and mathematics.

In addition, there have been a number of important indicators of the extent of the astronomical information in the archives and as our research intensifies, fascinating and enticing pieces of information continues to emerge which indicate that not only will we be successful within the parameters of our research objectives but also that astronomical and scientific knowledge may have been more extensive than ever previously imagined. A casual look at the entries of the Ahmed Baba library catalogues indicates the existence of 37 manuscripts that deal with topics on astronomy and astrology. We also found 27 articles in the Mama Haidara library. While we are more interested in the astronomy, articles on astrology will be very useful as a window into the ancient Malian view of the night sky, their cosmology, and their divination practices. More importantly, we also found articles on the relations between Islamic and non-Islamic calendars, a text on the "introduction to astronomy" and on calculating time. As we have shown before, time calculations were based on knowing trigonometry and knowing the position of stars accurately (King 1986).

Finally, there is evidence of the recordings of some astronomical events such as the one below of the meteor shower of August 1583 recorded by a Songhay historian, Mahmud Al Kati (see Hunwick 2001):

> "In the year 991 [1583] in God's month of Rajab the Goodly [August 1583] after half the night had passed, stars flew around the sky as if fire had been kindled in the whole sky – east, west, north and south. It became a mighty flame lighting up the earth, and people were extremely disturbed about that. It continued until after dawn.
> Recorded by the humble servant of his Lord, Alfafi Kati Mahmud ..."

The process of revealing the contents of the Timbuktu manuscripts involves identifying the relevant manuscripts and digitizing them to avoid damage during transportation. There is already a programme for digitizing manuscripts in the Ahmed Baba library. Thus, once we have identified manuscripts of interest from their catalogue, we submit request for the digitized copies to be sent to the two teams for study. Two Arabic-to-English translators have been employed on a full-time basis to work on the manuscripts. The translated works are then studied by the Malian and South African teams.

Some Interesting Results

We report on preliminary findings of our research in 2006. We have translated over 15 manuscripts into English. They vary in size from two pages up to 100 pages long. Unfortunately many have missing pages, which means we do not know their authors nor their origins. We think we know the origins of the two papers we briefly discuss below.

Geocentric Model of the Universe in 1700s Timbuktu

This manuscript, written in 1723, is a copy of a commentary by Abul Abbas on a work by Mohammed bin Said bin Yehya bin Ahmed bin Dawud bin Abubaker bin Ya-aza from Suz (probably Morocco). In a page from the manuscript, shown in Fig.1 , the writing in red colour ink is a comment by the copier of the manuscript and that in the black ink is the writing of the original author. We do not know much about the Author except that he lived or comes from the area of Timbuktu since he mentions Ahmed Baba, the most famous scholar from Timbuktu in the 1500s.

The manuscript starts by explaining what astronomy is, and what its uses are. Here is a direct translation of what Abul Abbas thinks Astronomy is:

> “. . . it is also called Science of Arithmetic. Because he who wants to know this science must look at the sky to observe the individual stars and to know their names. It is called Arithmetic, because he who wants to know it must learn Arithmetic.”

Furthermore here are the uses of Astronomy:

> “It is useful for five things:
> - people’s guidance in and off sea. As God said: . . . so that you might guide yourselves by them in and off the sea.
> - Knowing estimation of the years, . . .
> - Decorating sky nearest to us. God said: we decorated the nearest sky with stars.
> - One of the uses of this science is knowing prayer times . . .
> - So that the angels can hurl them at the devil”

In other words, astronomy is used for guiding people on and off the sea, determining calendars, decorating the sky and determining prayer times.

This manuscript was a teaching manual for students in 1723, and yet these concepts of astronomy (with the exception of the third and last items above) are exactly as they are being taught in classes of basic general astronomy today.

The manuscript also includes precise definitions of Islamic calendars, month, leap years, etc. The author also gives algorithms on how to determine leap years

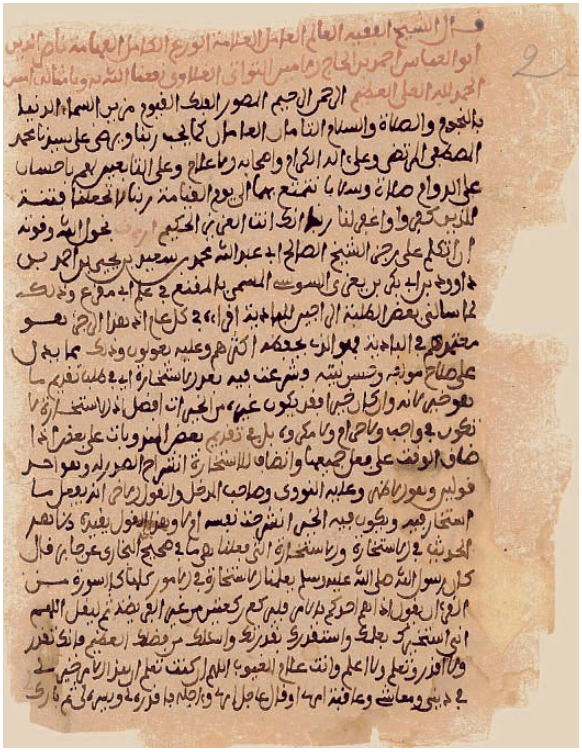

Fig. 1 A page from Abul Abbas's manuscript. The red writing are comments from a copier

in an Islamic calendar. These algorithms were converted into FORTRAN programs and found to be correct.

The final chapter deals with a description of a geocentric model of the heavens. Here is a translation of their model:

> "He said that the orbits that God created in Heavens are nine. Seven of them bear planets. The eighth bears some other stars. The ninth is void of planets. The illustration of that is; the moon is in the orbit next to us. There is no other planet next to us if not the moon, except those stars that are said to be destined to hurl the Devil with. The next one is bigger it contains Mercury. He hinted here that orbit is bigger than the one below it and smaller than the planet above it. The third orbit bears Venus. The fourth bears the Sun. the fifth bears Mars. The sixth bears Jupiter. The seventh bears Saturn. The eighth bears other planets rather than these ones. The ninth is void of planets. This means that there is no planet there but the eight planets share it. Every one of them rotates round it once every day and night with the might of God. The orbit is where a planet makes a round voyage. God said every one of them swims in an orbit. We are in its center. The orbits are layered on each other like onion shells. The closest to us is what is in the earthen sky."

In Fig. 2 is a page from another manuscript showing diagrams of planetary orbits. The above quote shows that Islamic astronomy borrowed a lot from ancient Greek Ptolemaic astronomy. Although this is a long known fact, it has not been known that Black Africans were learning these ideas at their schools over three hundred years ago. This also shows that Islamic astronomers (at least in Timbuktu) were

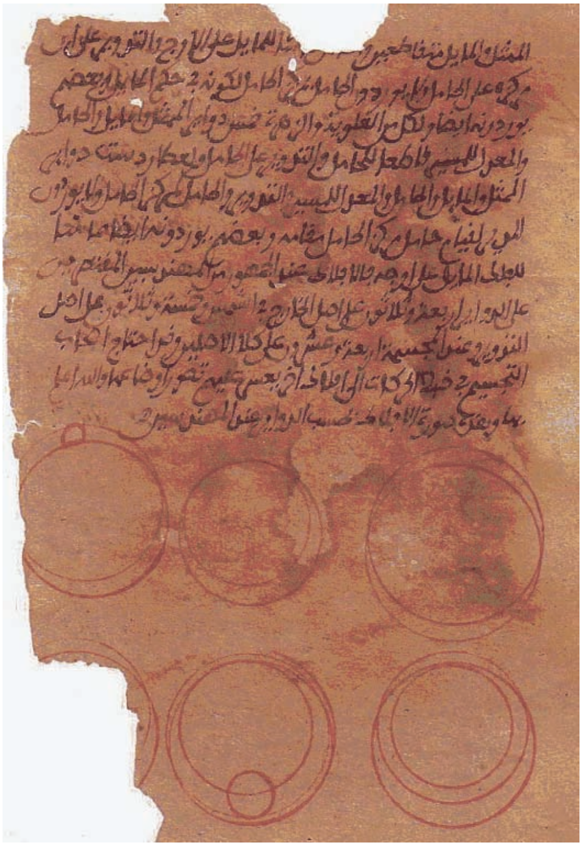

Fig. 2 Diagrams demonstrating orbits of planets in the solar system from another manuscript from Timbuktu

not in contact with European astronomers as this manuscript was written over two hundred years after Copernicus proposed a sun-centered model of the universe.

Direction to Mecca

Figure 3 shows an example of how stars were used to determine direction to Mecca. It is a requirement of Islam that every mosque be orientated to Mecca. This direction was determined in some cases by using stars to determine latitude and longitude for both Mecca and the locality of interest. Then trigonometric identities were applied to determine angles. This picture comes from a manuscript probably written in North Africa (since the point from which direction is sought is Algiers). It was probably traded in Timbuktu. The author died in 1572. A redrawn sketch with English translations is shown Fig. 4.

Fig. 3 A diagram from a manuscript originally written in Algiers in 1575, but probably later traded in Timbuktu. It shows the direction to Mecca from Algiers

Conclusions

The search for science content in the Timbuktu manuscripts marks an important chapter in the discipline of history of science. It is hoped that the study of the history of science in Africa will receive recognition it deserves as a result of this study. We have shown that there is ample evidence to suggest that Africans were studying mathematical astronomy in their schools in Timbuktu over four centuries ago, much earlier than was expected. The project is multi-disciplinary and involves research collaboration between two African countries with potential benefits for education in Africa and African Diaspora.

The contents of the manuscripts shown in this paper cover the subject of astronomy, mathematics and geography. We plan to produce a high school book showing

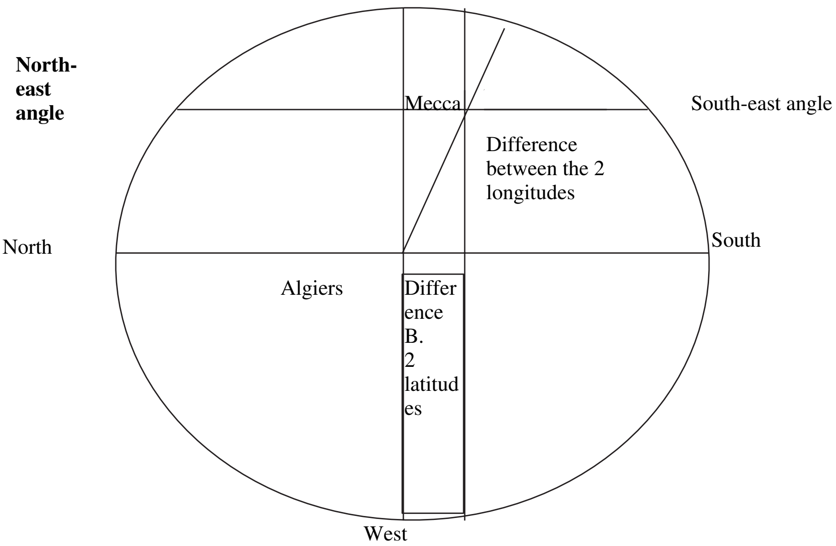

Fig. 4 A translation of Fig. 3 into English

how mathematics was used to understand astronomy and geography in West Africa over four centuries ago. We hope that in this way we can use Africa's proud heritage to attract African youth into careers in science and technology.

More information about the project can be found at www.baghayogo.ast.uct.ac.za

Acknowledgments This research was made possible by a grant from the South African department of Science and Technology (DST). We also wish to thank DST and ministry of Education in Mali for facilitating access to the Ahmed Baba Centre in Timbuktu, Mali. We wish to thank the Ahmed Baba Centre for their kindness in allowing us access to their manuscripts.

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The Cosmological Vision of the Yoruba-Idààcha of Benin Republic (West Africa): A Light on Yoruba History and Culture

Aimé Dafon Sègla

Abstract The essay examines Idààcha cosmological vision as a kind of incorporation of Yoruba cosmology. It shows a process where the two strands, that is to say, knowledge and belief can not be readily distinguished. The divinatory traditional calendar is indeed based on a scale of fixed number values whose definitions are drawn from the concepts early traditional people have of the universe. Thus, the signification of the terms that designate entities such as angle, circle, center of the circle, midnight, time zone, the number of days in a week, etc., in the Yoruba dialect Idààcha, mirrors cosmological standards. These words constitute a landscape of memory shedding light on early Yoruba culture and history. Hence, Idààcha being a significant western periphery of the Yoruba region, we examine why its divinatory calendar would preserve an older spatio-temporal logic, beyond Ifè and Oyo revisionism in Yoruba history. Finally, the article points out that the translation of spatial and geometrical relations into temporal terms and vice-versa may suggest a new indexical approach to the study of cosmology in relation to the human body. As the body is in the mind, we say in relation to the human mind.

Resume L'article examine la vision cosmologique du groupe dialectal Yoruba-Idààcha comme un type d'incorporation de la cosmologie Yoruba dans la rationalisation de la vie sociale. Il met en exergue le lien à peine dissociable entre croyance et connaissance. Le calendrier est en effet construit sur la base d'une échelle de valeurs tirées de la vision cosmologique de l'univers. Ainsi, les significations, dans le dialecte Yoruba-Idààcha, des termes qui désignent les entités comme l'angle, le cercle, le centre du cercle, minuit, fuseau horaire, le nombre de jours de la semaine, etc., renvoient systématiquement à l'échelle des valeurs standardisées inventées par la cosmologie. Ces mots Idààcha qui ≪ parlent ≫ constituent un paysage de mémoire qui renseigne sur les symbolismes originels dans l'histoire et la culture

Aimé Dafon Sègla
ORKESTRA Consulting, 16 Place de la Madeleine,
75008 Paris, Tel: 01 44 51 51 53/57, Portable: 06 19 31 87 42
E-mail: a_s_aime@yahoo.fr, asegla@orkestra.biz, aime.segla@ethnologie.uni-halle.de

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Yoruba. Partant, l'article examine soigneusement la question de savoir pourquoi le calendrier divinatoire du pays Idààcha qui est un pôle significatif de la périphérie occidentale du pays Yoruba préserve une logique spatio-temporelle très ancienne par-delà Ifè et le revisionnisme oyo. Finalement, il conclut que la lecture simultanée des représentations spatiales et géométriques, en même temps comme des données temporelles, suggère une nouvelle approche de l'étude de la cosmologie en rapport avec le corps humain. Puisque le corps est dans le cerveau, nous dirons, en rapport avec l'esprit humain.

Keywords: /Mots-clés: *Cosmology in metrology, belief and knowledge, Yoruba history, spatio-temporal thinking* / Cosmologie en métrologie, croyance et connaissance, histoire yoruba, représentation spatio-temporelle/.

Introduction

This paper is in honor of and was presented shortly after the 2006 Total Solar Eclipse in West Africa. In connection with that particular historical and celestial event, one major theme is developed in this essay: the recovery of layers of historical memory in Idààcha practices and language forms to shed light, first, on Idààcha-Yoruba cosmological vision and second, on early Yoruba culture and history – Idààcha is a western dialect of Yoruba in the center of Benin Republic (Fig. 1). For this analysis, we use specific techniques of semantic reconstruction in Idààcha dialect of Yoruba and spatio-temporal encoding based on the mathematical foundations of – perhaps – an earlier form of Ifa divination. We examine different cases as kinds of incorporation of Yoruba cosmology into real life. Using Idààcha as a case study, we try, first, to show the intrinsic character of the human mind. We then give some epistemological conclusions and lessons to engage young African people and we suggest the importance of teaching African technology and particularly cultural astronomy in African classrooms. Secondly, we show why, Idààcha being a significant western periphery of the Yoruba region, its divinatory calendar would preserve an older spatio-temporal logic, beyond Ifè and Oyo revisionism in Yoruba history.

The Intrinsic Character of the Human Mind from a Case Study of Yoruba-Idààcha Cosmological Vision

Celestial observations and the associated beliefs and Deities are common to people around the world. The cosmologies of the Batammaliba from northern Benin and Togo, the Sotho, the Tswana, the Xhosa and the Zulu of south Africa, the Mursi of Ethiopia (Holbrook 1998), and of course that of the Dogon of Mali and the Yoruba of Nigeria, Benin and Togo, are not in anyway envious of that of Western people.

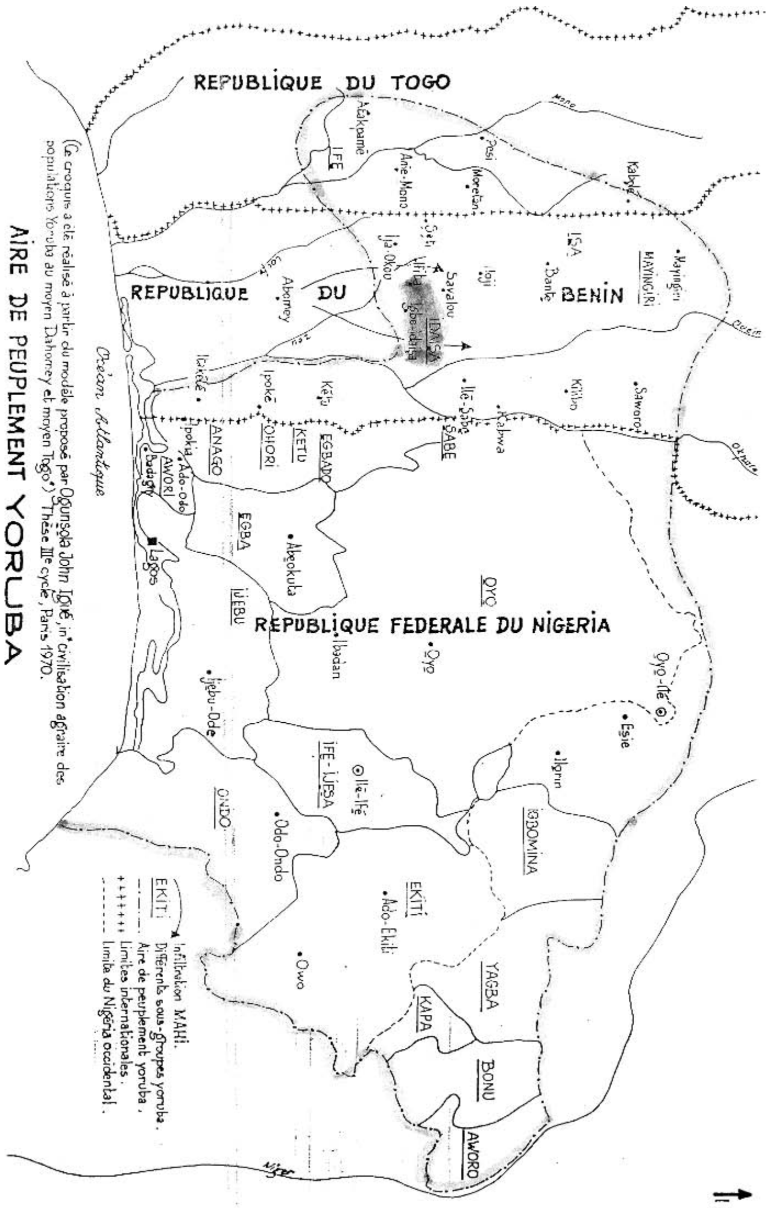

Fig. 1 Yoruba population area from Igue (1970)

Let us take the example of the Yoruba. The 29th March 2006, day of total solar eclipse in West Africa, the Idààcha people chanted their ritual telling the sun to let the moon go. The traditional song says: *"ojurun (oju orun) mu osupa, bi alele e jo e [...]"*, which means: "*the eye of the sky (sun) has captured the moon, it will let her go when comes the evening...*". The Idààcha eclipse song considers indeed the sun like a magnet which captures the moon and lets it go after some time. This sounds like the heliocentric conception model of the universe developed and defended by Galileo. From a comparative standpoint, the difference is that traditional Idààcha people's knowledge is highly intuitive and oral, while the knowledge of Galileo is theoretical and highly developed and written.

Again, from the Yoruba Idààcha people, the reading of eight consecutive time zones from midnight, *iwon ri iwon ogun mejo* which means "*the adding of measurement*" (Measurement has seen measurement and so on eight times, the process giving finally a total accumulation of eight measurements) is reminiscent of the practice of the Italians who also used to count 24 hours consecutively and not twice a dozen hours. The practice is also that of the moderns astronomers like Ptolemy who counted "24 hours consecutively between two middays" (Arago 1854). If midnight which is said to be called in Idààcha *iwon ri iwon* (measurement has seen measurement eight times) has been taken as the beginning and at the same time as the finishing point of the whole day, in other words, a time which goes from the unit time zone *iwon* (the base of the measurement) to eight units *iwon ri iwon ogun mejo* – measurement added eight times (Fig. 2), the modern astronomer Copernicus, the Egyptians, Hipparcus, the ancient Romans, the French, the English, the Spanish did the same way in fixing also midnight as the beginning of the civil day (for more details about *iwon ri iwon*, see Sègla et Boko 2006).

Let us give again another example: in Europe, it is speculated that the observation of the seven visible celestial bodies – five visible planets and the sun and moon – inspired the Gregorian week of seven days. But for all the Yoruba, the original and founding myth says that the world had four corners at the time of its creation. This is the bases of their week of four days. It is what the Yoruba call *orita* – the crossing road. In Idààcha, the same idea is more mathematically explicit (Sègla 2003). The conception is indeed unusual. According to the legend recounted by an Idààcha man in Magoumi in Benin Republic, a Yoruba Idààcha man, who wanted to avoid having his four sons each hide in a corner of the rectangular *ogba (hut)*, preferred to build a hut that was circular *agbo*, a word associated with the expression *ilé eniyan merin* or in a shortened form *amerin* (Idààcha),

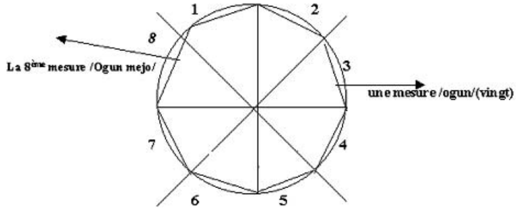

Fig. 2 Iwon ri iwon – measurement has seen measurement eight times consecutively

meaning *house people four*. In this way, the father ensures the unity and power of his family. In fact, for the man from Magoumi, the four corners of a rectangle are gathered together at the center of the circle. This is also the origin of the name given to the center of a circle *eerin* which means *four*. In traditional Yoruba enumeration, the series *one, two, three, four, five, six, etc*. corresponds to the sequence of cardinal numbers *ookan, eeji, eeta, eerin*.... The equivalent numeric adjectives are *mokan, meji, meta, merin*..., which are noun-phrases containing a verb. The verb that acts in them is *mu,* which means *take* or *separate*. Thus the sequence is *mu ookan (take one), mu eeji (take two), mu eeta (take three), mu eerin (take four)*...etc. The imagining of the circle in the language system starts from the conception of the rectangle with its four corners. Thus taking these corners away one by one, the figure of the circle is like *four corners dissolved in the center* (Fig. 3) or *four corners taken to the center, amu eerin* (Idààcha) meaning *having taken away four.*

It is this idea that is intuitively present in Yoruba cosmological belief. According to that belief, the universe is round, and its creation starts with four corners, the four points of the compass encoded in the language system as *igun merin* (*angles four)*. A belief that inspires the Yoruba traditional calendar with the four-day market cycle and the Yoruba four-day week, each of the four days having been given the name of the four most important deities in Yoruba history who created the universe, Orunmila (the supreme God that is in the sky), Obatala (the first Yoruba aborigine king between 2000 before common era and 500–700 common era), Oduduwa (the king that founded the dynastic power in Ilé-Ifè between the Vth and the VIIIth century CE) and Shango (the king that represent the founding and the power of Oyo). Moreover, in the expression *igun merin*, *angle four, igun* is a noun in which, the verb *gun* expresses the idea of *meeting* or *bringing together* and so, *igun* signifying *corner* expresses the notion of making two walls meet making a right angle. Thus, in Yoruba, *igun* is in principle a right angle, and indeed the traditional Yoruba house is rectangular *ogba*, with four right angles. Here we see how the conception of the circle is obtained starting with the center defining the totality, meaning the circle and all his other elements in the "*powerful*" center. The traditional organizations of a Yoruba village and the family group can serve as a social illustration. The chief of the family group whose house is situated generally at the center of the family compound, in a Yoruba town or village, is indeed *baale agbo ilé chief circle houses*;

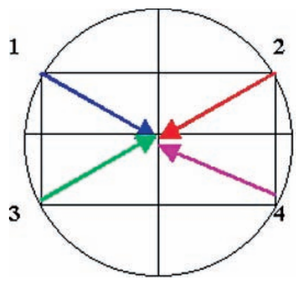

Fig. 3 Orita (crossing road)

the wives of the chief having their rectangular houses on a perimeter that forms the circumference of a circle *agbo ilé*. This shows how the mnemo-technical device of geometrical and spatial order is also a landscape of memory.

But how came this to be? In fact, these different concepts and representations of Yoruba people – the Idààcha in particular – have a cosmological origin. It is that cosmological vision that gives Figures 2, 4 and 8 sacred status placing them in the center of all Yoruba cognitive activities. A type of priest, Babalawo – *owner of secrets-* in Idààcha country speaking old Idààcha – a dialect closed to the original Yoruba language ''Ifè tutu, Icha tutu" – described the rituals sequences before a divining process (Sègla et Boko 2006): the diviner, before divination, refers to the *air* to announce an imagining body in circular movement. This is symbolized by the divinatory chain that the diviner turns around a vertical axe. He then marks the center of the imagining circle. The divining chain with 8 cowries, each of them having a concave and a convex face, is then put down following the vertical axis in the center of the circle. The diviner recovers the chain with the bag that was used to contain the chain before. By this way, the diviner looks for *heat*, in another word *fire*. Then, the diviner continues the ritual in putting a little water at the four corners of the circle, in front, behind, at the right and the left of the divining chain set down at the center. This manner, he called for *water* and by referring to the four cardinal points, he signifies that the body in movement is *earth*. And finally, the chain being always at the center, the diviner calls for the cosmos spirit to complete the process of *Eeji-Onilè* which means *the two that possess the world*. The diviner says: "I *have now got the four necessary elements on earth. May God give me the four counterpart corresponding elements which sit with Orunmila or Olodumaré in the sky.*" At that stage, the diviner can throw down the divining chain and identify a configuration for interpretation (Fig. 4).

The divinatory traditional calendar is so based on two forces – as is also the divinatory Ifa system: first, there are the earth forces with four (4) signs (fire, earth material, air and water) and second, there are cosmic environment forces also characterized by symmetric correspondent signs of that of earth counterparts in the sky. It is the elements of that couple *Earth-Sky* which interacts with each other and gives indication to the diviner for predictions. The association of the two gives meaning to the Yoruba expression *Eeji-Onilè, the Two that own the Earth*. In comparison,

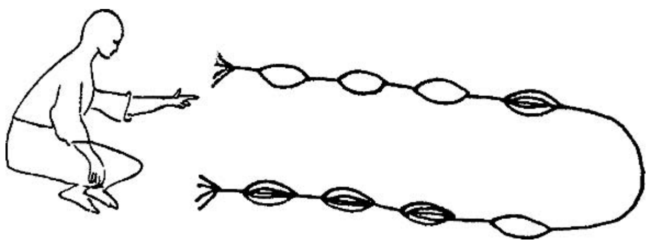

Fig. 4 The divining chain

Swerdlow (1998) reported a similar practice among the Chaldean. Swerdlow who reported Oppenheim (1974) wrote that

> The principles of divination from natural phenomena are set out in a text of the Neo-Assyrian period, [. . .] as "A Babylonian Diviner's manual", containing catalogues of two series of ominous signs on the earth and in the heavens, both astronomical and meteorological, that explains the relation of signs in the heavens and on the earth to each other [. . .] The signs in the sky just as those on the earth give us signals [. . .] their good and evil portents are in harmony (i.e., confirming each other). The Sky and earth both produce portends; though appearing separately, they are not separate (because) sky and earth are related. A sign that portends evil in the sky is (also) evil on earth, one that portends evil on earth is evil in the sky [. . .]. These are the things you have to consider when you study the two collections. (Swerdlow 1998: 3–4).

In the Yoruba case, the signs of the sky and that of the earth forming the *Eeji Onilè* reflect and clarify the duality inherent in Yoruba system. Four signs on earth and four signs in the sky interacting is the reason of the presence of eight cowries on the divining chain. In fact, for all the Yoruba, Morton'Williams (1964) has reported that

> The House of the Sky is the domain of the supreme God, Olorun Olodumaré (Olorun means 'Sky-Owner') [. . .]. The Earth is the domain of the Godess Onilè, Earth-Owner, who is sometimes simply called Ile [. . .]. Life in the third cosmic realm, Ilé aiye, the house of the World, is good only when good relationships are maintained, with the gods and spirits of the other two [. . .]. (Morton-William 1964: 245–246) (Fig. 5).

This cosmological conception and vision of the Yoruba people – the Idààcha in particular – is incorporated in real life: we already described before the day and the night equally divided into four (four time zones) and the whole day divided into eight parts. The week has four days, the month has seven weeks of four days. A particular use of this principle in Yoruba-Idààcha country is the mortuary ceremony

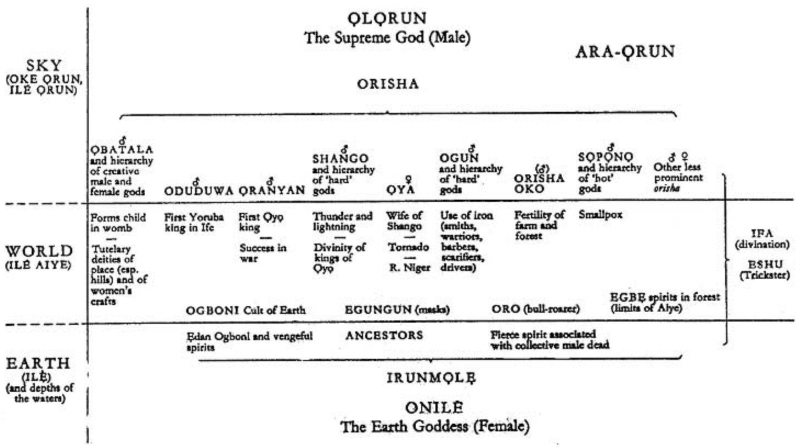

Fig. 5 Eeji onilè(the two that own the earth): Cosmological model of the Yoruba, from Morton-William (1964: 249)

which takes place the day of the sixth market after the death of a dead person, *oja mefa (market six)*, in other words, six weeks of four days after the death (Fig. 6).

More interesting, all the traditional ceremonies in Idààcha [the ikodun (annual harvest ceremony to celebrate the sufferings of the year), the oja mefa (the mortuary ceremony), the eru gbigba (the acquit-ment ceremony of the dead person) or the ode gbigbe (the hunter ceremony to acquit the dead person who has been a hunter in his life)] are regenerative rituals that recreate original time (titi *lailai ati lailai*) (*lost in the past and deeply lost in the past*). This has been also an observation by Horton (1970) in his work about Africa. Horton has given it the qualification of "rites of recreation" or the "return to the beginning" (Horton 1970). Even the most fundamental Yoruba deities and the secondary deities are derived from the diagram of worldly creation Orita. In other words, they are all derived from two and four. The most fundamental deities are 4^2 or $2^4 = 16$, and the secondary deities are 32, 64, 128, 256 (2^5, 2^6, 2^7 et 2^8). The scale of sacred Yoruba values, 1, 2, 4 and 8 (2^0, 2^1, 2^2 et 2^3) and 16, 32, 64, 128, 256 (2^4, 2^5, 2^6, 2^7, 2^8) are the products of the divining chain giving a total of 256 divination chapters which are all coded linguistically in Yoruba language. It is not only an incorporation of cosmological standards for the rationalization of life but the system affects also the intellectual activity. Indeed, the Yoruba mental model built from cosmovision is a generative scheme that has founded the twenty base oral numeration system which was originally a five base system. The five base system moved then further to twenty base by the incorporation of the cosmological mental model (Sègla 2004b). It is the same principle that founded the binary and hexadecimal code bases in Ifa. Indeed, in Ifa, it is the divining chain as a medium and form of inscription that gives a place value numeration system. Because the cowry shells appear on two sides of the divining chain and are aligned, viewed from the left to right and from bottom to the top, there is a resource for the hexadecimal system to occur. The 256 Yoruba linguistic codes in Ifa are thus all hexadecimal and at the same time they are convertible to binary codes (Sègla 2004a). In the computer machine language, a structurally identical system represents all numbers and all alphabetic characters that is also the base of high modern computing. Of course, the US army developed and used the same principle to improve its computer data system and organization in the sixties. It is the same principle which is nowadays generalized and is at the basis of the Great Computer Data and Audio revolution.

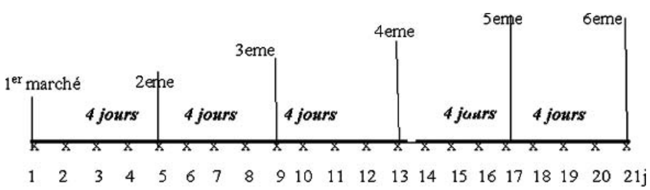

Fig. 6 Oja mefa (mortuary ceremony: market six), from Sègla et Boko (2006: 23)

Idààcha Divinatory Calendar – a Spatio-temporal Logic Beyond Ifè and Oyo Revisionnism: A New Light on Yoruba History and Culture

Considering several data gathered from Idààcha, we affirm that this essay addresses earlier pre-colonial constructions in a divination calendar rather than echoes of European contact. We maintain that study of Idààcha divinatory calendar gives evidence of a pre-Ifa divination system that remained immune from Ifa hegemony, sharing claims of aboriginal status with a cluster of associated cults; or evidence of archaic ritual language forms, echoing earlier spoken dialects that resurface in the voices of possessed devotees in Idààcha land. But, does a simpler divinatory matrix imply earlier history? Many parts of Yoruba land have nowadays divination with (*obi) (kola nuts)* and cowries. Does this imply an earlier form? Indeed, if formal correspondences between 2's, 4's and 8's do not in and of themselves prove anything, what is a proof is the straight path that Idààcha divinatory calendar draws towards Yoruba past, reaching the aborigine original Obatala period in going through cosmological and spiritual sacred Ilé-Ifè. To maintain why Idààcha is a significant western periphery of the Yoruba region and why its divinatory calendar would preserve an older spatio-temporal logic, beyond Ifè and Oyo revisionism, we give two series of arguments: First, we take into account the considerable debate concerning the sacred status of Ilé-Ifè in relation to the Oduduwa migration or conquest, on the one hand, and the rise of the Oyo Empire, on the other hand. Robin Horton (1979) covers a lot of important ground and makes an "elder statesman" argument that we address, engaging the positions of Akinjogbin (1980), Atanda (1996), Olomola (1976) and Shaw (1980) on the fact that a pre-Oduduwa ancient and aborigine period exists in Yoruba history. Akinjogbin (1980), when reconstructing the oral tradition of origins (Ikedu) confirms a later Oduduwa conquest of Ilé-Ifè. We also mention Obayemi (1979), Apter (1987) who cautiously reviewed the historical problematic of the Pre-Oduduwa Yoruba "base-line", highly mythic and hypothetical, as is the Ilé Ifè's enduring sacred status well illustrating a cosmological and spiritual origin of Ifè – *Oduduwa coming from the sky, from the earth or from the ocean to create Yoruba cradle in Ilé-Ifè*. We also cite Samuel Johnson's *History of the Yorubas* [1948(1921)] in relation to the rise of the Oyo empire and to colonial discourses of Yoruba nationhood and imputed migrations from Egypt or Mecca denying the cosmological origin and therefore the sacred status and spiritual dimension of Ilé-Ifè. Indeed, Oyo neglected, ignored and contested the ideological and cosmological text that Ifa represents in Yoruba history and that Ifè was taking care of as well (Apter 1987). In situating the political and historical contextualization of these three great Yoruba periods (Sègla et Boko 2006), it appears that Oyo is a revisionist vision in Yoruba history while Ifè remains its spiritual and ideological virgin version permanently in opposition to Oyo. Not surprisingly, Oyo empire and colonial Oyo have been for long dominated by conquerors and looters who were, somehow, very less interested in intellectual and cultural matters. [For more detailed analysis on these three periods, see Sègla et Boko (2006) and Apter (1987)]

Regarding the frontier line between the ancient period and the Oduduwa period, we cite Obayemi (1979):

> The Oodua-Obatala legends, the Igbo-Ifè rivalries [...] answer unequivocally in favour of the "imposition of a new order from outside", of Oodua landing from "orun" on Ora Hill and from there encroaching upon, overthrowing and being resisted by the bearers of the indigenous culture, the Igbo culture with its artistic fluorescence, under the leadership of Obatala. Dynastic Ilé-Ifè was the fusion, the compromise of the two. The Oodua-obatala legend, following the archaeological reconstruction would then be telling us of the pangs of integration of two systems – an "indigenous" one with its multi-settlement character, with the new socio-political monolithic dynastic culture, with its idea of a nucleated settlement (a city wall).

According to Obayemi (1979) and on the basis of archaeological findings around Ilé-Ifè, the Igbo, from the actual Ile-cha and the Ifè who spoke the same language (the ancient original language Ifè-tutu or Icha tutu) continued to live together after the establishment by Oduduwa of the new dynastic political order V-VIIth century at the latest (Horton 1979). However, dispersions, at the same period, from Ilé-Ifè and Ilé-Icha to the East and to the West are plausible. To the West, we have in mind here very ancient Yoruba kingdoms like Igede, Popo, Ketu, Chabe, Iloji and Ifita which already existed from the X–XIth century at the latest (Dunglas 1957), (Igue and Yai 1973), (Gayibor 1985), Eades (1980). To take it briefly, giving archaeological data and glutto-chronological analysis results, Yoruba language differentiation as a distinct group from that of the Kwa would take place near by 3000 BCE, somewhere in the actual region of Niger-Benoue-Congo (Horton 1979). More ever, some independent groups developed an original proto-Yoruba language near by 500 BCE (Horton 1979). These groups were probably those who spoke original language Ifè-tutu or Icha-tutu. Horton (1979) thinks that dispersions of proto-Yoruba from there to the south and to the west would have begun already 500 BCE. These dispersions have continued reaching their highest point at 500 CE – at the time the actual Yoruba population has been constituted and completed. It is these dispersions that have been accelerated by the new dynastic political system introduced by the dynastic king Oduduwa near viiith–ixth century (Obayemi 1979). One can then says that the Yoruba kingdoms at the West of Ilé-Ifè like Igede, Popo, Ketu, Chabe, Iloji and Ifita existed already from the ixth century at the latest. Ifita (Ifè ita) which means *the Ifè of abroad, the Ifè of the west* has given rise later to the kingsdom of Idààcha from the XV–XVIth century under the pressure of the Fon raids and invasions (Fig. 7).

Second, we supplement the semantic reconstruction of Idààcha root-morphemes in divinatory calendar with other linguistic data, that is, oriki (litanies, – *erikin* in Idààcha)-, oral histories, hunter's chants which tell of various migrations to see how local Idààcha historical consciousness agrees with our claims. And interviews with diviners illuminate the fact that the spatio-temporal metrics of the divinatory paradigm E*eji onilè* (*the two that possess the universe*) makes local sense. We hear for instance from different Olorisha and Aworo and from the Ogboni elders (adepts of secret cults, secret holders) in Idààcha, and their esoteric well confirms claims about the earth – the Edan Ogboni captures the pairing of the owners of the earth very nicely. They all are those who are original owners of the land before the

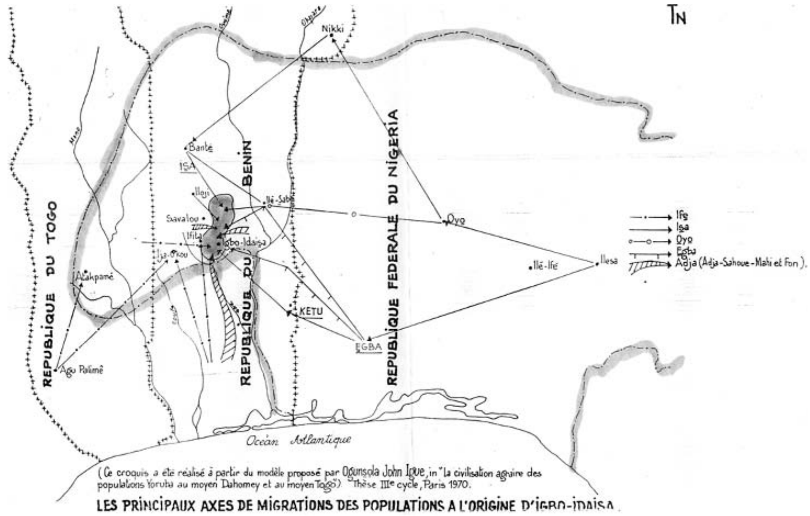

Fig. 7 Main migration axis at the origin of the foundation of Idààcha

dynastic Ifè Egba Omojagun immigrants arrived from Ifè – In fact, the Omojagun are those who rule the dynastic power nowadays in Idààcha country. We also see the major Orisha cults in Idaacha, and what visions of the past they perpetuate, that is Obatala orisha cult or localy called Baba n'la or Ocha. Here are below some of selected linguistic data about such claims:

Leading by a so called *Oba Ayaba Oké* (Adédiran 1984), the litany (*oriki or erikin in Idààcha dialect)* of the first Ifita says they had simply emerged from the earth on Ifita neighboring mountains. Parts of the Ogoja litanies – one of several Ifè ifita lineages in nowadays Idààcha – is told and explained by Bara Boko[1] (Boko 1997):

"- Tete ase ti wa li eyinode
- Ifita ti wa li itemu li ijemu
- Ifita ti wa li ajiwo li ajite
- Atilese a san li isuyi omo ase mu. . .
- Omo eweka si a ni onia ku
- Omo atilese li Oke Ejofa."

Which means:

- Before everything, there is the principle of creation out of time and space
- The Ifita existed long time before at the worldy creation
- The Ifita appeared on at the same moment with the earth and the sky. . .

[1] By Bara Boko, 102 years old, Dassa-Zoumé, 16th august 1993.

- Descendants of those who came out directly from the earth on Ejofa mountain…

The Ifè and the Icha in nowadays Idààcha country preserv the consciousness of their oriental origin from Ilé-Ifè by giving the name of *Odi Ifè* to nowadays Idààcha area, Odi Ifè meaning *the opposit of Ifè, the Ifè of the west, the sunset Ifè*. The litany of the *Agenu,* one of the Ife pre-Oduduwa lineage still living at Ifita near by the city Igbo-Idààcha tells it. It is racounted and explaned by Allagbe Ogugara Mathieu Ogija[2]

"- […]Omo Agenu kee je Ere […]
- Omo a bi ko je gbomsa […]
- Omo Agenu li Iwudu li Odi-Ifè",

Which means:

- […] Descendants of those who dont eat the boa because it is their father
- […] Descendants of those who dont eat gbomsa fruits […]
- The Agenu are from the village of Iwudu in Odi-Ife.

Of course, the Ife and Icha lineages in Idààcha name the East as *ese ocha, ese baba n'la*, that is to say, the leg of the deity Obatala or Baba n'la. As to the West, they name it as *ese buku*, that is to say*, the leg of the deity* Nana-Buku. It is so surprising to see that while the pre-Oduduwa people in Idààcha worship *Baba n'nla (Ocha, Obatala),* the same are less interested in Oduduwa who is nearly non-existent. They also ignore Shango and they adopt Nana Buku, the deity they appropriated after their later contact with the Akan people of the West (Badjagou 1986). How to explain such jumping in their history from Obatala to Nana-Buku without Shango, the terrific king and deity of Oyo if not their intimate, considerable and strong links with the original aborigine Ife. The apparent solid attachment with aborigine pre-Ifè is locally expressed by the following litany:

"Ilé-Ifè, Ilé Owuro,
Ilé-Ifè Oodaiye, nibiti ojumo ti mo wa,
Ilé-Ifè ori aiye gbogbo"…

Which means:

- Ilé-Ifè where the worldy creation took place and from where came the first light,
- Ilé-Ifè, the country of past times, the house of the beginning (aurora),
- Ilé-Ifè is the place of worldy creation of the whole universe.

[2] By Allagbé Ogugara Mathieu Ogija, 69 years old, in the village Itangbé (Dassa-Zoumé), 26th august 1993.

Other litanies are chanted by worshipers and devotees of earliest traditional Yoruba cults in Idààcha like sapata or sanponan, omo-olu, osumare, iji, baba-n'la and ogun. That is the case of the descendants of the pre-Oduduwa who came from Ile-Icha through Oyo and living nowadays in the areas of Kamate – that is the Isagule-, in the areas of Oké n'la – that is the Ayangi of Oké n'la -, in the areas of Chachégun – that is the Isasiogun (*the Icha have avoided the war, have won the war)* – and in the areas of Ichopa with the Omo-Icha d'Ichopa. Morton-William (1964), in his studies concerning Yoruba cults has given a particular attention to the languages very close to original Yoruba languages Icha-tutu and Ifè-tutu. Indeed, Morton-William (1964) believes that the secret Yoruba cult named *Oro* in Oyo is not under the contrôle of the Oyo themselves but rather under the leadership of the very old Yoruba community groups called the Jabata (Sapata). Morton-William (1964) could therefore write that "*Jabata is said to be a community of Sa (Sha) Yoruba origin, a western Yoruba people now mainly in Dahomey*" (Morton-William 1964: 256). The Omo-Icha in the actual city of Ichopa (Soponta in nowadays Benin Republic) in Idààcha country are of those people Morton-William is talking about. The litany of the Omo-icha lineage in Ichopa todays still keeps in mind the memory of their coming from Oyo under the leaderchip of the great hunter *Oba oli Iso Erin*, the chief hunter who drove them out of Oyo where they had been before the main persons in charge of the secret cult Egungun. Their litany chanted and explaned by Baso Ogunlaye Joseph tells the story[3]:

"- Omo iba liiso, Omo oloke,
- Omo Oba pasan li Eyo
- Omode ekiri meji l'owo
- Omo adara e ba onia gbe
- Omode afunwe tee l'ori oke
- Omo sebusebu ire omi ko dun sa
-Osese omi ko dun pa.
- Omo adara aa je onia aa f'abere ta eyin."

Which means:

- Descendants of Iba li iso or Baso, descendants of masters of hightinesses,
- Descendants of the chief Egungun of Oyo
- Descendants of great hunter, they always have two pieces of dry meat in their mouth. . .
- Descendants of those who own the deity Majufe and are always white dressed
- Descendants of those who know that it is not easy to run in water, even slowly (in slow strides). . .

[3] By Baso Ogunlaye Joseph, 72 years old, an Omo Isa, 4th september 1993.

The other layers of historical memory in Idààcha are the Ogboni elders. Within the Ogboni or Oloro in Idààcha, we have the amule or the Oji (*the possessors of the earth)*, the ile (*the earth people)* of ilule, the Ikona or the Igangan, the Omo-iroko and the Omo-ayan or the Mamahun. Members of secret associations and priests of secret cults, they are omnipotent during king intronisation or king mortuary ceremonies. The litany of the Oji or the Amule lineage in Idààcha can express that very nicely:

> "- Omo Oji li Kere,
> - Omo isa Omo Ikee [. . .]
> - Omo a mu ile fu se odun da,
> - Omo oloro ko ro li ile. . ."

Which means:

> - Descendants of the Oji in the village of Kere from Iloji,
> - Descendants of the Icha from the Ikee group [. . .]
> - Descendants of those who know how to use the sand to replace gun-powder,
> - Descendants of secrets priests who never tell their secret. . .

The Igangan or Ikona, the Isesin or Agenu are good hunters very close to spirits, to nature and to ancestral lands. They have wild life and good habituation to wild animals, some of which are their totems. Their housing and living conditions remain nearly unaltered. They live in hamlets somehow. The litany of the Isesin is explicit on that[4]:

> "- Bi osan pan ka ma te li ilaju li Isesin Ilagbe
> bi o ko ri ejo e ri agema
> - Omo a mu ekun digbaro.
> - Omo a mu ekun laye se aja. . ..
> - Omo Asipa eru li Ijaoku li Ikunu.
> - Omo eru meji li ajiba.
> - Omo eru li Agalaju li Isesin.
> - Omo osan pan ko oja iku li Isesin."

Which means:

> - It is forbiden to enter the Isesin houses at midday,
> - Anyone would try it will meet a misfortune, a snake or a chameleon
> - Descendants of those who have panthers as guards. . .

[4] Recounted by Karita Hélène, an Isesin, 65 years old, in the village Kèrè (Dassa-Zoumé), 18th and 26th august 1993. Explained by Obalé Lucien, Chief of the Isesin lineage.

- Descendants of those who use panthers in place of dogs
- Descendants of Asipa, the terror of Ikunu in Ijaoku.
- Descendants of the two terrors of the wilderness, the hunters Oba Etan and Soaketedogu.
- Descendants of those who are able to cause death every time they want. . .

Like all the pre-Oduduwa people in Idààcha, the Igangan or the Ikona work outside the political order but surrounding and controlling it at the same time. Part of the Ikona or Igangan litany expresses it[5]:

"- [. . .] Omo efan dundun abe ira
- Ikona ko kale kin olu
- Ikona ko dagoo itannan ko wo odi Jagun [. . .]
- Omo aa se awo li iwanriwan ogun mejo
- Omo a je ohun oro maa bu f'aya."

Which means:

- [. . .] Descendants of the black buffalo under the Ira tree
- The Ikona who worship the divinity Arigbo can not kneel down when greeting the king Jagun.
- The Ikona enter the palace without submitting themselves to the protocol [. . .]
- Descendants of those who accomplish rituals and sacred ceremonies in midnight
- Descendants of those who eat offering sacred meals which can never be sent to women at home. . .

In summary, we have described and illustrated what Apter (1987), in Yoruba history, has called the "*euphemism of conquest*" which consists of a tacit distributing and sharing role between the dynastic groups and the autochthonous pre-dynastic groups. About Yoruba "*euphemism of conquest*", Apter (1987) citing Lloyd (1955) wrote the following:

> "Yoruba ideas of legitimate authority require a king to rule by virtue of his royal genealogy and reputable judgment, not by the military power of his ancestors. For this reason, conquest is rarely mentioned in the founding myth of kingdoms. Instead, a common euphemism of conquest is that the original ruler of a town invited the conqueror to assume leadership while he devoted his whole attention to town rituals." (Apter 1987: 8).

And also the role the Ogboni elders *(Oloro)* play in Idààcha is the one that was assigned to the most ancient inhabitants of the lands in order to reward them from

[5] By Karita Hélène. Explained by Ajasin Josué. Chief of the Ikona (Igangan) lineage, 85 years old, 26th august 1993.

losing the political power in Idààcha. Nowadays Idààcha, the power is in the hands of the Jagun who are Oduduwa lineage descent. The tradition in Yoruba history is maintained since the conquest at Ilé-Ifè by Oduduwa when the autochthonous Igbo people set up a secret cult called O*gboni* in order to pursue the worship of their Orisa (deities). These rituals and traditions are still in practice in Idààcha country in memory of the pre-Oduduwa Yoruba founding myth who is Obatala, Baba n'la or Ocha. Obviously, the given above answers many questions about Idààcha and confirms well the essay's main assumption, that is, why Idààcha and its divinatory calendar would preserve a spatio-temporal logic beyond Ifè and Oyo revisionism. Let us look at these important questions, that is: why in the pantheon in Idààcha land, there is principally the deity Obatala also called locally Baba n'la or Ocha?; why the Oduduwa cult is less represented while Nana Buku, the deity they appropriated from their early contact with the Ashanti of the West is more represented?; why in Idààcha land is there the Ayira cult and not the Shango cult as in Oyo for the same deity (*deity of thunder)*? – Shango was a major king of Oyo, was a terrific king and has been associated with thunder; why the priests of the deity sanctuaries and the Ogboni elders in Idààcha are the owners of the lands or the first arrived in Idààcha, the Ifè and the Icha tribes? And why all the rituals, the cults and all the traditions in Idààcha accord with the symbolism of the crossroads, the diagram of worldly creation (*orita*)?

Epistemological Conclusions and Lessons

First of all, on the technical level, the Yoruba-Idààcha idea of reading spatial and geometric relations as temporal and algebraic terms – and vice-versa may suggest a new indexical approach to the study of Yoruba cosmology in relation to the human body and mind. These facts reported from Yoruba-Idààcha case studies demonstrate the intrinsic character of the human mind and they need to be known by African people, especially the young people by introducing disciplines such as cosmology and astronomy in school curricula in Africa south of the Sahara. The young students and the young researchers must know that they can mine the stock of traditional knowledge to augment the actual state of science and technology. For example, taking the Batammaliba of northern Benin and Togo or the Dogon of Mali examples, cosmovisions are set down – incorporated – in local everyday life. Indeed, they give inspiration to meticulous and ingenious traditional architecture and ways of local building techniques – structures, aeration, urbanism, design, etc. It is in these examples that young researchers should draw references for new technological innovation to improve housing accommodations for people in villages and in cities. Because, nobody sleeps very well now in these so called modern cement houses – they are in fact heating machines – inherited from the colonizers. In the same way, young philosophers, mathematicians and linguists should consider that African languages convey the same universal concepts though their particular contextualization – have the same ability of conceptualization of new phenomenon – so that, if integrated in school curricula – the scientific cultural level of African people can be raised to that of those in the West. Socio-economical success in Africa south of the Sahara depends partly on how African rationalities will be restored and stabilized. In fact, like other studies presented at the Solar Eclipse Conference 2006 in Cape Coast, Ghana, and in light of this Idààcha case study, the cultural perspective on science and technology, and its development in a traditional society depends on anthropological research. It illustrates a form of rationality serving as an empirical basis for theoretical constructions and technological innovations resulting in the stability of traditional foundations.

On the historical level, study of Idààcha divinatory calendar gives evidence of a pre-Ifa divination system that remained immune from the current Ifa hegemony, sharing claims of aboriginal status with a cluster of associated cults; or evidence of archaic ritual language forms, echoing earlier spoken dialects of Ifè-tutu and Icha-tutu, that resurface in the voices of possessed devotees in nowadays Idààcha land.

Idààcha should be regarded as a laboratory for the study of the ancient original Yoruba languages Ifè-tutu and Icha-tutu to shed light on original Yoruba historical memory and culture. Obayemi (1976) describes the situation of some Yoruba peripheral regions like Kaba and Ikale in Nigeria, or Ifè in Togo as something that reminds the social political organization that has existed at the time before the establishment in Ilé-Ifè of the dynastic centralized political power. About that, Horton (1979: 95) exclaimed: "*It seems unlikely that the social organization and culture of this diaspora remained homogenous for very long*." However, it seems to be the case. The absence of chieftaincy Oba or Oli Ilu (chief, owner of the land) in Ifè-Togo or in nowadays Icha land in Benin Republic would probably be due to the fact that "*euphemism of conquest*" did not take place at these places. And this would tell us why it is only the pre-Oduduwa lineage tribes who arrange common social life without any dynastic established political traditional power as is the case in Kétu, in Igbo-Idààcha or in Chabè. Anyways, the pre-Oduduwa relics or clusters seem to represent important layers of historical memory and moreover semantical truthfulness in Yoruba history and culture. More seriously, exploring the three great historical periods in Yoruba history, we ask which historical layer is the most important in Yoruba history – it is the pre-Oduduwa cultural baseline that Icha-Tutu or Ifè-tutu represents, or an Ifè-centric system that survived Oyo revision, or an Oyo-based system that survived British and French colonialism? Our conclusion is that, it is the Ifè centrism system that is primary, the pre-Oduduwa period that is secondary and the Oyo empire and colonial Oyo that is at the bottom. Finally, a case study concerning Idààcha that uses a technique to reconstruct some important elements in Yoruba history may suggest not only a new indexical approach to the study of Yoruba cosmology in relation to the human body but also may suggest the interpretation of Yoruba cosmology as a collective generative mental model.

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The Relationship Between Human Destiny and the Cosmic Forces – A Study of the IGBO Worldview

Barth Chukwuezi

Abstract The Igbo Society in Nigeria has a complex relationship between their destiny and the cosmic forces, which is reflected in their various ontological worldview and cultural configuration. The moon, stars and other heavenly bodies have a lot of import on the socio-cultural activities of the Igbo people. This paper seeks to examine how these heavenly bodies influence and even direct various socio-cultural organizations of the people. These are quite evident in the various life cycles and beyond such as at birth, death and even life after. The paper is situated in the realm of cultural astronomy, which will examine the various cosmological beliefs that affect the Igbo cultural organization. This paper is quite necessary since some of the beliefs are being lost and not articulated due to the impact of Christianity and modernization.

Introduction

The Igbo live in the southeastern part of Nigeria and are largely patrillineal descent oriented with strong religious inclination that pervades social activities both in the traditional and modern society. They are one of the many ethnic groups that make up Nigeria. The cosmic forces being referred to here are the heavenly bodies – the moon, the sun, the heavens (sky) and the stars, which have relevance to the social structure and social organization of the Igbo people and consequently influencing their worldview. Worldview here refers to the various beliefs and practices, which inform Igbo belief systems, social structure and social organization including the entire cosmogony and ontology of existence or being. Nwala (1985) has referred to worldview as the basic belief which a people may have about the origin and nature of the universe and life existence. It is a system of ideas, opinions and conceptions of nature, society, humans and their place in the world. Throughout human history and culture, people of all cultures have looked at the sky to improve their daily lives, gather food, survive the environment and use the sky to find meaning in their

Barth Chukwuezi
Association of Professor, Department of Sociology/Anthropology, University of Nigeria, Nsukka

existence. For example, Holbrook in her study of the people of Kerkennah in Tunisia has recorded that the fishermen still use the stars for navigation for their fishing activities (Holbrook, 1998).

Destiny in this discourse will refer to the various forces, heavenly forces, which the Igbo people believe influences what happens to them. This is inextricably interconnected with their worldview which orders their existentialism.

The study will attempt to situate the discussion in the traditional Igbo society in order to understand the various facets of social structure and organizations that have been influenced by these cosmic forces. The traditional Igbo society is quite appropriate for this analysis because it captures the period when these practices were discernable in the social structure before the influence of Christianity and modernization. Some of these traditional cultural practices anchored within the Igbo worldview are still evident within contemporary Igbo social activities and thought patterns. The traditional worldview in some respects still influence the modern worldview of the Igbo. The belief in spirit forces, which was quite preponderant in the traditional society, is still relevant today. The people still believe in spirit forces. There are ritualists both in the traditional religion and Christian Pentecostal gatherings who claim to see beyond the natural eye, (Kalu, 2002: 350).

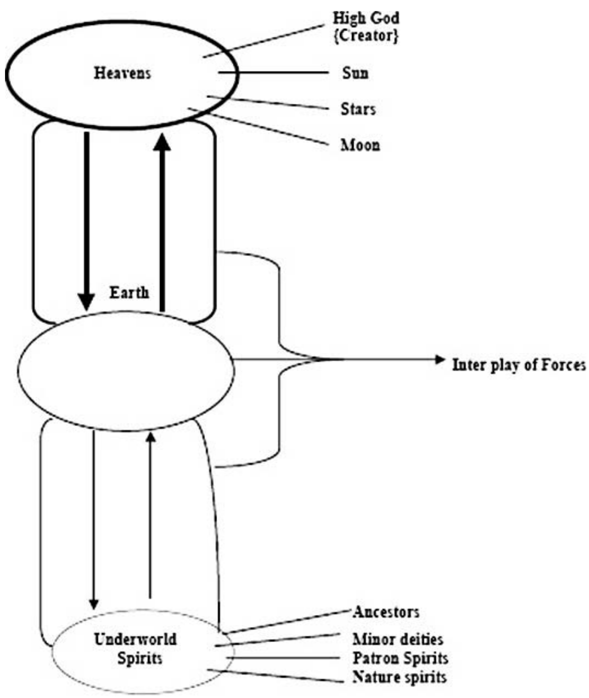

Fig. 1 Diagrammatic representation of the Igbo worldview

Igbo Cosmogony

The Igbo cosmogony or ontology is rooted in the belief that there are various beings that inhabit the universe. The supernatural beings inhabit the realms above, the spirit beings including the ancestors and other spiritual forces inhabit under the earth and finally the human beings inhabit the earth. The heavenly abode is where the creator Chineke, the Almighty lives and he is quite far from humans. The other heavenly forces that are highly revered such as the sun, the sky, the stars and the moon also inhabit the heavens. The Igbo believe in the dynamic interactions among these forces and beings with corresponding powers and hierarchy. The supreme God and his heavenly bodies have the highest power followed by the spiritual world of spirits and ancestors and finally the humans who live on earth. It is left for humans to manipulate and harness the spiritual forces on earth, above and under to fashion a well-deserved society. The Igbo people have specialists such as medicine men, dibia (native doctors) spiritualists, etc. who are quite versed in ways of harnessing these spiritual forces for orderly existence. It is the aggregate of beings both in the natural and spiritual reams, which order the world space and activities of the Igbo society. The preponderance of religion in most of the Igbo people activities derives from the people's perception of their universe and worldview. The activities of humans, social, economic, political, technological, etc. are the concern of humans as well as the gods and the universe (Kalu, 2002).

Van Gernnep (1960) argues that the universe is governed by a periodicity, which has repercussions on human life with stages and transitions which involve different types of movements and development. The celestial changes tend to depict changes from month to month season to season and from year to year. This statement also applies to the Igbo people. The universe is seen as the regulator of human events and human cycles that are divided into various cultural activities denoting the passage of time and events. The religious cosmological worldview tends to be validated by the various life cycles of the Igbo right from birth to the grave. The various rites of passage are sanctioned and were related to the cosmological worldview which involve various ceremonies right from birth, naming of a child, initiation to boyhood/girlhood, manhood/widowhood, marriage and finally death. The various forms of relationship of the cosmic forces in the people's social structure and social organization will now be discussed in Igbo ontology.

The Heaven (Sky)

In Igbo the heaven or sky is called 'Igwe'. The heaven is said to be the highest of the abodes. In Igbo adage there is a saying 'Igwe Ka ala' – the heaven is higher than the earth. In some parts of Igboland the sky or heaven has been transformed into a god or cult deity called 'Igwe Ka ala'. In Umunoha close to the town of Owerri there is a deity called 'Igwe Ka ala' which commands lots of respect and patronage from various Igbo groups. People come from far and near to consult the *Igwe Ka ala* deity.

The god is consulted for various purposes to mediate in the affairs of human beings. Ilogu (1974) has noted that the sky (Igwe) is highly revered and venerated in many parts of Igboland. In the current quest for title and status some Igbo people will assume the title ‘Igwe’ meaning the highest, for a highly placed individual. The traditional and even current Igbo society rulers in some parts of Igboland rightfully still bear the titled name ‘Igwe’ of their various communities. This title and status marks the person as the highest ruler of the community. Igwe symbolizes a high level of authority and status.

The sky is the harbinger of rain. In conjunction with the earth the sky produces food and plentiful harvest for human survival and as such the sky or heaven could be seen as an enabling source of fertility. The Igbo believe that the sky brings rain through the movement of the clouds. The clouds at various points in their movement release the rain. As a result of the manipulative force of the humans, people could engage ritual specialists who specialize in sending down the rain when required and these ritual specialists are called rain makers. Rainmakers use the manipulative ability of their ritual power to bring down rain when needed. The position of Rainmakers is commonly recognized in Igboland and they occupy a special position in the Igbo social structure.

Red Cloud (*Urukpu*)

Nwala (1985: 30–31) has pointed out that certain events on earth are symbolized in the sky. The movements of clouds in the sky have various social significance and are tied to various forms of activities. The red colour of the sky or clouds has significance in the Igbo people’s social activity. Among the Igbo people of Owerri the appearance of a red sunset is interpreted as a sign of death. When the read clouds appear, they interpret that someone has been killed and their blood is reflected in the sky. Nwala remembers as a child how his people of Mbaise, close to Owerri, felt great sorrow and anguish upon sighting a red cloud in the evening sky. They felt that the colonial masters had killed someone at Owerri. Owerri was the colonial administrative headquarter for the Owerri district. It has a magistrate court that sentenced people to death depending on their crime.

Sky watching and its concomitant experience in social life can be seen with observations and interpretations of the phases of the rainbow. When there is a cloudy sky with dark cloud gathering close to the earth and other signs of threatening rain, people associate it with coming rain. But if a rainbow suddenly appears during this time there is a general belief that it will not rain again. People fell free to go about their normal business believing that it will not rain. When there is not much cloud in the sky and the rainbow suddenly appears people are gripped with fear and apprehension. There is the general feeling that someone, an important person, is about to die since the rainbow appeared suddenly. There is another symbolic interpretation that the sudden appearance of the rainbow is an evil omen that is going to cause great sorrow to the community.

In Igbo mythology and ontology it is assumed that the sky is the husband to mother earth and people hold this concept in their various forms of relationships.

They see the earth as a female goddess and the heaven a high male god. The high god heaven sends its semen, the rain, to water and fertilize the earth for food production and bounty harvest. It is generally believed that when the heavenly powers are angry they seize the rain resulting in famine and drought and there is a special ritual to cleanse and appease the earth and heaven for rain to come down again.

It is also necessary to remember that the sky could be angry due to pollution of the earth by evil acts and behaviour, which may offend the earth, and as such the heaven may withdraw its bounteous harvest through withholding the rain. There is therefore the dual intricate relationship between the earth and the sky in Igbo worldview.

The sky is also seen as a defender of justice and the punisher of the wicked through the sending of lightning and thunder. In Igboland there is a deity or cult called Amadioha (Kamalu in some areas of Igboland) representing the thunder. Through the power of the sky it can send thunder, Amadioha. To any known evil person in the community to kill that person. The god of thunder sends thunder to unearth any devilish charm planted or buried against an innocent fellow. At times people go to look for such evil medicine at the onslaught of thunder. The Amadioha deity is propitiated through the Amadioha priest who works on his behalf. It is a dreaded cult in Igboland and at times people curse their sworn enemies to be destroyed by Amadioha. In traditional Igbo society the Amadioha cult is located at various Igbo communities where the god is worshipped by its devotees but also to assuage the anger of Amadioha.

The Moon (*Onwa*)

The moon plays a very important role in Igbo cosmology. The moon is not worshiped neither has it a cult or is it regarded as a deity. Yet it has much influence in Igbo society. The moon is always an interesting object to gaze at unlike the sun that is seen as harsh and too powerful to toy with. The moon is looked at as being benign and loving. Igbo people have the feeling that the moon lightens the darkness of the night. Various moonlight plays are staged among the Igbo communities to while away the night and prepare for the next day.

The moon influences various activities of the Igbo people. The various phases of the moon have different significance. There is the beginning, the quarter, the half and full moon. At full moon, people with mental problem get worse and at that period, people whose level of madness was regarded to be low could be seen acting violently. The moon also influences the Igbo calendar. In fact the Igbo calendar month is named after the moon, *Onwa*. The Igbo have 12 calendar months and each of the various months have activities ascribed to them. The third month is the period for planting though if the rain comes early planting could start in the second month. The fifth month marks the first harvest of New Year. Though in some areas this varies. The seventh and eighth months are usually marked by cultural festivities which may reflect particular festivals like dancing, masquerading, etc. The Igbo month has 28 days and the Igbo week (Izu) has four days. In present day Igboland people have continued to assume socially titled names like '*Onwa na etiri oha*' – the person that shines his or her light on people like the moon does.

The Stars (Kpakpandu or kpakpando)

The stars are known among the Igbo though there is not much information about the relationship of social activities with the stars. The stars are puzzled over at night and people admire the constellations that beautify the sky at night. People admire a night full of stars with shinning moon. Again when the sky is full of stars they know there would be no rain. But when the stars disappear and the sky becomes cloudy and threatening they associate it with rain and begin to prepare for that.

Shooting stars have social significance for the Igbo. The Igbo believe that when a shooting star appears in the sky, it means some important person is dead or about to die. Among some Igbo people, however, shooting stars are associated with good omens, that is, something good is about to happen.

The Sun (*Anyanwu*)

The sun is highly relevant in Igbo society and it influences the concept of the Igbo worldview which is reflected in their various social organizations. The sun is seen as the harbinger of day and night. It regulates when to work and when to rest and sleep. In parts of Igboland it is symbolized as a deity or cult, or even referred to as 'sungod'. The cult is used to propitiate the sun for its influence in the affairs of human beings. The Igbo have an ambivalent relationship with the sun. The sun is feared and regarded as harsh yet the sun is the giver of life and strength to humans. The sun is equally revered and respected. It symbolizes strength and masculinity. In parts of Igboland like in the town of Nsukka, the sungod cult is symbolized with an earthen pot and a ritual tree planted beside the earthen pot in front of the entrance to the family compound. It protects the family members. The Igbo name their children after the sun and at times they refer to some of their children as the sons of Anyanmu (Ilogu, 1974).

Conclusion

The paper has tried to examine the various socio-cultural practices associated with the cosmic forces among the Igbo, which influence their worldview. It has been posited under the rubric of Cultural Astronomy, which has to do with the cultural practices relating to heavenly bodies such as the sky, moon, stars etc. This exploratory work of Igbo cultural astronomy reveals a rich relationship with the sky. It is hoped that more studies would be carried out to consolidate this field of Cultural

Astronomy in Igbo anthropology discourse and studies. Soyinka (1976) has posited that in much of the traditional societies including the Igbo, most of the activities depended on the natural phenomena within observable processes of continuity, waxing and waning of the moon, rain and drought, planting and harvest. There is much to be explored in cultural astronomy to understand the various intricate relationships between humans and the universe.

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Cultural Astronomy in the Lore and Literature of Africa

Damian. U. Opata

The Sun is my God
And I shall worship Him
And His Wife the Moon
Who guards over us and puts us to sleep so we can be
Alive the following morning.

taban lo liyong.

Introduction

As Von Del Chamberlain and M. Jane Young (1996:XIII) have observed "Different people have visualized the sky in many wonderful ways through art, crafts, architecture, belief, religion, story-telling, lore literature and mythology." This paper examines the several ways in which African people have through belief, lore, literature and mythology, attempted to examine the sky—a profound phenomenon that the human imagination cannot but ponder on from time to time. Its positioning is so spatially strategic that only blindness can prevent one from encountering it. Its overall strategic positioning must have led the Igbo to coin the proverb: "If the eyes do not look at the Sky, what else would they look at?" Yet, all that eyes have been able to see while looking at the Sky are the clouds, the Sun, the Moon, and the stars. Despite the fact that these things are seen on daily basis all over Africa, the Sun, the Moon, and the stars continue to remain a mystery. Not only that, they continue to constitute objects of wonder, puzzlement, and admiration although the fact of their cyclic appearance and disappearance has compelled human beings to rely on them for ordering events in their life. This compulsion to order events of life according to human perception of these sky entities is best captured in the Igbo proverb to the effect that, "when the sky suffers from cholera, people begin to move their property about." This proverb refers to a situation in which people rush to secure their property whenever there is a heavy downpour. In this paper, therefore, I want to examine the ways in which different African peoples have reflected on the sky entities. Consequently, this paper is organized into two broad categories: the ontology and functions of these sky entities.

D. U. Opata
Department of English and Literary Studies, University of Nigeria, Nsukka, Nigeria
E-mail: optdamian@fastmail.fm

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Ontology of the Sun, Moon and Stars

In traditional Africa, hardly any attempts have been made to describe the shape and structure of these sky entities beyond what normal human eyes can see. Nothing is said about their size beyond what is seen and people never talk about their weights or mass. The stars are described as tiny objects. People rarely gaze at the Sun, but those who do know that at first visual encounter, the Sun is white and dazzling, but a sustained 30-seconds gaze would reveal a charming and alluring velvet, bluish colour, sometimes a resplendent dark green colour. One requirement among the Igbo who want to "open their eyes" *itu anya*, is that they must look straight to the Sun when it is bright, usually between 1 and 3 in the afternoon [Editor's note: This is not recommended and can cause permanent eye damage]. The conceptual equivalent of "itu anya" is the mystical notion of the "third eye" which enables people to behold what cannot been seen by the aid of normal human eyes. On such occasions, Sun gazing appears to be the most profound aesthetic and humbling experience a person could have.

In traditional and indigenous African world views, things that exist are either male or female, or sometimes, but rarely, neither male nor female. Many African languages are not genderised. The consequence is that an impersonal pronoun is used to refer to persons and entities, thus making it difficult to know the gender of many phenomena. Generally, however, traditional knowledge experts, especially diviners and medicine men and women can identify the gender of almost everything, from plants to stones and spirits. In addition, some African mythologies identify the gender of the sky entities especially that of clouds, Moon, and Sun. Taban lo liyong's poem from which the opening quotation to this study is taken is titled: "The Sun is my God and I Shall Worship Him When He Rises, Reaches His Zenith, and Reposes for the Night". In this poem by a famous East African poet, the Sun is regarded as male while the Moon, being the wife of the Sun, is female. Although Parrinder (1967:67) argues that, "There is not much mythology of the Sun and Moon, for in tropical Africa the Sun is always present and there is no need to call it back in winter", he goes on to give examples of countries and communities where the gender of the Sun and Moon is known. Among such people are the "Kraki people of Togo" where the Sun is said to be the husband of the Moon; the Dagomba of the same Togo, and some unspecified people in Angola. Among the Luiya/Abaluiyia of Kenya, both the Sun and Moon are regarded as males (Wagner, 1954:28).

The average African is not concerned about the gender of the Sun and the Moon. Traditional healers and medicine men and women are interested in the gender of the Sun and Moon because the cooperation of male and female forces is solicited for the efficacy of some medicinal preparations. As Umeh (1999:43) has noted, "certain entities or *Ogwu* are made when the Moon is waning, some when it is waxing and some when the Moon has gone in (i.e., Moonless night periods – New Moon). Feminists, especially radical ones are also concerned about the gender of the Sun and Moon. Particularly of interest to feminists is the question of whether it is the Sun or Moon that was first created. Although this has not yet featured in the discussion of goddess religions, the debate will logically extend to this issue. Eric Ten Raa (1965–6) recorded this myth about the Sun and the Moon among the Sandawe people of Tanzania.

> *Very long ago the Sun, who was the son of Mathunda,*
> *Lived in the north [the country of] Omi.*
> *In those olden days the earth was very beautiful and cool,*
> *And the ruler of the earth was the Moon.*
> *When the son of Mathunda looked up and saw the Moon,*
> *He loved her very much, and he followed her to the south,*
> *There where she lived in the sky. And he said: "Her I shall marry".*

If "the ruler of the earth was the Moon", then there may be some significant credence to the claim by feminists that the world was perhaps matriarchal before the new dominant and oppressive matriarchy. Among the Igbo, Southeastern of Nigeria, Umeh (1999:39) observes as follows: "It is to be noted that cancer the crab is identified as *Akwu Okala* by *Igba Afa* which may also refer to the ancient sacred *obi* building . . . One can look at the position as analogous to the God of Light, *Anwu* or *Akwu Okala* or *Atu*, Whose Eye the Sun is, coming out of His *obi* [a house where the father in a family stays] to announce the passing away of the old year and proclaim the commencement of the new year. The Sun is in cancer annually from June 21 to July 22. Its ruler is the Moon".

An interesting point in this Sandawe myth is the fact that the Sun "looked up and saw the Moon", suggesting as it does that the Sun and Moon (male and female) originated differently, one in the North and the other in the South. This gives some credence to a certain Igbo myth which has it that after God first created plants and non-living things; he then created birds and animals and asked them to take care of the other things. Both birds and animals failed to obey this command of God, failing which God then created man. Man went about performing his duty peacefully until one day that he chanced upon the daughter of Earth, fell in love with her, and ravished her. Upon this God got angry and decreed that man's punishment for this act of transgression shall be death, and that when man dies, he shall be buried in the ground to appease the Earth. This too suggests that woman was there before man was created, and that they have different sources of origin. The implications are grave, pointing to the fact that neither science nor myth nor religion has solved the mystery of creation or evolution of the world, notwithstanding whatever scientists say. For Africans, there was no problem deifying the Sun and the Moon, given their big size and brightness.

Deification of the Sun and the Moon

It is already common knowledge that Sun worship was rampant in tradition African societies; the most widely noted being the worship of Ra – the Egyptian Sun god. Many homes in contemporary Igbo society today still have the Onu Anyanwu – the shrine dedicated to the Sun. Such a shrine is usually located very close to the entrance to a compound; which is to say that it is always located in front of a compound, no matter the direction. Because of the abundant evidence of Sun worship in Africa in particular and the world generally, I will not belabour the reader with more examples. Rather I shall analyze the poem by taban lo liyong earlier alluded to and the "Hymn to the Sun" in Chinua Achebe's *Anthills of the Savannah* to see the creative enunciation of reasons for the deification of the Sun.

The poem "The Sun is My God and I Shall Worship Him When He Rises, Reaches His Zenith and Reposes for the Night", by its mere title, displays the protagonist's unswerving determination to worship the Sun. This insistence is achieved through the elaboration of the times that the Sun must be worshipped. The reasons for this irresistible willingness to continue to worship the Sun at all times are numerous. The Sun is seen as a protector of life because he "guards us"; he is also an energizer since he "puts us to sleep so we can be active the following morning". Moreover, the Sun is seen as an overlord who "rules over the firmaments" and "There is none stronger than he". From an implied comparatist position, the protagonist further attests to the fairness of the Sun to all and Sundry. The entire relevant stanza is worth quoting:

The Sun is my God
For he is fair to all.
Unlike other men's Gods
He favors none and victimizes none.

The obvious reference here is to the Christian God who has a "chosen people", the Israelites. The same comparison is carried on further when the protagonist asserts:

He has no wrath to punish to the last generation
anybody
For He is benevolent.

In other words, the Sun is not as vengeful as the Old Testament God. Indeed, the entire poem may be read intertextually as an extended comparison with the Christian God in which the Sun easily comes out as the superior moral being. Take another stanza:

The Sun is my God
For He teaches by example
Frightens us not with heaven and hell
Life under Him is all He gives us
And we grow like Him early in the morning, reach the
heights of our power in midday, and gradually
decline in a thoroughly expected way.

This stanza illustrates the natural temporal order of succession of events, pointing as it were to the pattern that human life ought to take in the world. It also depicts a certain stable order of the world in which the Sun is used as a model. The final point is underscored when the protagonist affirms again,

The Sun is my God
And see how much He lives us free, unlike other gods
Who make you work through trauma for disputable ends.

From all indications, taban lo liyong not only uses this poem to justify the worship of the Sun but also to graphically depict the comparative advantage to be gained from Sun worship as opposed to the worship of other Gods. And even though the use of the expression "unlike other gods" is recurrent through out the poem, the allusions to "heaven and hell" "He favours none, and victimizes none", and "Unlike other gods who make you work through traumas" suggest that the specific reference is to Christianity.

The image of the Sun in *Chinua Achebe's Anthills of the Savannah,* the context of the composition of a Hymn to the Sun by Ikem Oshodi, one of the major Characters in the novel, is itself a cynical one. One, the Dictator in the novel is referred to as "The wild Sun of April" (28). Ikem, a journalist is invited by his friend Chris Oriko, to cover "a good will delegation from Abazon" (26). He is late for several hours on the road due to a severe traffic jam. Interestingly, in the usual manoeuvre for space by motorists during such traffic jams, Ikem beat a taxi driver to the game. In a cynical note, the narrator notes that, "In all known such encounters [taxi drivers attempting to overtake private car owners] between taxi and private drivers, the taxi driver always won, is decisive weapon, the certainty that the owner-driver- will soon concede his place than risk a dent on his smooth, precious carapace". It is this victory that Ikem decides to celebrate by composing a hymn to the Sun. In the Hymn the Sun is severally conceptualized as "great carrier of sacrifice to the Almighty: Single Eye of God", "Undying Eye of God", "One – Wall-Neighbour to blindness", "Wide-eyed insomaniac", and "Great Messenger of the Creator" (30). These appellations stand in sharp contrast to the role of the Sun in the unfolding crisis and dictatorship in Kagan, the fictional country in which the novel is set. Indeed, it would appear that the Sun is being chided for not doing what He should be doing, and for apparently appearing to have taken sides with the dictatorship. Thus in several instances in the Hymn, the Sun is almost being reprimanded for abandoning the people. Thus, we have the following examples: "What hideous abomination forbidden and forbidden and forbidden again seven times have we committed or else condoned, what error that no reparation can help to erase?" (30). This is a direct address and challenge to the Sun, a challenge arising from a trauma in the life of the people, leading them to doubting the enormity of their whatever unforgivable crime. Then next, there is an appeal to Him: "relent then for your own sake; for that bulging eyes of madness that may be blinded by soaring motes of an incinerated world" (32). There is also a direct accusation levelled against the Sun for seemingly taking sides with the dictator: "What has man become to you, Eye of God, that you should hurt yourself on his account? Has he grown to such god-like stature in your sight? Homeward bound from your great hunt, the carcass of an elephant on your great head, do you now dally on the way to pick up a grasshopper between your toes?" (30). It is not just that the Sun is accused of seemingly taking sides with the dictator, there is a suggestive accusation of irresponsibility on his part.

All in all, the Hymn to the Sun reveals that the Sun has great powers. It reveals that He is the messenger of God, but a messenger of God accorded a deistic status. The worry expressed in the poem is that with such powers, the Sun looks on unconcerned when the people are traumatized by dictatorial leadership. But the narrator does not stop at this experience of the powers of the Sun in the Hymn. It is not only the people that have been subdued by the Sun; the elements of nature are equally victims. The passage containing this insight is very telling in the power of the poetic language in which it is conveyed, thus:

> *In the end even the clouds were subdued though they had held out longest. Their bedraggled bands rushed their last pathetic resources from place to place in a brave but confused effort to halt the monumental formations of the Sun's incendiary hosts. For this approach the Sun wreaked a terrible vengeance on them cremating their remains to their last flumes and scattering the ashes to the four winds. Except that the winds had themselves fled long ago. So the clouds' desecrated motes hung suspended in a mist across the white face of the sky and gave the Sun's light glancing off their back the merciless tint of bronze (32).*

Given this severe treatment by the Sun, the people are totally bewildered, but they can take solace in the fact that "it had happened before" (32) in a legend. But even in the legend, the people were not so confused that they did not know what action to take. But the present predicament of the people is loss of focus, even to take a drastic step. So the narrator justifies this: "Because today no one can rise and march south by starlight abandoning crippled children in the wild, savannah and arrive stealthily at a tiny village and face upon its inhabitants and slay them and take their land and say: I did it because death stared through my eye" (33).

The upshot of all this is: why the evocation of the Sun in this manner? I imagine that the sole thrust of these poetic evocation of the Sun is to illustrate the death of the revolutionary, spirit among the people. But it is also to depict the inertia responsible for this loss of the revolutionary spirit. In any case, it can also depict a certain ambivalence characteristic of deities in Igboland. Otherwise, it would not be suggested that the Sun would not relent an account of the people's plea, but for its own sake. There would also not be the suggestion that the Sun was becoming irresponsible. But if it represents the death or lost of the revolutionary spirit, it shows how in the cycle of things event have dramatically changed – for the better.

While Achebe and liyong may have been dealing with a creative exploration of the possibilities of the Sun as god or deity, Mazisi Kunene's "collection of poems translated from Zulu to English" (Xi) reveals the Sun as a benefactor, a guide, a muse, and a protector. In a collection of poems translated from Zulu, and titled *The Ancestors and the Sacred Mountain* (1982) Kunene presents to us various images of the Sun. In the "Song of the Sun" (60), the Sun is presented as a benefactor, a deity, an inspirer, and teacher. These are illustrated in the following lines:

It was the Sun that invited us
It made us sing the deep songs of the earth
From his voice we learnt their secret and them.
He said: 'Bring the song'
And I saw him bend down on the horizon
To hug all the children of the earth.
He uttered these words of command:
'spread your hands for my gifts'
And I raised them to his alter.
On my right hand I saw a giant mushroom
And on my left were two faces of the sacred ram.
He said: 'this shall lead into the memory of endlessness
To link the past with the present,
To ensure the continuity of life,
To bequeath the child with the titles of the Sun
These promises I shall keep.

The Sun is personified in its act of bending "down on the horizon/To hug all the children of the earth", but at the same time deified when the protagonist raises his hands "to his altar". The Sun is also depicted as the guardian of memory from when we can learn the "secret anthems" of the earth. More importantly, through the Sun's benevolence, we can aspire to its status since it is his "promise to bequeath the child with the titles of the Sun".

In "To a Navaho Boy Playing a Flute" (58), the poet protagonist depicts the glory and grandeur of the Sun when he describes the image of the Navaho boy:

I saw him rise before me like a spirit
He was tall like one who learns on the Sun-rays.
His broad feathers swayed like the crown of the Sun

The evident simile and hyperbole in these lines lead us not to the Navaho boy as they evoke for us the grandeur of the Sun to which the Navaho boy is now being likened. There is no doubt that the song of the Navaho boy is alluring and ethereal, and that the poet- protagonist is entirely absorbed in the event. We are, therefore, not surprised at the celebratory tone of the final lines of the poem:

All hail to the creators of the earth.
All hail to the singing voices of the morning.
All hail to the Ever-Turning Eye of the universe.
Let the red sky be cleansed by a blazing Sun.

Here, the Sun, "the Ever-Turning Eye of the Universe" has the powers to cleanse "the red sky", which can portend nothing but rage and violence.

In one of the shortest poems in the collection, "Breaking off from Tradition", the poet-protagonist reminds us that "memory persists and punishes/Those who dare forget the moment of their awakening". But then, how does this "awakening" come about? It is not by our power, but by the merciful intervention of the Sun. This is why we are then further reminded that:

Everyone is born into the terrors of the night
There the guardians are fierce and do not sleep
Bringing the constant promise of disaster
But the Sun breaks open the line of the horizon
And from it new faces rush from all directions,
We are tempted to proclaim a new era.
Yet it is only an illusion.
When ultimately we cut the links of our past,
It is only to trace the path of our deeper beginning.

Notice how complex and intricate these simple lines are. The phenomenon of birth as a leap into the unknown is depicted as being thrown "into the terrors of the night", and because the night is perceived as dark and ghoulish in many cultures, it is generally believed that evil spirits pervade the night and therefore portend danger. On another level, the earth itself could be read as constituting "the terrors of the night" in which case life on earth is entirely perceived as a precarious one. The Sun representing the positive *Other* of the earth because life-giving and sustaining becomes a redeemer, a deity that guides and guards people against "the terrors of the night". In other words, the Sun as redeemer, as bringer of light and dawn rescues humanity from the darkness of the night. But the poet-protagonist cautions us against reading a new dawn, "a new era" as just something that is novel and unrelated with over history, with our beginning. The Sun "breaks open the line of the horizon" not to put us into confusion because of the "new faces" that "rush from all directions", but to remind us of our roots, our origins, "the path of our deeper beginning:" This is because, as the poet says in another poem, "Those who begin a new journey must inherit the sacred staff/and through them the Sun must point to the centre of our universe."

There are many other writers who employ the Sun as strong motifs in their writing, but now, I turn to those who have represented the Moon in writing. The Moon, like the Sun, is sometimes deified. The Moon is also seen as benevolent as the Sun. Romanus Egudu (1981: 250–251) calls attention to a poetic song composed at the installation of a chief at *Owa* in Enugu state, southeastern Nigeria. The chief had chosen *Onwa,* Moon, as his title – name. The composer uses the occasion of the installation to, perhaps, enlighten the chief on the nature of the Moon, thus

Son of Ojiwadu
Moon that shines for Owa
. . .
if you are the Moon-king
that shines for the earth,

[note that] the Moon never kills yams
it never kills woman's cocoyams.

Like the Sun as depicted by taban to liyong, the Moon shines for all, it does not discriminate. But unlike the Sun, its light does not kill or lead to crops or plants becoming blighted.

It is not only that the Moon is benevolent; among the Igbo, the Moon is seen as a unique and singular phenomenon. This is probably why it is very common as a title name among the Igbo. Not long ago, a certain man, immersed in the frames of western cosmology and worldview saw himself as a "star" among his people. In choosing a title name, he opted for "*kpakpando"*, that is, star.

You can imagine the man's consternation when another kinsman who had earlier taken the title *Onwa,* Moon, assembled children to sing the popular children's song drawn from an Igbo proberb: "*Kpakpando gbara onwa na-uza, na onwa adigi abuo na igwe"* meaning: "star(s) give way to the Moon, there are no two Moons in the sky".

The Moon is a fascinating phenomenon, and many writers have drawn inspiration from it. One of the most significant of these writers is the Nigerian poet, Niyi Osundare. One of books of poetry is titled Moon*songs* (1988). One of the poems in the collection is a definition of the Moon, thus:

some	say
you	moon
are	the
ash	es
of	the
sun	bath
ing	limpid
night	in
the	grey
ing	of
your	silence
pallid	echo
of	solar
thunder	s
are	you

The entire book of poems is a celebration of the Moon as a phenomenon. But many a time, the Moon is used to make a statement about contemporary social conditions: urban slum as in poem XXII, tyranny as "Noonview", etc. The Moon, "wife of the Sun/Brother of the wind" (8), "the eye of the sky, the ear/of patient twilights, the adder of looming seasons" (24) is also "mask dancing". As the poet-protagonist says:

With its ears the Moon sees the Soweto of our skin
And painfields so soggy with the sweat of a thousand seasons

But the Moon is also able to see into

> *. . . the sorrows of our south deep, so deep*
> *like scars of millennial lessons.*

The Moon is also used as a motif to contrast beauty and slum, as in poem XXII where we are made to see
Ikoyi

> *The Moon here*
> *Is a laundered lawn*
> *Its grass the softness of infant fluff,*
> *Silence grazes like a joyous lamb,*
> *Doors romp on lazy hinges*
> *The ceiling is a sky*
> *Weighted down by chandeliers*
> *Of pampered stars*

Ajegunle

> *Here the Moon*
> *Is a jungle,*
> *Sad like a forgotten beard*
> *With tensioned climbers*
> *And undergrowths of cancerous fury;*
> *Cobras of anger spit in every brook*
> *And nights are one long prowl*
> *Of swindled leopards.*

The too, reveals the impartiality of the Moon, recording what it sees the way it see it.

Functions of the Sun and Moon

The Moon is the commonest and best guides for the determination of indigenous calendars. Again, there is abundant literature in traditional and indigenous calendars not only in Africa, but also worldwide. I concern myself with the way literary writers have utilized the Moon motif in the determination of time of events in their societies. In Africa, the earliest and the most remarkable is in Chinua Achebe's *Arrow of God* (1964). The timing of events is so important to traditional peoples, and things could go wrong both in the physical and spirit world when things do not take place the time they are supposed to take place. This abiding concern with keeping accurate time to endure the adequacy of events which take place in time informs the opening of *Arrow of God,* thus:

> *This was the third nightfall since he began to look for signs of the new Moon. He knew it would be today but he always began his watch three days early because he must not take a risk. In this reason of the year his task was not too difficult, he did not have to peer and search the sky as the might do when the rains came. Then the new Moon sometimes hid itself for days behind rain came. Then the new Moon sometimes hid itself for days behind rain clouds so that when it finally came out it was already halfgrown. And while it played its game the chief priest sat up every evening waiting... The Moon he saw that mother. He peered more closely to make sure he was not deceived by a feather of cloud (1).*

The passage here refers to the activities of the protagonist of the novel, Ezeulu, Chief priest Ulu. As the custodian of the time-table of the events of the community, umuaro, Ezeulu knows too well why "he must not take a risk" in ensuring that he sights the New Moon on the exact day [Editors note: This is the first sighting of the smallest crescent after New Moon]. When he finally sights the Moon the same day, it is an unusual one that he sights. He does not fail in announcing to the people that the new Moon has been sighted. He is also quick at performing the appropriate rituals (3).

The narrator does not fail to leave us without the people's responses. The children sing and rejoice over the appearance of the new Moon. The adults, represented by Matefi, Ezeulu's senior wife, and Ugoye, his younger wife, are more concerned with understanding the nature of the new Moon. Ugoye begins the probing:

> *'oho, I see it, Moon, may your face meeting mine bring good fortune.*
> *But how is it sitting? I don't like its posture.'*
> *'why?' asked Matefi*
> *'I think it sites awkwardly – like an evil Moon?*
> *'No', said Matefi, 'A bad Moon does not leave anyone in doubt.*
> *Like the one under which Okuata died. Its legs were up in the air'.*

Here the notions of the goods and evil Moon are introduced. The way and manner in which a new Moon is perceived determines whether it is a good or evil one. The narrator uses the words, "posture", and sitting "awkwardly" to describe this one. Actually, the Igbo word would more appropriately translate as "the way the Moon is staying/showing itself". What is important is that the Igbo take time to observe a new Moon to determine whether it portends good or bad for them. This is why there is an Igbo saying to the effect that there is nothing that can be done to change the way an ill-positioned new Moon shows itself.

The conversation between Matefi and Ugoye foreshadow the tragic events which trail the tragedy in the novel. Indeed, the entire tragedy of *Arrow of God* stems from Ezeulu's incarceration in the hands of the colonial masters, an incarceration which prevents him from being present at Umuaro to eat one of the twelve sacred yams which can only be eaten at each new Moon. For them, this new Moon was an evil one, a bad omen. Even the next new Moon which was seen by Nwafo, one of Ezeulu's children during the time Ezeulu was still detained at Okperi is not a good one. The narrator talks of it as a "young thin Moon" that "looked very thin and reluctant" (166). Ezeulu could not announce the date of the New Yam Festival, leading a traumatized people to resort to church harvest as a way of eating the new yam. The death of Obika, Ezeulu's son and the mental disorientation which Ezeulu himself suffers influence the people into believing that Ulu "had taken sides with them against his headstrong and ambitions priest" (230). But the closing paragraph of the novel is not categorical about this:

> *If this was so than Ulu had chosen a dangerous time to uphold that truth for in destroying his priest he had also brought disaster on himself, like the lizard in the fable who ruined his mothers funeral by his own hand for a deity who chose a moment such as this to chastise his priest or abandon him before his enemies was inciting people to take liberties; and Umuaro was just ripe to do so. The Christian harvest, which took place, a few days after Obika's death saw more people than even Goodconutry would have dreamed. In his extremity many a man sent his son with a yam or two to offer to the new religion and to bring back the promised immunity. Thereafter any yam harvested in his fields was harvested in the name of the son (230).*

Conclusion

There are many more texts from which more examples could be taken to depict the way in which the Sun and the Moon are depicted in creative expressions in Africa. One immediately thinks of Peter K. Palangyo's *Dying in the Sun.* Although this title is not discussed in this essay, the evident paradox in the titling provides the illumination for this conclusion. Ordinarily, the Sun is always the usherer of a new dawn, a new life, a new beginning, but it has in itself the potential of violence, which could lead to death. It is this potential for violence, or is it the actualization of such a potential that is depicted in a "Hymn to the Sun" of *Anthills of the Savannah.* If the Sun provides violenence in this novel, even apparently taking sides and aligning powers with a dictatorial regime, the Moon takes no sides in *Arrow of God.* And although the dominant motif in the novel enthrones it as the sole symbol for synchronization of events for the people of Umuaro, it is aloof to the trauma the people undergo. It is no wonder then that the people begin to look in the direction of the new faith for an escape route. So, in the end, the Moon may be the popular entity after which people may fashion title names, it may kill neither the yam of man nor the cocoyam of women, but it may have no devotees, no shrines erected in her honour because it has neither power nor ambivalence. The Sun, life-giving and life-destroying, is the hero, the deity that graces the entrance to every traditional Igbo compound.

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Astronomy and Culture in Nigeria

J. O. Urama

Abstract Astronomy cannot be said to be entirely new in Nigeria. There are hundreds of cosmogony and ancient astronomical practices in Nigeria, but these need to be studied systematically. Nigerian ethnoastronomy is revealed in the folklore, ancient architecture, religious practices, traditional poetry and art works of the different ethnic groups. Though expressed within a cultural framework, much of Nigerian ethnoastronomy contains scientific principles of astronomy. This paper discusses the need to bridge the gap between ethnoastronomy in Nigeria and modern astronomy by providing scientific interpretation to such cosmogonies and ancient astronomical practices.

Introduction

Astronomy has been said to be "a science that has a universal appeal because it encompasses all fields of human interest and endeavour" (Celebre & Soriano 2001). It has been argued that, "astronomy is more than the science of stars; it is intimately connected to our ideas of ourselves, our purpose and place in the universe" (Campion 2003). As the science that provides the framework knowledge of where we, and the planet on which we live, fit into the environment of the universe, astronomy is a vital part of the culture of all mankind. A person deprived of the broad outlines of astronomical knowledge is as culturally handicapped as one never exposed to history, literature, music or art (NRAO Bulletin).

The description of creation told by followers of *cabbala*, – a form of Jewish mysticism – for example, has been interpreted (Wertheim 1997) along modern cosmological views. The *cabbalists* developed a theoretical system portraying God as having ten aspects, known in Hebrew as the *sephirot*. Beyond the *sephirot* is *Ein Sof,* the unknowable aspect of God, from which emanated a light that created the *sephirot* and the physical universe. Of the ten *sephirot* the first three deal with creation, and they correspond fairly closely to the concepts from the cosmological theories. In

Johnson Urama
University of Nigeria, Nsukka +234 42 771107
E-mail: johnsonurama@yahoo.com

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Nigeria, there are hundreds of such theories about creation, life and living, etc., that need to be studied likewise systematically to reveal connections to modern cosmological views and astronomy principles. As observed by Kunene (1980), "each society is concerned with its destiny within the cosmic arena; without this perspective, the society can only be stampeded into directions it does not fully comprehend or does not feel ready to follow." In this paper, I highlight the need to investigate some of the culture and traditions of the different ethnic groups of Nigeria with a view to re-interpreting this body of knowledge in the light of modern astronomy.

Modern Astronomy in Nigeria

Modern astronomy came into Nigeria only four decades ago. Many universities and research centres in Nigeria have been involved with teaching and research in astronomy for many years. This was first introduced in the Departments of Mathematics of the University of Nigeria, Nsukka, in 1962. From Mathematics, it moved to the Department of Physics of the same university, which later became the Department of Physics and Astronomy. In the past ten years, astronomy programs have been introduced in four other Universities in the South-eastern Nigeria, mostly at the graduate level. Nigeria also hosts an international centre in Ile-Ife involved with space science, – the African Regional Centre for Space Science and Technology Education in English Language (ARCSSTE-E), which was inaugurated in November 1998. And two years later the National Centre for Basic Space Science was set up at Nsukka with the mandate to conduct and carry out active frontline research in Atmospheric Science and Astronomy. However, despite these advances astronomy remains largely unpopular in Nigeria. There are only about a dozen professional astronomers and no amateur astronomers in the country since it is popularly perceived to be of only esoteric interest and devoid of any practical and economic value.

It is, however, worthy of note that a Nigerian – Samuel Okoye – was the first black African to obtain a doctorate in radio astronomy. His doctoral research at the Mullard Radio Astronomy Observatory, University of Cambridge, led to the discovery – with his supervisor, Dr Tony Hewish – of an extremely high brightness temperature source in the Crab Nebula recognized as the first example of a neutron star. This source later turned out to be none other than the famous Crab Nebula Pulsar. The discovery was widely recognized of being of fundamental importance to basic physics and for which Prof. Hewish was awarded the Nobel Prize in Physics in 1974.

Dr. Okoye returned to Nigeria to set up a radio observatory in Nsukka. His initial efforts to set up a space research centre was frustrated by lack of funds until in 1977 when the late Dr. Nnamdi Azikiwe made a handsome donation of the sum of one hundred thousand Naira (about US $150,000 then) towards creating the space centre. "With this initial assistance Professor Okoye and his group were able to set up a 10-m dish operating at 327 MHz as the initial facility of the group. This was done with a little assistance from University of California. With little funding and little international technical support a lot of indigenous technology was built into the project. With this facility, the centre planned to carry out the following projects: a two station pulsar observation with India, a Very Long Baseline Interferometer (VLBI) observation programme with Germany...All these experiments involve signing of agreements with other governments and some financial support. There was no support from the Nigerian government or from any other source, as a result, all the above mentioned projects could not commence. Since no serious activity was taking place around the telescope, which was situated in a remote corner of the University, as is usual with radio instruments, the dish and all the facilities were vandalized" (Okeke 1999).

Overview of Cultural Astronomy of Various Regions in Nigeria

The Hausa speaking tribal nation of West Africa have a good number of myths and folktales about the sun, moon and the stars. The stars are said to visit each other and talk. There are even names for the constellations, a typical example being the Pleiades, a star cluster that appears at the commencement of the rains, which is known as ***kaza Maiyaya*** (the Hen with Chickens) and, "the morning-star in harvest time (probably ***α-Aquila***) is known as the eagle star" (Tremearne 1970). One of their folktales has it that the moon and the sun were friendly until they gave birth. Then the sun called the moon and asked him to hold her daughter while she went and washed herself. The moon took the sun's daughter, but was not able to hold it, for it burnt him, and he let it go, and it fell to the earth – that is why people feel hot on earth. When the sun returned, she asked the moon where her daughter was, and the moon replied, "Your daughter was burning me so I let her go, and she fell to earth". Because of that the sun pursues the moon. Another legend is that the moon's path is full of thorns, while that of the sun is sandy, and on that account the moon cannot travel quickly, as does the sun. So when the moon can proceed no farther, he gets on the sun's path, and the sun catches him. When the sun has caught him the people take their drums and ask the sun to spare the moon. This "catching-up" occurs during an eclipse of the sun.

In Igala land, when such an eclipse happens it is believed that the world wants to come to an end, so the people would start beating the drums, buckets, plates and bowls as a praise to their gods to spare the world. And when the eclipse is over they would start chanting, "thanks be to our gods for they have heard our prayers". Here, it is also believed that the moon has two wives – and these are the brightest stars that stay very close to the moon when it appears in the night, the most loved one staying closest to him (Joan Edime, private communication).

Yoruba is the second largest ethno-linguistic group in Nigeria. In Yoruba cosmogony, *Obatala* was issued with the task of building the Earth by Sky God *Olorun*, who gave him blueprints, a handful of mud, a chain, a five-toed chicken, and detailed instructions. Unfortunately, on his way to perform this important task, *Obatala* accidentally gate crashed a God-party and spent the rest of the evening roaring, drunk on palm wine. Seeing the chance for fame and glory, his younger brother, *Oduduwa*, stole the holy building materials and attempted to jerry-build the Earth himself. Advised by a friendly chameleon, he lowered the chain over the edge of heaven, climbed down, and tossed the lump of mud into the primeval sea. The chicken hopped onto the mud and began scratching it in all directions. Pretty soon there was a decent size landscape and thus was the Earth born (Saunders & Ramsey 2004). *Oduduwa*, the first Ooni (traditional ruler) of Ife, is the father of the Yorubas and progenitor of all Yoruba *Oba's* (traditional rulers) and the *Oba* of Benin. *Oduduwa* is believed to have had 16 sons who later became powerful traditional rulers of Yoruba land, most notably *Alafin* of Oyo, *Ooni* of Ife, *Oragun* of Ila, *Owa* of Ilesha, *Alake* of Abeokuta and *Osemawe* of Ondo. *Oduduwa* is believed to have left a beaded crown for Yoruba, and the Ooni of Ife wears this up till now (Fig. 1). The *Ooni* wears the crown only once a year at the *Olojo* festival and it is believed to have curative powers as any prayer said once the *Ooni* adorns the crown is said to be answered.

The Igbo, like every other people, have observed their natural environment and interacted with it. The Igbo have had to live in very close proximity and intimacy with nature. In Igboland, unlike the situation with the Edo, Yoruba and Hausa, there is a dearth of written material for the period before the 19th century. Although an ideograph (sign-language), ***nsibidi***,had been in use, literacy as it is understood today, was introduced into Igboland after the first European visitors (John & Richard Lander) traveled down the lower Niger down to the Niger Delta in 1830.

Fig. 1 A village shrine in Nsude, Enugu State of Nigeria. Photograph was taken in the 1930s by the late G.I. Jones.
(Source: Museum of Archeology and Anthropolgy, University of Cambridge.)

In Igbo land the supreme being *Chukwu* is commonly identified with the sun *(Anyanwu)* so that the supreme being is often described as *Anyanwu Eze Chukwu Okike* (The sun, the Lord God, the creator). In the Nsukka area, almost every household in those days had a shrine to *Anyanwu* in his compound consisting of a round pottery dish sunk into the ground bottom upwards at the base of an *ogbu* tree. There can be little doubt that this pottery dish is used to represent the sun's disc. Offerings at the shrine are usually made at sunrise or sunset. In some cases the *Anyanwu* (sun-god) shrine is a mound of sand as is shown in Fig. 2. The mound of sand, just like the pottery dish, may be a representation of the sun's disc.

Among the Jukun (a neighbouring ethnic group to the Igbo) of the Benue basin there is the same partial identification of the sun with the supreme being and it is noteworthy that the Jukun words for sun and supreme being viz: *Nyunu (Anu*) and *Chi-do* embody the same roots as the terms used by the Igbo. In the Okpoto groups the sun is called *Enu* and the sun-god *Olenu*. It is interesting to note that Heliopolis the centre of sun-worship in Ancient Egypt was known by the Egyptians as *Anu.* It is also noteworthy that the use of mounds of sand in connection with Sun-rites was common in Egypt and that among the Jukun today the Sun-altars are two mounds of sand (Meek 1930).

In many places in Igbo land, the general life of the community still largely hinges on the lunar calendar and the people look up to the king-priests who determine agricultural seasons based on the lunar calendar. These priests examine the motions of the sun, moon and even the planets in some cases, to come up with the calendar. Each lunar month has a name, a ritual associated with it and also an economic activity specially connected with it. Each moon (month) has seven market weeks (*Izu asaa)* and each week (*izu)* is four days, that is *Eke, Oye (Orie),* A*for* and *Nkwo*. The Igbo year consists of twelve lunar months (354 days) and as this falls short of

Fig. 2 A village shrine in Ovoko, Enugu State of Nigeria

Table 1 The calendar of Umuawulu town

Moon	Event	Calendar
Onwa Mvu (I)	Ogugu Aho	Afor before Moon appears May/June
Onwa Ibo (II)	Onwa Ibo feast	Afo, June
Onwa Ito (III)	Akwali Chukwu feast	
	Akwali Omufu Ritual	July
	Iba na Akwu-Ozo	
Onwa Ano (IV)	Ikpa Unwu ritual	August
Onwa Ise (V)	Fejioku ritual	Oye
	Okike-Onwa-Ise feast	Eke
	Okpukpo Ngu	Oye, September
Onwa Ishi (VI)	Nshi Ji	Afo
	Ikpo Ngu	Oye, October
Onwa Isa (VII)	Mgba Ajana	Nkwo
	Egwu Aruja	Eke, November
Onwa Asato (VIII)	Olili Kamanu	Izu n'ese onwa
	Onwa Asato feast	Afo (izu ato onwa)
	Ikpo Ngu Onwa	Eke
	Asato	Eke (izu ise onwa), December
	Okike Onwa Asato	
Onwa Iteghete (IX)	Olili Onwa teghete (women feast)	Afo, Izu n'ato onwa January
Onwa Ili (X)	Okpukpo Oye feast	Oye, Izu n'ato onwa, February
Di Okpala Onwa Ili (XI)	Obele Ede (women)	Eke, March
Onwa Uwhoro I (XII)	Nnukwu Ede	Afo, April
Onwa Uwhoro II (XIII)	– do –	May

Fig. 3 A wall typical painting, which could be portraying some astronomical information

the solar year by eleven days it is necessary to add a thirteenth month from time to time so as to make the year correspond with the seasons. The thirteenth month, when introduced is usually a “nameless”, “void” or “lost” month.

The calendar of Umuawulu (Anambra State), a typical community in Igbo land, is as shown in Table 1 (Nkala 1982). Yam-planting controls the timing of all the festivals in Umuawulu. The significant thing is that *Onwa mvu* (first month) is the beginning of the farming season for the entire community. It must be properly synchronized with the coming of the rains, or else the whole clan would be ruined for the whole year.

The Igbo has a mystical symbolism understood and used by *dibias* (diviners and herbalists). Some of these mystical symbolisms have information on the solar and astral systems buried in them (Umeh 1999). Figure 3 shows a typical example of such symbolisms.

Conclusions

Like ancient people everywhere, Nigerians wondered at the sky and struggled to make sense of it. So, while modern astronomy may be quite new and unpopular in Nigeria, ancient architecture, folklore, myths, religion, calendars, etc. are quite rich in astronomy. The cultural astronomy of the West African sub-region, and Nigeria in particular, is among the least investigated in the African continent. Ancient astronomical practices of parts of Southern and Northern Africa have been relatively well studied. Nigeria’s endogenous astronomy is as diverse as her over 300 ethnic groups. Most of the ethnic groups have astronomy-rich cultures, hence there are hundreds of ethnic cosmogonies and mythologies that need to be studied systematically. Such a study would investigate various aspects of the culture and tradition of the diverse ethnic groups of Nigeria and seek to re-interpret this body of knowledge in the light of modern astronomy. This is an interdisciplinary research field and would provide a good opportunity for collaborative works by astronomers/astrophysicists, anthropologists, archaeologists, religionists, and other humanistic scholars.

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Participation and Research of Astronomers and Astrophysicists of Black African Descent (1900–2005)

Hakeem M. Oluseyi and Johnson Urama

Abstract The second half of the Twentieth Century witnessed the emergence of the first modern Astronomers and Astrophysicists of Black African descent. In this paper we enumerate these researchers and briefly describe their activities. We also describe the broader social and political contexts which have impacted their participation and research. We focus primarily on researchers in the United States of America (28) and in Nigeria (19) who have together produced over 90% of the astronomical researchers known to the authors. We briefly mention researchers from other countries including South Africa (3) and in Eurasia (2). We conclude by describing the pioneering researchers and disseminators of the Black African Diaspora's contribution of to the modern astronomical sciences.

Introduction

The 20th century saw substantial change in the collective lot of Africans and the African Diaspora. The century began with nearly every African nation suffering under colonial rule and African Americans enduring the daily violence and humiliation that characterized the Jim Crow era. Seven decades later, Africa had shed its colonial rulers but their imperial legacy had bestowed widespread suffering whose effects linger until today. In America, the violence, segregation, and state-sponsored discrimination that plagued the Jim Crow era were reduced to lower levels, though not eradicated. Yet, in the face of these challenging environments, the 20th Century witnessed the emergence of the first professional astronomers and astrophysicists of African decent. Here we review the participation and research activities of these scholars.

We denote researchers of Black African descent who successfully entered into professional careers in the astronomical sciences. We define a successful professional astrophysical researcher as one with a substantial scientific publication record

Hakeem M. Oluseyi
Florida Institute of Technology (321) 674-7247
E-mail: holuseyi@fit.edu

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in the fields of astronomy, astrophysics, or cosmology, post-Ph.D. We exclude geophysicists, engineers and other support personnel who engage professionally in the astronomical sciences including educators and public outreach personnel. One trend that complicates matters is that there exists several researchers who performed astrophysical research during the acquisition of their doctorate degrees, but have not published the results of astrophysics research beyond this work. There is an additional complication introduced for those whose research lay at the intersections of astronomy and other fields such as mathematics and physics.

This review, while exhaustive, is recognized as not being complete. It is likely that there are, or have been researchers in Europe, Asia, South America and elsewhere who are currently unknown to the authors. Given these limitations, this review will nonetheless coalesce into one document a general overview of our topic which is more complete and accurate than has been previously presented.

African American Participation and Research

The Pioneers (1956–1965)

It was in the segregated 1950s that the first African American began his career as a professional astrophysical researcher. In 1956, Carl Rouse graduated from the California Institute of Technology with a Ph.D. in Physics. Over the next decade, from 1956 to 1965, four more African Americans would follow him into professional astrophysics careers. Harvey Banks became the first African American to graduate with a Ph.D. in the field of Astronomy, earned from Georgetown University in 1961. The very next year saw two more astrophysicists begin their careers. In 1962, Benjamin Peery completed a Ph.D. in Astronomy from the University of Michigan and Arthur B. C. Walker, Jr. completed a Ph.D. in Physics from the University of Illinois. George Carruthers completed a Ph.D. in Physics from the University of Illinois in 1964 to round out the first five African American astrophysics researchers.

Four of these first five researchers enjoyed distinguished research careers and three enjoyed distinguished academic careers. The astronomical research accomplishments of Dr. Rouse are perhaps best exemplified by his pioneering utilization of the supercomputer resources at Lawrence Livermore National Laboratory to create detailed models of the solar core [1]. He was the first to solve the Saha equation in the center of the Sun, which determines the degree of ionization there. Dr. Rouse continuously refined his models of the solar core, first published in 1961, which ultimately lead to a publication in the prestigious British journal Nature in 1969 [2]. He went on to publish 44 single author public publications over 35 years. He spent his early career at Lawrence Livermore National Laboratory (LLNL) where he focused on research in quantum mechanics theory. LLNL is a government national laboratory, which performs substantial defense-related research. Most likely then, a great portion of his research output produced there remains unpublished publicly.

He spent the later portion of his career in private industry yet continued to model the solar core, incorporating the latest helioseismology data from satellites and ground based observatories into his models [3].

Benjamin Peery is perhaps most famous for being the first African American astronomer to be shown on U.S. national television thanks to a 1991 PBS documentary, "The Astronomers." Prior to this groundbreaking appearance, most Americans would have been unaware that a single Black astronomer had ever existed. Although he would later appear in the 1997 video, "Stardust," Peery's accomplishments extend far beyond media appearances. His research utilizing stellar spectroscopy investigated the physics of stellar structure, evolution, and nucleosynthesis, and the physics of interacting binary stars. He was particularly noted for identifying novel species in stellar atmospheres like Technetium, an element first discovered in the spectra of Red Giant stars in 1952, whose presence was used to bolster the then young theory that the heavy elements are produced in stars [4]. His studies on the violet spectra of stars would also result in the discovery of some novel molecules [5]. His academic career spanned 20 years at Indiana University then finally at Howard University. He was responsible for teaching stellar spectroscopy to several successful astronomical researchers including John D. Fix, author of the popular American undergraduate astronomy textbook, "Astronomy: Journey to the Cosmic Frontier" [6].

Dr. Arthur B. C. Walker, II, enjoyed a very distinguished career of research and academics. In the 1960s, Dr. Walker, with collaborator H. R. Rugge, was the first to obtain satellite-borne astronomical x-ray spectra, using a Bragg crystal spectrometer of their own construction [7]. Walker performed this work while a senior member of the technical staff of The Aerospace Corporation. In 1972 he joined the faculty of Stanford University in the department of Applied Physics. There he was the Ph.D. advisor of Sally Ride, America's first woman in space. Years later, Walker and Ride would both serve on the committee which investigated the explosion of the Space Shuttle Challenger. In the 1980s Walker's pioneering achievements included acquisition of the first high-resolution, full-disk images of the Sun using soft x-ray and extreme ultraviolet (EUV) multilayer optics flown on a sounding rocket platform [8]. After this revolutionary work was introduced to the world via the cover of the prestigious American journal, Science, multilayer technology has now become the standard in solar EUV imaging. In the 1990s, Walker pioneered thermally differentiated imaging of the Sun's atmosphere with his *Multi-Spectral Solar Telescope Array (MSSTA)* rocket payload [9]. In his academic career Dr. Walker was the mentor not only Sally Ride but also two younger African American astrophysics researchers during the 1990s, Dr. Ray H. O'Neal and Dr. Hakeem M. Oluseyi. As such, Dr. Walker is the only African American astronomer to have produced other African American astronomers. Overall, ten of Dr. Walker's Ph.D. students are employed today as researchers with six of these being Professors at U.S. universities.

Rounding out the first five is Dr. George Carruthers. Dr. Carruthers is best known for being the Principal Inventor for the Lunar Surface Far Ultraviolet Camera/Spectrograph that was placed on the moon's surface in April 1972 during the Apollo 16 mission [10]. Carruther's instrument was the first human observatory to be placed on an extraterrestrial body and was also the first observatory to monitor ultraviolet emissions from Earth's extended atmosphere. Carruthers' work extends far beyond these initial results. He has built instruments for several rocket missions to study the ultraviolet universe including stars, nebulae, and galaxies, extending back to 1967. His more recent activities include developing instruments for space shuttle missions and satellite missions including Skylab and the ARGOS satellite. Dr. Carruthers holds two patents for his ultraviolet imaging technologies. Dr. Carruthers, though not an academician per se, has worked diligently in science education activities over several years. He has been involved in several public outreach programs particularly aimed at African American students living in America's capitol, Washington, D.C.

Two Decades of Struggle (1966–1985)

The first decade of African American participation in professional astrophysics resulted in the production of one scholar every other year on average. It would take more than 20 years to produce the next five professional researchers. Indeed, eight years would pass between the year of Dr. Carruthers' Ph.D. and that of the next successful researcher, Charles McGruder. Moreover, American society was embroiled in the civil rights movement of the 1960s during this same period. These events played an integral part in shaping the roles of African American astrophysicists for two decades. In the late 1960s it appeared to many young African Americans that their futures were limited in the U.S. because of racial discrimination. Rather than staying in the U.S. to accomplish his graduate studies, young Charles McGruder found himself immigrating to the more tranquil atmosphere of Europe where he obtained a Ph.D. in Astrophysics from the University of Heidelberg in Germany in 1972. After graduating, McGruder worked in sub-Saharan African countries including Kenya and Nigeria. He later returned to America where he made it his priority to facilitate the entry of young African Americans into astronomical research. His tireless efforts in this regard have led to the creation of new funding and jobs for minority astronomers.

The era from 1966 to 1985 differed from the first decade not only in the number of scholars produced, but also in the fields chosen. The first four researchers focused their activities primarily on stellar systems. Also, half of the original four were experimentalists. Dr. McGruder became the first African American to study extragalactic systems. Ron Mallet, who received his Ph.D. in 1973 from Penn State University, was the first African American to work on gravity, black holes, and time travel. These topics lay at the intersections of physics, astronomy, and philosophy. The next researcher, Gibor Basri, received his Ph.D. from the University of Colorado in Boulder in 1979. A throwback to the first decade of researchers, Dr. Basri focused his research interests on stellar systems. He is perhaps best known for his pioneering work on using the lithium test to identify sub-stellar objects (or failed stars), known as brown dwarfs [11]. In 1981, Barbara Williams became the first female African American to successfully enter into a professional astronomical research career. She received her Ph.D. in 1981 from the University of Maryland, College Park. Her research has focused on radio emission from groups of galaxies.

The Upturn in Participation (1986–1995)

The decade beginning in 1986 witnessed a sharp upturn in the rate of production for African American astronomers. On average, an African American successfully began a professional astrophysics career each year from 1986 to 1995. In 1986 Mercedes Richards, a native of Jamaica, received a Ph.D. from the University of Toronto and moved to the US for her professional career, becoming the second female astronomical researcher of Black African descent in the U.S. Her research has focused on close interacting binary stars. She has also achieved several "firsts" in astronomy. Using the technique of Doppler tomography, Dr. Richards obtained the first images of gas streams in interacting binary stars [12], the first UV tomogram of an Algol-type binary [13], and the first 3D tomography of an Algol-type binary [14]. In 1987 Charles "Chick" Woodward received a Ph.D. from the University of Rochester. His research has focused on star formation processes. In 1988 Alphonse Sterling received a Ph.D. from the University of New Hampshire. He has focused his research on the study of dynamic phenomena in the Sun's atmosphere.

The three years from 1990 to 1992 were the most productive three years for producing African American astronomical researchers ever, with five beginning their careers during this time period. In 1990 Leonard Strachan received a Ph.D. in physics from Harvard focusing his research on solar physics. In 1991 Arlie Petters received a Ph.D. in mathematics from MIT and made substantial contributions to the topic of strong gravitational lensing, a powerful tool for cosmology. In 1991 Neil Tyson received his Ph.D. from Columbia University focusing on dwarf stars but now focuses on galaxy formation and evolution. Dr. Tyson is best known for being the director of the Hayden Planetarium in New York. He has had numerous television appearances and written several popular books on astronomy and society. He is now, without question, the most famous of the African American astronomers. Reva K. Williams received her Ph.D. in 1991 from the University of Indiana. She was the first to work out the details of using the Penrose mechanism for extracting energy from a black hole. In 1992 Eric Wilcots received a Ph.D. in Astronomy from the University of Washington studying the evolution of galaxies and the gas within galaxies. Dr. Wilcots, like Arthur Walker and Charles McGruder, has also been a mentor of astronomers of Black African descent. He has played a role in the careers of two South African astronomers and at least one African American astronomer. In 1994 Ray O'Neal, a protégé of Dr. A. B. C. Walker, II, received a Ph.D. in Physics from Stanford University where he contributed to the development and launch of Dr. Walker's MSSTA payload and studied solar plasma loops utilizing MSSTA data. Finally, in 1995, Stanley Davis received a Ph.D. from Catholic University of America where he studied gamma ray bursts. Overall, the rate of African American astrophysics researchers produced from 1986 to 1995 represents more than a factor of four increase over the production rate of the previous two decades.

The Recent Period

The period from 1996–2005 saw a 20% decrease in the number of African American astronomical researchers produced. Indeed, at least two of the eight researchers produced during this period have taken positions devoted primarily to educational activities, which have adversely affected their research output.

The first researcher produced in the recent decade was Aaron Evans who received a Ph.D. in Astronomy from the University of Hawaii in (1996). He has had a prolific research career focused on the observation and analysis of colliding galaxies. Jarita Holbrook received her Ph.D. in Astronomy from the University of California, Santa Cruz in 1997. Though her dissertation focused on star formation in molecular clouds, Dr. Holbrook is best known as “the mother of African cultural astronomy.” She is a pioneer in the emerging field of African cultural astronomy, which seeks to uncover and preserve the astronomy knowledge of African societies. She is also known as the world’s expert on stellar navigation from this part of the world. Jason Best received a Ph.D. in Astronomy from Penn State University in 1997, researching galaxy clustering. Beth Brown received a Ph.D. in Astronomy 1998 from the University of Michigan. She has focused her research on the interstellar medium of galaxies. Dara Norman received a Ph.D. in Astronomy from the University of Washington in 1999. She has focused her research on the observation and analysis of the universe’s large scale structure. Though not of African descent, Sarah Heap of Goddard Space Flight Center mentored both Jarita Holbrook and Dara Norman before they received their Ph.Ds, thus making a significant contribution to the careers of African American Women in Astronomy. Hakeem M. Oluseyi, a protégé of Dr. A. B. C. Walker, II, received a Ph.D. in Physics from Stanford University in 2000. His broad research activities in technology development, solar physics, cosmology, and African cultural astronomy have resulted in eight patents based on the discovery of processes for manufacturing microchips with very small metal gates [15] and spectroscopic processes for improving the efficiency of microchip manufacturing in general [16]. In addition to his technology patents, Dr. Oluseyi’s discoveries include being the first to determine the structure of the Sun’s upper transition region [17] and discovering the “wax candle flying flame effect” at age 11 [18]. Stephon Alexander received a Ph.D. in Physics from Brown University in 2000. His research in quantum gravity lays at the intersection of physics and astronomy. He is the only theorist produced in the recent decade. Finally, Louis Strolger received a Ph.D. in Astronomy from the University of Michigan in 2002. A prolific researcher, Dr. Strolger has focused his work in observational cosmology, utilizing Type Ia supernovae to measure the expansion history of the universe and investigate the dark energy that has been invoked to account for the universe’s accelerating expansion.

Broad Trends in Participation and Research (1900–2005)

Table 1 gives the names, fields of research, educational institutions and current positions of 27 of the 28 African American astrophysics scholars produced between

Table 1 African American Astronomical Researchers

	Last	First	Year	Ph.D. Institution	Research Interests	Type	Location
1	Rouse	Carl	1956	Caltech	Solar Physics	theory	L/PI
2	Banks	Harvey	1961	Georgetown U	Educator	observer	U
3	Walker	Arthur	1962	U IL	Solar Physics	experiment	U
4	Peery	Benjamin	1962	U Michigan	Stellar Spectroscopy	observer	U
5	Carruthers	George	1964	U IL	UV Instrumentation	experiment	L
6	McGruder	Charles	1972	U Heidelberg	AGN & GRBs	observer	U
7	Mallett	Ron	1973	Penn State	Gravity, Time Travel	theory	U
8	Basri	Gibor	1979	U CO, Boulder	Very Low Mass Stars	observer	U
9	Williams	Barbara	1981	U MD, College Park	Radio Galaxy Groups	observer	U
10	Richards	Mercedes	1986	U Toronto	Close Interacting Binaries	observer	U
11	Woodward	Charles E.	1987	U Rochester	Star Formation	observer	U
12	Sterling	Alphonse	1988	U New Hampshire	Solar Physics	observer	L
13	Strachan	Leonard	1990	Harvard U	Solar Physics	observer	L
14	Petters †	Arlie	1991	MIT	Gravitational Lensing	theory	U
15	Tyson	Neil	1991	Columbia U	Dwarf Galaxies	observer	PT
16	Williams	Reva	1991	U Indiana	Penrose Mechanism	observer	U
17	Wilcots	Eric	1992	U Washington	Gas/Galaxy Evolution	observer	U
18	O'Neal	Ray	1994	Stanford U	Solar Physics	experiment	U
19	Davis	Stanley	1995	Catholic U. of Am	GRBs	observer	PT
20	Evans	Aaron	1996	U HI	Colliding Galaxies	observer	U
21	Holbrook	Jarita	1997	UCSC	Cultural Astronomy	historian	U
22	Best	Jason	1997	Penn State U	Galaxy Clustering	observer	U
23	Brown	Beth	1998	U Michigan	Galaxy ISM	observer	L
24	Norman	Dara	1999	U Washington	Weak Lensing, LSS	observer	L
25	Oluseyi	Hakeem	2000	Stanford U	Solar Physics	experiment	U
26	Alexander †	Stephon	2000	Brown U	Quantum Gravity	theory	U
27	Strolger	Louis	2002	U Michigan	Supernova Cosmology	observer	U

U – University; L – Laboratory; PT – Planetarium; PI – Industry

† indicates research lies primarily outside astronomy

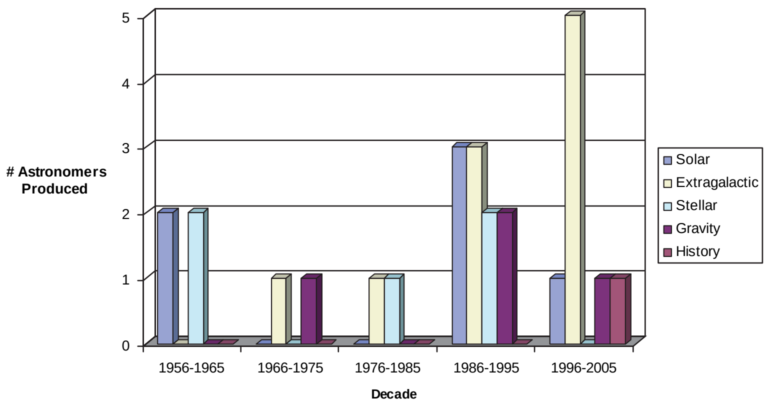

Fig. 1 Production of African American astronomical researchers by field and decade

1956 and 2005. We note that there is at least one researcher that the authors are aware of, whose detailed information (including his name) that we have lost. We see that 6 of these (∼21%) have been women. Whereas women constitute greater than 50% of all African American college students, their representation in astronomy as compared to male astronomers is about 5% lower than that of their White counterparts who constitute only ∼26% of U.S. astronomers [19]. We also see that only 3 of the 21 astronomers (∼10%) attended a historically Black college or university (HBCU). This is somewhat surprising considering that it has been estimated that ∼40% of African American Ph.D. physicists attended HBCUs and that greater than 60% of African American with graduate degrees in science, technology, engineering, and math fields are HBCU graduates [20]. Another interesting statistic regarding the participation of African Americans in professional astronomy is the connection between economic class and participation. All of the researchers in the table, with but

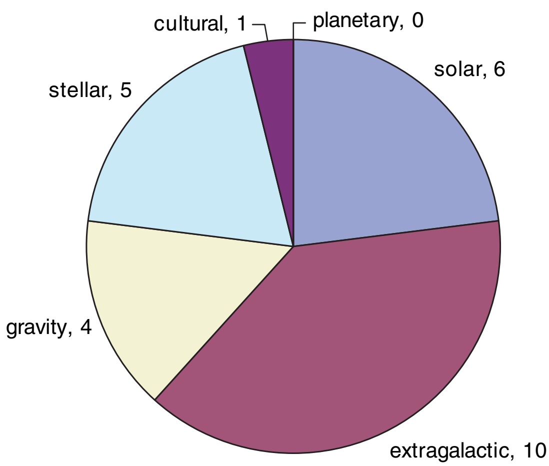

Fig. 2 Production of African American astronomical researchers by field and percentage

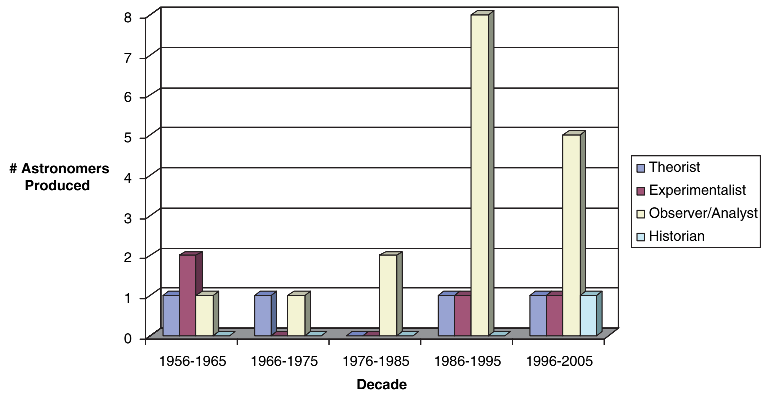

Fig. 3 Production of African American astronomical researchers by mode of research and decade

one known exception, originated from a middle class or better household. It is likely that this trend holds across all ethnicities practicing astronomy.

Figures 1 & 2 show the fields selected by African American astronomical researchers by decade and percentage. We see that the recent period saw a large upswing in the number of researchers selecting extragalactic systems for study. This reflects the broader trend in astronomy in general. Perhaps most surprising, not a single African American astronomical researcher has chosen to study planetary or extrasolar planetary systems thus far. This is especially surprising given the large amount of activity in these research areas. Figures 3 & 4 show the primary modes of research utilized by African American astronomical researchers in their work. An interesting point is that of the four who have chosen to be experimentalists as their primary mode of research, one was Dr. Walker and the other two are his students

Fig. 4 Production of African American astronomical researchers by mode of research and percentage

Dr. Ray O'Neal and Dr. Hakeem Oluseyi. We note, however, that researchers have crossed over from their primary mode of operation and participated in other activities. For example, both Dr. Leonard Strachan and Dr. Dara Norman have been involved in experimental developments.

Participation and Research in Sub-Saharan Africa

Sub-Saharan Africa (a term that excludes the North African countries from the rest of the continent) has close to 10% of the world's population but contributes less than 0.2% of professional astronomers in the world. The latest membership list of the International Astronomical Union (www.iau.org) shows that of a total of 9773 members as of January 2007, The continent of Africa contributes only 142 members made up of Algeria (3), Egypt (57), Ethiopia (1), Morocco (7), Nigeria (10) and South Africa (64). The sub-Saharan African countries in the list are only South Africa, Nigeria and Ethiopia. The only radio telescope in the continent of Africa, at present, is the 26-m radio telescope in South Africa. Also, the other major astronomical research facilities – optical and gamma-ray telescopes – in sub-Saharan Africa are located in southern Africa (South Africa and Namibia). Again, among the sub-Saharan African countries, it is only in a few Nigerian and South African Universities that astronomy programs are offered.

Astronomy in Nigeria

Modern astronomy came into Nigeria only four decades ago. However, like ancient people everywhere, Nigerians had always wondered at the sky and struggled to make sense of it. So, while modern astronomy may be quite new – and not yet popular – in Nigeria, ancient architecture, folklore, myths, religion, calendars, etc. are quite rich in astronomy.

One of the first major modern astronomy/space science activities in Nigeria was the setting up of NASA's space tracking facility in Kano in the early 1960s for monitoring the missions of Gemini, Apollo, and Skylab spacecraft. In South Africa, Australia, and other parts of the world, such NASA's space tracking facilities metamorphosed into radio astronomy observatories but, unfortunately, were dismantled in Nigeria. Astronomy, as a course, was first introduced in the Departments of Mathematics of the University of Nigeria, Nsukka, in 1962 by Dr. John Gaustad. He, however, left Nigeria shortly after that following the break out of the Nigerian – Biafran civil war that lasted from 1967 to 1970. Presently, there is no major astronomy facility in Nigeria, and indeed in any other part of the West African sub-region. It is, however, worthy of note that a Nigerian – Samuel Okoye – was the first black African to obtain a doctorate in radio astronomy, and probably in astronomy generally. His doctoral research at the Mullard Radio Astronomy Observatory, University of Cambridge (1962–1965), led to the discovery (with his supervisor, Dr. Tony

Hewish) of an extremely high brightness temperature source in the Crab Nebula recognized as the first example of a neutron star [21]. This source later turned out to be none other than the famous Crab Nebula Pulsar. The discovery was widely recognized as being of fundamental importance to basic physics and for which Prof. Hewish was awarded the Nobel Prize in Physics in 1974.

Astronomy in Nigerian Universities

Presently Nigeria has nearly eighty (80) universities and several polytechnics but the University of Nigeria, Nsukka remains the only one in which astronomy is offered at all levels (B.Sc., M.Sc., Ph.D). In the early 1970s, Dr. Samuel Okoye and his colleagues who had returned to the University of Nigeria, Nsukka, following the Nigerian–Biafran civil war proposed and designed curricula for post-graduate teaching and research in the four main physics sub-disciplines of Astrophysics, Geophysics, Materials Science/Solid State Physics and Nuclear/High Energy Particle Physics. Later, when he became the Head of Department (1978–1981), he took a further step of expanding the physics degree curriculum at the undergraduate level to include astronomy as a mandatory course in the third year as well as fourth year degree optional topics in astrophysics. It was therefore natural for a case to be successfully made to Senate, the Governing Council, and the National Universities Commission for the departmental name to be upgraded to "Department of Physics and Astronomy," thus becoming one of a handful of elite academic departments in the world so named, and certainly the first one in Africa.

Nigeria has produced 19 Ph.Ds in astronomy over its history. The University of Nigeria has produced only 10 Ph.Ds in astronomy/astrophysics in the past two decades. These are L.I. Onuorah (1984); C.E. Akujor (1985); M.W. Anyakoha (1988); A.A. Ubachukwu (1991); G.C. Anene (1991); F.C.C. Anyaegbunam (1992); I.E. Ekejiuba (1992); J.O. Urama (1999); A.E. Chukwude (2002) and R.N.C. Eze (2004). Starting from the early 1990s, some other universities, especially in the south-eastern Nigeria, started introducing postgraduate courses in astrophysics. Already, the Nnamdi Azikiwe University, Awka, the Rivers State University of Science & Technology, Port-Harcourt, and the Ebonyi State University, Abakaliki, have each produced one Ph.D. These are A.C. Ugwoke, F.B. Sigalo, and E.O. Ekpe respectively. Unfortunately, none of the universities in the northern and southwestern Nigeria is running astronomy program at any level.

Nigerian Astronomical Facilities

With the initial radio telescope set up in Kano by NASA in 1960s already dismantled, Dr. Okoye set out towards the setting-up a radio observatory in Nsukka. He arranged for a high quality 10 metre parabolic aluminum dish radio antenna (worth US$50,000 at 1973 prices) to be donated by the Astronomy Department of the University of California, Berkeley to the University of Nigeria, Nsukka (UNN). This was later followed up by a personal donation of one hundred thousand Naira (about US$150,000 then) by Dr. Nnamdi Azikiwe, the founder and first Chancellor of UNN and the first President of Nigeria, for astronomical research. Augmented by a further UNN Senate research grant of fifty thousand Naira, Okoye and his group were able to set up a 10-m dish operating at 327 MHz as the initial facility of the group. The facility was commissioned by Dr. Nnamdi Azikiwe during the University's silver jubilee celebrations in 1985 and became known as the Nnamdi Azikiwe Space Research Centre, Nsukka. However, there was no further support from the Nigerian government or from any other source, and as a result no serious activity was taking place around the telescope, which was situated in a remote corner of the University (as is usual with radio instruments). Consequently, the dish and all the facilities were vandalized.

With the recent restoration of democratic governance in Nigeria, the National Centre for Basic Space Science, Nsukka, was created, in 2000, under the leadership of Prof. Pius Okeke – another foremost Nigerian astrophysicist. Part of the mandate of the Centre is to conduct and carry out active frontline research in Atmospheric Sciences and Astronomy. Earlier in November 1998, the African Regional Centre for Space Science and Technology Education in English Language (ARCSSTE-E) was established at Ile-Ife. Unfortunately, however, none of these Centres has any astronomical facility for front-line research yet.

Astronomy and the Public

Astronomy remains largely unpopular in Nigeria. There are only about a dozen professional astronomers and no amateur astronomers in a country of about 140 million people. Here, astronomy is seen to be of only esoteric interest and devoid of any practical and economic value. The Astronomical Society of West Africa, Nigerian block, was formed in 2004 and part of the efforts of the group would be to create awareness and interest in astronomy.

Black African Astronomy in South Africa

Astronomy in South Africa began in 1751 with the observations of the Frenchman, Abbe de Lacaille. It would not be until 2002 that the first Black Africans received their Ph.Ds in astronomy in South Africa. Ramotholo Sefako, Thebe Medupe, and Lerothodi Leeuw each earned their Ph.D. in that year.

Dr. Leeuw received his Ph.D. in Astronomy from the University of Cape Town studying dust in active galactic nuclei. He has since begun studying cold dust in elliptical galaxies. He has held a couple of postdoctoral positions prior to his current position as a Research Scientist at the University of Toledo in the U.S. Dr. Medupe received a Ph.D. in Physics at the University of Cape Town studying oscillations in stellar atmospheres, investigating the relationship between radiative transfer and pulsations. He held a lectureship at the University of North West prior to taking his current position as a Lecturer at the University of Cape Town. Dr. Medupe is perhaps best known for starring in the documentary film *Cosmic Africa*. Dr. Medupe is also an avid researcher in astronomy history, leading the Timbuktu Science project which seeks to identify astronomical knowledge in ancient Arabic manuscripts from Timbuktu, Mali. Dr. Sefako received a Ph.D. in Astronomy from the Space Physics Unit of Potchefstroom, South Africa, studying neutron stars with very intense magnetic fields. After graduate school he worked briefly with Dr. Eric Wilcots of the University of Wisconsin as a postdoctoral researcher. He is currently a staff member at the South African Astronomical Observatory.

The contributions of Africans living in Europe are limited to two persons known to the authors. There is Jean Paul Mbelek, a native of Cameroon who resides in France. He research work has involved theoretical work in cosmology and gravity, closely matched to observational data. He also lectures on the history of science in sub-Saharan Africa. The second researcher known to the authors resided in Russia and is known simply as Bolotov. His work, as described by scholar Asa Davis was also in the field of gravity. Unfortunately, we know little about this scholar or his work.

Historians of the African Diaspora's Astronomical Contributions

The Pioneers

Ms. Hattie Carwell was the author of the first book devoted to illustrating the contribution of the African Diaspora to the sciences, including astronomy. Ms. Carwell's book, entitled *Blacks in Science: Astrophysicist to Zoologist*, was published in 1977. Shortly thereafter the Afrocentric movement was took hold in the U.S. Its leader, Dr. Ivan van Sertima, organized the movement and founded *The Journal of African Civilizations*. Volume 5 of this journal, entitled *Blacks in Science: Ancient and Modern*, was released in 1983. The next major works on the topic were presented by Robert Fikes, Jr. He published an article entitled "Careers of African American Astronomers in Academics," in *The Journal of Blacks in Higher Education*, in Autumn 2000. With the advent of the World Wide Web, Dr. Scott Williams, Professor of Mathematics at the State University of New York at Buffalo created the website *Astronomers of the African Diaspora*, initially utilizing information from the aforementioned sources and from Dr. Ronald Mickens, former Historian of the National Society of Black Physicists (NSBP). The astronomers listed doubled with contributions from Dr. Hakeem M. Oluseyi. In 2006 the effort to preserve and disseminate the contribution of Africa and the African Diaspora to astronomy coalesced in the founding of the African Cultural Astronomy Project, primarily due to the efforts of Dr. Jarita Holbrook.

The African Cultural Astronomy Project

It has been argued that, "astronomy is more than the science of stars. It is intimately connected to our ideas of ourselves, our purpose and place in the universe" [22].

Fig. 5 Some of the people that gathered at the University of Cape Coast, Ghana, to watch the total solar eclipse of March 29, 2006. Dr. Johnson Urama is holding the microphone while Dr. Herbert Charles is facing him

Like ancient people everywhere, Africans wondered at the sky and struggled to make sense of it. One of the greatest challenges of the Africa Cultural Astronomy Project (more information at www.africastronomy.org) is being able to "scientificate" these knowledge of the sky possessed by Africans. One of the ways of achieving this is by making a conscious and systematic effort to bridge the gap between cultural astronomy in Africa and the modern astronomy by providing scientific interpretation for some rich and detailed ethnic cosmogonies. In different parts of Africa, there are hundreds of ethnic cosmogonies and mythologies that need to be studied more systematically. The main objectives of the project are to unearth the body of traditional knowledge of astronomy by peoples of the different ethnic groups in Africa; and to re-interpret this body of knowledge in the light of modern astronomy. We hope that through this, we would be able to provide better insights into the science behind ancient architecture, folklore, myths, religion, rituals, etc., and use it as a very powerful tool for creating awareness and interest in modern astronomy and space sciences generally.

A good example of such ancient astronomy is that of the Dogon. The Dogon is one of the ethnic groups in Mali, West Africa. The Dogon beliefs, supposedly thousands of years old, include some knowledge of the star Sirius (8.6 light years from the earth). Dogon priests said that Sirius had a companion star that was invisible to the human eye. They also stated that the star moved in a 50-year elliptical orbit around Sirius, that it was small and incredibly heavy, and that it rotated on its axis. All these things happen to be true (the actual orbital figure is 50.04 +/–0.09 years). But what makes this so remarkable is that the companion star of Sirius, called Sirius B, was first photographed in 1970. While people began to suspect its existence around 1844, it was not seen through a telescope until 1862. The Dogon

Fig. 6 Some of the people that gathered at the University of Cape Coast, Ghana, to watch the total solar eclipse of March 29, 2006. From left to right Dr. Hakeem Oluseyi, Dr. Jarita Holbrook, Dr. Thebe Medupe, and a University of Cape Coast student

name for Sirius B, *Po Tolo*, consists of the word for star (*tolo*) and "*po*", the name of the smallest seed known to them. By this name they describe the star's smallness – it is, they say, "the smallest thing there is." They also claim that it is "the heaviest star," and white. The tribe claims that *Po* is composed of a mysterious, super-dense metal called *sagala*, which they declare is heavier than all the iron on Earth. Not until 1926 did Western science discover that this tiny star is a white dwarf, a category of star characterized by very great density. Many artifacts were found describing the star system, including a statue that is at least 400 years old. The Dogon also describe a third star in the Sirius system, called *Emme Ya*. Larger and lighter than Sirius B, this star revolves around Sirius as well. Around the star *Emme Ya* orbits a planet. To date, however, astronomers have not identified *Emme Ya*. Will our celestial observation devices one day be powerful enough for us to find this legendary planet, thereby adding still more mystery to the extraordinary – seemingly impossible – astronomical knowledge of the Dogon? [Editor's Note: There is gravitational evidence of a third body, but it is Jupiter sized and thus not a star.] In addition to their knowledge of the Sirius group, the Dogon mythology includes Saturn's rings and Jupiter's four major moons. They have four calendars, for the Sun, Moon, Sirius, and Venus, and have long known that planets orbit the sun.

Conclusions

As we have illustrated, the latter half of the 20th Century was revolutionary for the participation of Africans and the African Diaspora in the astronomical research enterprise. While the trend has been towards increased participation when averaged over the last 50 years, the numbers are not yet significant enough to assume a stable population of Black astronomers that will continue into the future. National science budgets are under pressure in both the U.S. and Nigeria. Political trends in the U.S. suggest that anti-intellectualism, jingoism, and religiosity are on the rise. And while most African Americans in science, technology, and mathematics careers are graduates of historically Black colleges and universities (HBCUs), surprisingly few of these institutions have astronomical curricula or facilities. What must be done to combat these factors?

Clear trends in the past success observed in Nigeria and the U.S. are collaborations and connections with the broader astronomical community, while simultaneously developing strong mentoring relationships within the Black community. One key to a successful career in science is exposure to research and its personnel very early on in a person's intellectual development. The process of mentoring young undergraduate students – and even high school students seeking to pursue a technical college degree – is of enormous value, and is usually the method of exposure to research which most successful scientists have been fortunate to have enjoyed. The teaching and mentoring of the younger generations by the older ones is of utmost importance to the advancement of all the sciences. The importance of role models and teachers may be related to the findings of Lewis and Collins, which showed that African American students were making the decision to stay or leave the sciences based on (A) misinformation about what scientists do, and (B) what the lives of scientists are like, among other factors [23].

The development of collaborations and support networks is important not only for maintaining the pipeline of Black astronomers and astrophysicists, it is also important for maintaining the careers of current researchers. Tighter research budgets result in more scientists competing for fewer research dollars. As proposal funding decisions are provided by the scientific community itself, it is of the utmost importance for Black scientists to focus on remaining connected and respected in order to compete.

If Black astronomers and astrophysicists are able to successfully maintain their own careers, train and mentor the next generation, include the next generation in the process of expanding knowledge, and inform the public of the cultural and scientific contributions of Africans and the African Diasporadiaspora to astronomy and astrophysics, we will be well positioned to be full participants in the next century of discoveries.

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