African Skies

Cieux Africains

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Stone megalith at Nabta Playa in the Egyptian desert, dating from the 5th millenium BC (see Malville et al, p. 2–7).

In this Issue:

Proceedings of the African Astronomical History Symposium held in Cape Town on 8 & 9 November 2005

The Working Group on Space Sciences in Africa

The Working Group on Space Sciences in Africa is an international, non-governmental organisation founded by African delegates at the 6th United Nations/European Space Agency Workshop on Basic Space Science held in Bonn on 9–13 September 1996. The scientific scope of the Working Group's activities is defined to encompass: (a) astronomy and astrophysics, (b) solar-terrestrial interaction and its influence on terrestrial climate, (c) planetary and atmospheric studies, and (d) the origin of life and exobiology.

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African Skies/Cieux Africains

Editor: Peter Martinez
Guest Editor: I.S. Glass
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Editorial

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This issue of *African Skies/Cieux Africains* is devoted to papers presented at the African Astronomical History Symposium held in Cape Town on 2005 November 8 and 9, under the auspices of the Astronomical Society of Southern Africa (Historical Section), in conjunction with the opening of the Southern African Large Telescope (SALT).

Many parts of Africa possesses unusually clear skies and it is not surprising that these have always attracted the interest of its various peoples as well as of visitors from less fortunate parts of the world. The Symposium brought together a surprising variety of contributors, reflecting points of view that are not always represented in the astronomical literature. This broad approach taken by many speakers is a testimony to the high value placed on all sorts of astronomical knowledge by Africa and Africans today.

An informal account of the meeting is available at www.saao.ac.za/assa/aahs and, in print, in *Monthly Notes of the Astronomical Society of Southern Africa* (*MNASSA*), Vol 64, Nos 11 and 12, December 2005, pp 189–199. The contribution by Dr Wayne Orchiston, "Amateurs in the Antipodes, The Common Denominators of Nineteenth Century South African, Australian and New Zealand Astronomy", has already been printed in *MNASSA* (Vol 65, Nos 9 and 10 , October 2006, pp 148–159; Vol 65, Nos 11 and 12, December 2006, pp 194–208). Another, "Transit of Venus Observations and Relics in South Africa", by W.P. Koorts, appeared in *MNASSA* Vol 65, Nos 1 and 2, February 2006, pp 8–22.

The Organising Committee consisted of Mr Chris de Coning, Mr Willie Koorts, Dr Clifford Nxomani, Mr Auke Slotegraaf and Mr Maciej Soltynski. The Scientific Programme Committee comprised Dr Ian S. Glass, Dr Dave Laney, Ms Anne Rogers, Prof. Keith Snedegar and Prof. Brian Warner.

The organisers wish to thank the SAAO for granting the use of their new auditorium, the National Research Foundation for travel grants for the invited participants, and those, not already mentioned, who helped substantially with organisational matters (Cliff Turk, Treasurer of ASSA, Mrs H. Glass, Mrs H. Carter, Ms Karen Koch and Mrs V. McConnell). All the participants, especially those who travelled long distances, are thanked for their contributions. Finally, the editor of *African Skies/Cieux Africains* (Dr Peter Martinez) and the Editorial Assistant, Ms Di Cooper, are thanked for their help.

Le présent numéro de African Skies/Cieux Africains s'articule autour des exposés donnés lors du symposium sur l'histoire de l'astronomie en Afrique. Symposium organisé à Cape Town, les 08 et 09 Novembre 2005 sous les auspices de la Société Astronomique d'Afrique Australe (commission Histoire), en conjonction avec l'inauguration du Southern African Large Telescope (SALT).

Plusieurs régions d'Afrique présentent des ciels nocturnes particulièrement clairs. Ciels nocturnes ayant stimulé la curiosité des peuples d'Afrique mais aussi celle de visiteurs venant de régions moins pourvues. Le symposium sus-mentionné a réuni des intervenants de divers horizons, reflétant des points de vue peu représentés dans la littérature astronomique.

L'approche élargie, adoptée par de nombreux intervenants est un témoignage de la haute estime que les Africains et l'Afrique ont aujourd'hui pour la vaste palette des savoirs astronomiques.

Une synthèse de cette rencontre est disponible en ligne à www.saao.ac.za/assa/aahs et sur papier dans *Monthly Notes of the Astronomical Society of Southern Africa* (MNASSA), Vol 64, Nos 11 et 12, Decembre 2005, pp. 189-199. La contribution de Dr.Wayne Orchiston intitulée, « *Amateurs in the Antipodes, The Common Denominators of Nineteenth Century South African, Australian and New Zealand Astronomy* «, a déjà été publiée dans MNASSA (Vol 65, Nos. 9 et 10, Octobre 2006, pp. 148-159 ; Vol 65, Nos. 11 et 12, Décembre 2006, pp. 194-208). Une autre, «*Transit of Venus Observations and Relics in south Africa*», par W.P. Koorts, est parue dans MNASSA Vol 65, Nos 1 et 2, Février 2006, pp 8–22.

Le comité d'organisation était formé de Mr. Cris de Coning, Mr. Willie Koorts, Dr. Clifford Nxomani, Mr Auke Slotegraaf et Mr Maciej Soltynski. Le comité scientifique comprenait Dr Ian Glass, Dr Dave Laney, Mlle. Anne Rogers, Prof. Keith Snedegar et Prof. Brian Warner.

Les organisateurs souhaitent remercier le SAAO pour la mise à disposition de son nouvel auditorium, le National Research Foundation pour le soutien au voyage des invités, mais aussi ceux, non mentionnés ici, qui ont substantiellement contribué à l'organisation (Cliff Turk, trésorier de l'ASSA, Mme H. Glass, Mme H. Carter, Mlle Karen Koch et Mme V. McConnell). Tous les participants, particulièrement ceux venant de fort loin, sont à remercier pour leurs contributions. Enfin, l'éditeur de African Skies /Cieux Africain (Dr Peter Martinez) ainsi que son assistante, Mme Di Cooper, sont également à remercier pour leurs contributions.

Astronomy of Nabta Playa

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Abstract. 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 heavens at Nabta Playa, Egypt. The groups of shaped stones facing north may have represented spirits of individuals who died on the trail or locally. A second piece of evidence for astronomy at Nabta Playa is the stone circle with its two sightlines toward the north and toward the rising sun at the June solstice. Finally, the five alignments of megaliths, which were oriented to bright stars in the fifth millennium, suggest an even more careful attention to the heavens. The "empty tombs" and deeply buried table rocks of the Complex Structures provide some of the greatest enigmas of Nabta Playa. The recurrent symbolism of the ceremonial centre involves issues that would have been of both practical and symbolic importance to the nomads: death, water, cattle, sun, and stars.

Sommaire. L'orientation répétée des mégalithes, des tombeaux humains, et des restes bovins vers le ciel nordique révèle une connexion symbolique claire entre Nabta Playa et le Nord. Les groupes de pierres faisant face au nord pourraient représenter les esprits des individus morts localement or durant leurs voyages. Le second indice de la pratique de l'astronomie à Nabta Playa se trouve dans le cercle mégalithique et ses deux repères visuels indiquant le nord et la position du soleil levant au solstice d'été. Enfin, les cinq alignements de blocks mégalithiques, pointant vers des étoiles brillantes au cinquième millénaire avant notre ère, suggèrent une attention bien particulière portée aux cieux. Les «tombeaux vides» et les mégalithes profonds formant la surface de la Structure Complexe constituent les plus grandes énigmes de Nabta Playa. Le symbolisme récurrent observé au centre cérémonial implique des sujets qui auraient été d'importance pratique et symbolique pour les nomades: la mort, l'eau, le bétail, le soleil, et les étoiles.

Introduction

The southwestern desert of Egypt, now one of the driest areas on 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.[11,12,13,14] Even with rains it was still a dry environment with an annual rainfall of no more than 100–150 mm. Rain was unpredictable, and the climate was punctuated by 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 in Kenya. Cattle allowed people to live in the desert, thereby controlling their lives and dominating much of their ceremonialism.

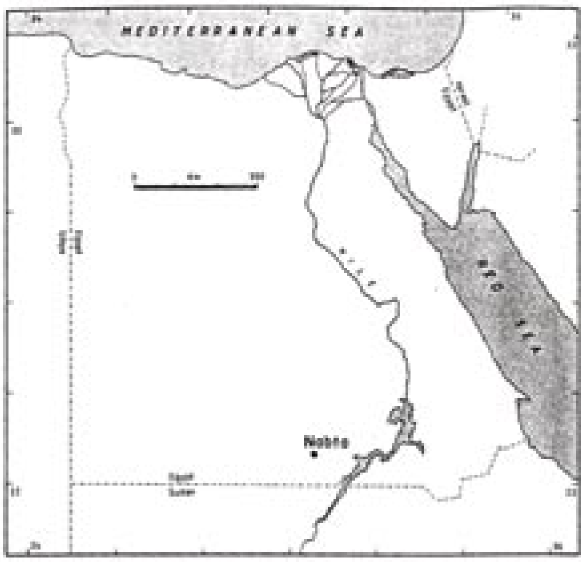

Fig. 1. Location of the Nabta Playa.

Located 100 km west of Abu Simbel, Nabta Playa is a large internally drained basin (Figure 1). During the early Holocene (ca 9000–3500 BC), the playa was occasionally flooded, attracting nomads to settle intermittently on its shores. 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 autumn, when the water in the playas dried up, they had to return to the Nile or to better-watered areas in the south.

By 7000 BC the settlements became larger, and their inhabitants were able to live in the desert throughout the year by digging large, deep wells. They lived in organised 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, almost certainly introduced from southwest Asia.

Ceremonial Centre at Nabta Playa

Nabta probably began to function as a regional ceremonial centre during the Middle Neolithic period (ca 6100–5600 BC) during the summer wet season, when the playa had reached its largest size. By a regional ceremonial centre, we mean a place where related but geographically separated people gather periodically to conduct ceremonies and to reaffirm their social and political identity. These gatherings occurred along a dune on the northwestern shore of the playa where there are hundreds of hearths, extensive cultural debris, and many cattle bones. 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, for whom cattle represent wealth and political power. They are rarely killed other than on important ceremonial or social occasions such as the death of a leader or a 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 organisation and control not previously seen. These new people, the Ru'at El Baquar people (the Cattle Herders), were responsible for cattle burials in clay-lined and roofed chambers covered by rough stone tumuli.

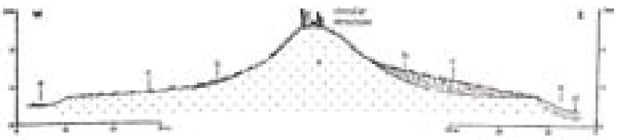

Fig. 2. Cross-section of the calendar circle mound cromlech. (*Profile by R. Schild*)

The Valley of Sacrifices and the Cromlech

Along the western rocky bank of a wadi entering Nabta Playa from the north, which we have called the Valley of Sacrifices, there are about ten identifiable tumuli. Built of broken sandstone blocks, the tumuli contained offerings of parts of butchered cattle, goats and sheep. The largest and perhaps the oldest tumulus contained an entire young cow, the most precious offering that a pastoralist can make. A piece of tamarisk from its roof yielded a radiocarbon date of 5270 $\pm$ 270 years BC. Probably a female just entering adulthood, the animal was lying on its left side, oriented approximately north-south, with its head in the south. This wadi brought water to the playa and would have been an appropriate spot to ask the gods for rain by performing cattle sacrifices.

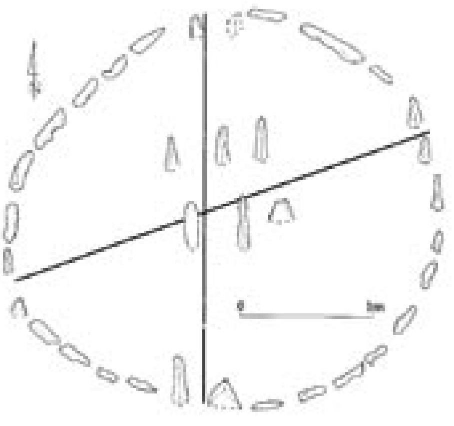

Fig. 3. Reconstruction of the calendar circle cromlech. (*Applegate 2001*)

The wadi ends in a small cromlech or stone circle, on top of a small sandy knoll[1,10] (Figures 2, 3, 4). The circle, approximately

Fig. 4. Calendar circle cromlech. (*Photograph by J. Malville*)

4 m across, contains sets of upright, narrow slabs aiming the eye approximately to the north and to the position of the rising sun at the summer solstice, which would have been near the start of the rainy season. A radiocarbon date from a hearth adjacent to the cromlech yielded a date of 4800 $\pm$ 60 years BC. The centre of the cromlech 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 in the sand and use their moving shadows as time keepers. Another well-known stone circle was discovered by Bagnold[2] in the Libyan desert. It is larger (8.5 m) 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.

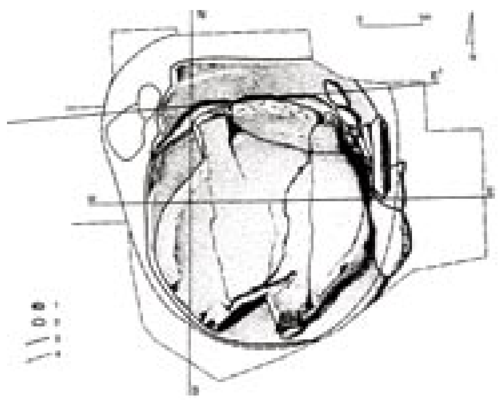

Fig. 5. Complex Structure A - Table Rock. (1, table rock; 2, other rock; 3, edge of original pit; 4, limits of excavation). (*Map by R. Schild and H. Krolik; drawing M. Puszkarski*).

The Complex Structures

To the south of the Valley of Sacrifices is a series of knolls carved in the ancient lake clays by the desert winds. The area contains about 30 complex megalithic structures built during the Terminal Neolithic by Bunat El Ansalm people or Megalith Builders. The Terminal Neolithic at Nabta Playa extended from 4600 BC to the abandonment of the area in approximately 3400 BC. The complex structures or tumuli were set in silt deposited during the final part of the Middle Neolithic.

Some of the stones on the top of these complex structures are standing upright, typically arranged in an oval with a larger recumbent stones in the centre. The ovals are 5–7 m long and 4–6 m wide, oriented north-south or rotated slightly to the west of north. The recumbent stones have a similar orientation.

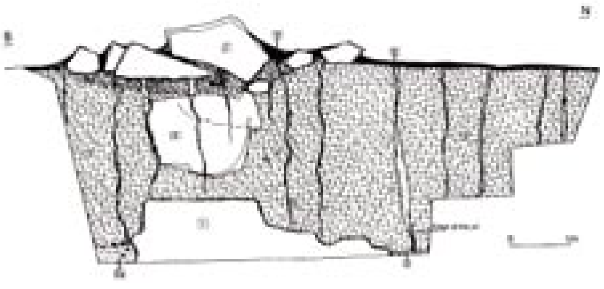

Fig. 6. Complex Structure A, north-south profile. (note the upright cow-like rock 5)

The largest of the complex structures, A, appears to play a major role in the symbolism that becomes manifest in the ceremonial centre during the Final Neolithic.[13] We originally thought the structure might contain elite graves, but excavation has failed to disclose any human remains. Very significantly, it is the focus of the five radiating megalithic alignments. The builders of Complex Structure A dug a pit through playa sediments to expose a table rock at a depth of 2.6 m (Figure 5). The rock is a thick lens of hard, quartzitic sandstone that remained after the surrounding softer sediments had been removed by erosion. A similar rock was found in the second complex structure that was excavated, and in a third structure another table rock was located 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 side was flattened to the east-west and the western side was rounded. Its top appears to have been worked and smoothed. After shaping the oval rock measured 3.3 m by 2.3 m with its long axis aligned north-south.

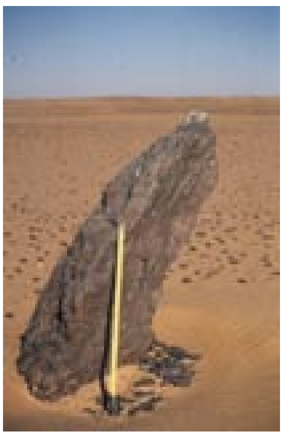

Fig. 7 Stele A-0: note blow-out on north side. (*Photograph by J. Malville*)

How or why the buried table rocks were chosen remains a puzzle. It seems unlikely 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. It is conceivable that these round, large quartzitic lenses were part of the symbolic landscape of the Middle Neolithic and became significant before the establishment of the complex ceremonial centre. Perhaps their locations had been marked by rock cairns before gradual burial by playa sediments.

The pit was partially refilled and a large secondary stone, weighing 2–3 tons was placed over the centre of the table rock (Figure 6). This secondary stone was also carefully 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 sacrificial cow.

Fig. 8. Stele A-2: note blow-out on north side. (*Photograph by J. Malville*)

Alignments

After reanalysis of our previous measurements and a new campaign of mapping the sandstone blocks of the area, we identified five alignments of megaliths that radiated outward from Complex Structure A. Many of the megaliths, if not all, are sculptured with anthropomorphic shoulders suggesting that they served as stele, perhaps representing the dead (Figures 7, 8, 9).

Dates for the quarrying and placement of these stones in the sediments of the playa are based on radiocarbon dates from the nearby quarry. Five radiocarbon dates from the quarry are 4500BC to 4200 BC. Not all the blocks that had been quarried were used, as approximately 100 m east of the quarry is a storage area where dozens of additional sandstone blocks have been stored. Since we also have a carbon date of 3600 BC for Complex Structure E , we estimate that the megalith period lasted for approximately 800–900 years from 4500 BC to 3600 BC.

Fig. 9. Artist's reconstruction of Stele A-2 and adjacent rocks.

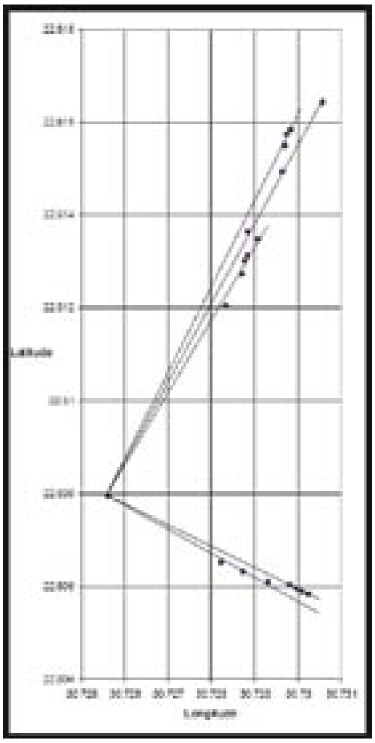

Fig. 10. Alignment of Megaliths. The Complex Structure A lies at the focus of the five alignments.

Our original measurements of the locations of the megaliths[9,10] have been complemented by satellite imagery by the Quickbird satellite and additional GPS measurements by Brophy and Rosen[5]. We are gratified that there is good agreement on the locations of the megaliths by these independent measurements. In our analysis we combine the two sets of GPS data and the satellite results (Figure 10).

For our calculations of precession, we have used the formulae of Bretegon *et al.*[3] and have included the effects of refraction and extinction. Because of the movement of the dunes over 6–7 millennia, it is difficult to estimate the actual horizon, and we assume a level physical horizon. Many of the stele 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^{o}. This uncertainty is meant to include not only the effect of fragmentation, but also the inherent irregularities of the locations of the stele as we suspect high precision in orientation may not have been a high priority.

Megalithic Alignments

Alignment	Azimuth (degrees)	Possible Astronomical Targets	Dates (BC)
A3	26.3	Arcturus	4530-4320
A2	28.1	Arcturus	4220-4020
A1	30.6	Arcturus	3810-3630
B2	116.6	Alnilam Sirius Winter Solstice	4340-4150 3700-3430
B1	120.1	Sirius α Centauri	4640-4400 4500-4260

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 (4600–3600 BC). It is the brightest star in the northern celestial hemisphere and the fourth brightest star in the night skies. There are three occasions when alignments A1, A2 and A3 were oriented to the rising positions of Arcturus in the period of the megaliths. Each of these three alignments may have been built to account for the changing location of that star due to precession.

The alignment, B2, may have been lined up with Alnilam, one of the three stars in the belt of Orion between approximately 4300–4100 BC, with winter solstice sunrise and later with Sirius, near the end of the Terminal Neolithic. The set of stele, B1, would have lined up with Sirius and α Centauri which is the third brightest star in the night sky, in the period 4600–4300 BC. A closer inspection of the southernmost alignment, which we had initially designated as C, indicates that it consists of stones resting on the sides and tops of dunes and may not represent an original set of aligned stele; we refrain from interpreting that alignment.

Four Brightest Stars in the Night Sky

Name	Visual Magnitude
Sirius	-1.46
Canopus	-0.72
α Centauri	-0.01
Arcturus	+0.6

With the exception of Canopus, these alignments may have been associated with the brightest stars in the night sky of Nabta. In 4500 BC, Canopus would have risen with an azimuth of 159^{o} and would have reached a maximum altitude of approximately 8^{o} 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.

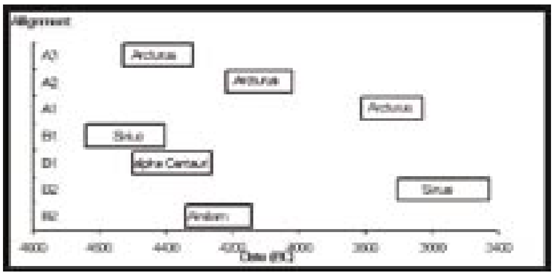

Fig. 11. Stellar Associations of the Megalithic Alignments.

The two major periods of alignments appear to be 4600–4200 BC, which would encompass Sirius, two orientations toward Arcturus, α Centauri, and the Belt of Orion. The second window at 3800–3400 BC, which would have included Sirius and Arcturus, may reveal a resurgence of interest in the heavens just as life was getting increasingly difficult in the desert. There are some interesting geometrical aspects of the alignments which may have been important for the Megalith Builders. In their navigation across the desert, nomads would have paid attention to cardinal directions and right angles. Two sets of megaliths, A3/B2 and A1/B1 differ by approximately 90° and connected Sirius with the brightest star in the northern sky. During the second window of time at approximately 3820 BC Arcturus rose 30.35° east of north. which was also the angular distance of the star from the zenith. With a declination of 52.85° at its upper culmination Arcturus reached 30.35° from the zenith.

In their analysis of the positions of the alignments, Brophy and Rosen[5] propose that the southernmost alignment, C, was associated with Sirius in 6088 BC and that the other alignments were associated with Vega and stars of Orion in 6270 BC. Their suggested dates are about 1500 years earlier than our best estimates for the Terminal Neolithic and the construction of megalithic structures by the Bunat El Ansalm people. Brophy[4] has also suggested that the table rock of Complex Structure A is a map of the Milky Way galaxy dating from 17500 BC showing spiral arms and a neighbouring dwarf galaxy. He proposes that the stones of the cromlech represent maps of the stars of Orion as early as 16500 BC. These extremely early dates as well as the proposition that the nomads had contact with extra-galactic aliens are inconsistent with the archaeological record.

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

Fields of Stele

In addition to the alignments, there are clusters of smaller sandstone blocks, ranging in weight from several tons to less than 50 kg.[110] A few are upright, and others with broken bases embedded in the clays suggest that originally the stele 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 northern faces of the collapsed blocks. Many are sculptured in a manner similar to the blocks of the alignments, with anthropomorphic shoulders suggesting that they too served as stele, representing the dead. Groups of stele may represent departed members of specific clans or extended families.

Prehistoric Herdsmen

Judging from the elaborate burials at the nearby cemetery at Gebel Ramlah about 20 km from Nabta Playa, the nomads associated with the ceremonial centre were prosperous and healthy, possessing a strong aesthetic sense and interested in preserving and honouring their dead.[7,6,8] Since it is a rare opportunity to learn about people associated with such an early ceremonial centre, it seems worthwhile describing these prehistoric herdsmen in some detail. The cemetery contained 67 individuals in both primary and secondary inhumations. The most reliable carbon date is from bone collagen giving us 4360 BC $\pm$ 60 years. Inspection of dental features indicates that two different populations, Mediterranean and sub-Saharan, were represented in the cemetery. The lack of differences in burial goods indicates there was little, if any, social stratification in the community.

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 also accompanied by sets of cosmetic artifacts consisting of stone pallets, stones for grinding colour-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. One slab was shaped in the form of a tilapia, a fish frequently encountered in the Nile. This is the oldest known sculpture to be discovered in Egypt.

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 travelling. All seven primary inhumations were in flexed positions, head oriented to west, facing south.

The cemeteries indicate that there was a keen interest 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 after death. Many of the burials were sprinkled with large amounts of red hematite dust which, in numerous 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 turquoise from the Sinai Peninsula, shells from the Nile, mica from mountains along the sea coast and ivory from elephants.

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 can be interpreted as burials of high status individuals who died during the distant migrations of the herders. It must have been important to bury them in the clan cemetery at a site that was believed to be the "centre place" for the culture.

Summary and Conclusion

The evidence for astronomical observations by these ancient herdsmen comes in three forms. The repetitive orientation of megaliths, stele, human burials and cattle burials toward the northern regions of the sky reveals a very early symbolic connection to the north. The apparent emphasis on death in the area suggests that the ceremonial centre may have functioned as a necropolis; the tumuli may have held stone cenotaphs or may have been cenotaphs ("empty tombs") themselves. The groups of shaped stele facing north may have represented spirits of individuals who died on the trail or locally. The second bit of evidence for astronomy is found in the cromlech with its two sightlines toward the north and toward the rising sun at the June solstice. Finally, the alignments of stele, which were oriented to bright stars in the fifth millennium, suggest an even more careful attention to the heavens.

Interest in the northern part of the heavens does indeed seem pervasive during the Late and Terminal Neolithic at Nabta Playa and Gebel Ramlah. The northern circumpolar region of the sky is that realm where stars never set, and, later in dynastic Egypt, it became identified as the realm of eternal life. Survival in the desert must 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 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 also have been established during the day by shadow-casting of a vertical stick or gnomon.

The "empty tombs" of the Complex Structures provide the greatest enigmas of Nabta Playa. How or why the buried table rocks were chosen remains a puzzle. It seems unlikely 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. It is conceivable that these round, large quartzitic lenses were part of the symbolic landscape of the Middle Neolithic and became significant before the establishment of the complex ceremonial centre. Perhaps their locations had been marked by rock cairns before gradual burial by playa sediments. Regardless of how they were initially located, the buried table rocks underneath the megalithic slabs apparently became manifestations of the sacred for the nomads. The symbolism embedded in the archaeological record at Nabta Playa in the Fifth Millennium BC is very basic, focussed on issues of major practical importance to the nomads: cattle, water, death, earth, sun and stars.

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‘The Sky’s Things’: |xam Bushman ‘*Astrological Mythology*’ as recorded in the Bleek and Lloyd Manuscripts

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Abstract. The Bleek and Lloyd Manuscripts are an extraordinary resource that comprises some 12000 pages of |xam Bushman beliefs collected in the 1870s in Cape Town, South Africa. About 17% of the collection concerns beliefs and observations of celestial bodies. This paper summarises |xam knowledge about the origins of the celestial bodies as recorded in the manuscripts and situates this within the larger context of the |xam worldview. The stars and planets originate from a mythological past in which they lived as ‘people’ who hunted and gathered as the |xam did in the past, but who also had characteristics that were to make them the entities that we recognise today. Certain astronomical bodies have consciousness and supernatural potency. They exert an influence over people’s everyday lives.

Sommaire. Les manuscrits de Bleek et Lloyd est une extraordinaire collection de 12 000 pages sur les croyances du peuple Xam-Bochiman recueillies pendant les années 1870 à Cape Town, Afrique du Sud. Près de 17% de cette collection se rapporte aux croyances astronomiques et à l’observation des corps célestes. Cet article récapitule les croyances Xam au sujet de l’origine des corps célestes telles qu’elles ont été rapportées dans ces manuscrits, et les place dans le contexte plus large de la vision Xam du monde. Dans ces croyances, les étoiles et les planètes sont vues dans un passé mythologique comme faisant partie d’un ‘peuple’ de chasseurs qui a vécu et qui s’est rassemblé comme le peuple Xam, mais qui ont eu des caractéristiques spécifiques leurs donnant leurs aspects d’aujourd’hui. Certains corps célestes ont une conscience et des pouvoirs surnaturels leurs permettant d’exercer une influence sur la vie quotidiennes des peuples.

The Bleek & Lloyd Manuscripts

Over 125 years ago a remarkable group of people came together in Cape Town under equally remarkable circumstances. The project upon which they embarked involved nothing less than the writing down of the language and beliefs of the |xam people, a Bushman group that lived over much of what is now South Africa. This testimony runs to some 12000 verbatim notebook pages and is housed in the library of the University of Cape Town. The collection is listed on UNESCO’s Memory of the World Register.[1] The manuscripts have been digitised and are on the World Wide Web[2]. The significance and value of the labours of philologist Wilhelm Bleek, self-taught linguist Lucy Lloyd and their |xam teachers are now well-known,[3,4,5,6,7,8] but little of their beliefs and observations about stellar bodies is readily available.

The three |xam teachers who contributed the bulk of the material were ||kabbo (a |xam name meaning ‘Dream’; he also had a Dutch name, Oud Jantje Tooren), Dia!kwain (or David Hoesar) and |han≠kasso (Klein Jantje Tooren). They were all former prisoners at Cape Town’s Breakwater Prison, serving sentences for homicide and stock theft. They were released into Bleek’s custody and after their sentences expired they stayed with the Bleek family, returning later to the hinterland of the then Cape Colony (now Northern Cape Province).

About 2079 of the 12000 notebook pages concern beliefs and observations about the sun, moon, planets and stars. The Bleek and Lloyd manuscripts are faithful records of oral narratives. In oral cultures, words evaporate as they are spoken – the ‘same’ story can therefore never be told twice in exactly the same way[9]. There are many stories about celestial bodies and narrative details differ from version to version. One notes too, the use of anthropomorphism – the attribution of human thought and emotion to non-human species and the sun, moon, stars and planets. Hunter-gatherer metaphors and idioms describe the origins and movements of celestial bodies.

Origins of the Celestial Bodies

In the mythological past the sun, moon and stars, and all the animals (and many insects too) were people. They were *!xwe:-/na-se!ke* – the ‘first-there-sitting-people’ – a phrase that Lucy Lloyd translated as ‘The Early Race’. These folk looked human and lived much as |xam hunter-gatherers did, but possessed simultaneously attributes that made them unique and different from people. It was this formative and unstable combination of human and non-human qualities that eventually caused the collapse of Early Race ‘society’ and the subsequent establishment of an order in which the planets, humans and other organisms became the distinct entities we recognise today.[3]

The Sun

The possession of anthropomorphic characteristics by stellar bodies is integral to |xam interpretations of their behaviour. The story of the sun’s origins illustrates this principle.[10, 11, 12] The sun was an old man of the Early Race who lived in a hut on earth. The light of the sun shone out of his armpit (a source of sweat, considered supernaturally potent by Ju/’hoansi Bushman groups in Botswana and Namibia[13]) and only lit up the space around his house. The ‘Bushman rice’, ant or termite larvae that people collected, could not dry out because there was no warmth from the sun. Everybody walked around cold and in darkness because the sun selfishly refused to share his light. At their mother’s behest, children of the First Bushman picked him up and threw him into the sky where he now sheds light all over the earth. The anthropomorphic elements in this story are obvious – the sun is an old man who selfishly keeps to himself the warmth and light that he generates. It is women in the community who decide that he must be forced to share these qualities and children (small boys) who are sent to carry out the task.

The Moon

The moon and its phases played an important role in |xam life. It is closely associated with |kaggen the |xam trickster-deity. Although the word |kaggen means 'mantis', he most commonly took on human form and lived in much the same way as |xam hunter-gatherers did. The moon is one of the 'things' that he made and it is gendered – the |xam teachers refer to it as 'he'. There are two versions of the moon's creation. According to ||kabbo[14], |kaggen took his shoe and threw it into the sky, commanding it to become the moon and shine. The moon is red because the shoe was covered with red dust. It is cold because it is 'darkness's thing.'[15] In another version, by |han≠kasso, |kaggen threw an ostrich feather into the sky and told it to become the moon.[11,16] The moon can talk, because it is one of |kaggen's things, all of which are 'clever' and have the faculty of speech.[17] The moon talks in a peculiar way – Wilhelm Bleek's daughter, Dorothea Bleek,[18] states that:

> The most difficult click of all is the one used by the Moon…It is made by curling the tongue backwards in a sort of roll and then withdrawing the turned up part of the tongue from the upper palate.

Moon and Sun (waxing and waning of the moon)
The moon was also considered to be a man of the Early Race.[10] He runs along a path in the sky. The sun follows the spoor of the moon across the sky. The sun cuts the moon with a knife (i.e. the rays of the sun) as they run. The moon shrinks in size as the sun cuts pieces off the moon. Eventually all that is left of the moon is its backbone. This 'hollow' moon carries the spirits of the dead. The moon begs the sun to spare his life for the sake of his children and the sun agrees. The moon then grows a big stomach and thus returns to his former size.

The Moon, the hare, and the origin of death
Many Khoe-San groups link the moon and the hare to the origins of death and there are different versions of how death originated.[10] The same theme runs through all of them, however; the moon dies and then comes back to life, but all other living things (with the exception of the male ostrich which can be resurrected from a single feather[10]) die outright. The moon strikes the hare on its mouth giving this animal its characteristic harelip. Here I quote a version of this story by ≠kasin or Klaas Katkop, another of Bleek and Lloyd's teachers[8,19] (my parentheses):

> The moon was the one who ordered the hare to go to tell the people that a man who is ill will rise up, like himself. For he who is the moon, when he dies, he comes again, living.
>
> The hare went, but he turned the story round. He said that a man who dies will not arise; he decreed that a man who dies shall die completely and be finished. That is why people do not rise up. People who die do not arise. Dying, they are finished. Therefore people who die do not come back living; they die and are completely finished. They do not arise, for they are truly finished.
>
> This is the argument about which the moon hit the other one's (i.e. the hare's) mouth. Therefore we who are ill are finished; we do not arise again. We who are ill, we are finished. Our thoughts, ascending, leave us. Our bodies, our bodies are those which lie in the earth. That is why our thoughts leave us.

Since this episode, the moon and the male ostrich are the only entities that die and then return to life.

The Moon and game
The |xam had an intricate web of observances concerned with hunting, known as !*nanna-sse*, 'hunting observances showing respect.'[20,12] This code of behaviours was derived ultimately from |kaggen himself – he did not want people to kill eland and other large game – and it governed people's chances of success in hunting large game animals, especially eland.[18] Beliefs about the moon were also intimately linked to the behaviour of game animals and people had to respect the moon by observing a code of behaviours, probably because the moon itself was one of |kaggen's 'things'.

People could predict the results of a hunt by observing the moon, as Dia!kwain explained[21] (my parentheses):

> Our mothers used, when they saw the moon, when they had seen that the moon did not lie hollow (i.e. when it was full), they spoke, they said 'This moon it is a good moon, it does not carry people (recall that the new moon was believed to carry the spirits of the dead in its hollow), for it comes like that which a man is used to do when he carries food, when he has put food into the (carrying) net. It seems as if it knew that our men will carry, that is why it (i.e. the moon) carries with the net. It seems as if it knew that our folk will going find (food), their going will be lucky…for the moon seems as if it knew, for a thing which knows it is, the time at which we shall get food. For it and the stars are things which know matters which we do not know.

In another instance, a |xam woman interprets a red-coloured moon as a promise of a successful outcome to the hunt[21] (my parentheses):

> Behold! The moon is bloody, a man will shoot game, its blood will flow, the head of game, its blood is that which is there (on the moon). That is why it is red…

The woman equates the redness of the moon with the redness of the animal's blood and interprets this as a sign that the hunt will be successful. Once an animal had been shot with a poisoned arrow, another set of respect observances regarding the moon came into play[21] (my parentheses):

> That is why our mothers used to say, they taught us who were children, that we should, when we shot game, we should not look at the moon…if we looked towards him (the moon) he would…swallow down the game's fat…the thing (i.e. the dead animal) would seem as if the game had been completely lean, although the game had been fat…he (the moon) would not allow the game to die, because he would cool the mouth of the game's wound that the game might recover, the game would not die even though the poison with which the man had shot the game

it nevertheless had been strong, he [the moon] would allow the poison to become water.

A hunter should not look at the moon for fear that the animal would become lean or even recover from the poison through the moon's intervention. Nor should children anger the moon by shouting certain 'words of derision' at it when the moon is rising.[10] The moon was a sentient being imbued with some of |kaggen's powers with a direct influence on people's good fortune, especially as far as hunting was concerned.

Stars

The |xam teachers named many of the prominent stars and constellations (Table 1). The names reflect a hunter-gatherer world – stars named after animals prominent in their lives (lion, large antelope, tortoises) and objects of material culture (digging stick stone). ||kabbo links the appearance of the ||kohai stars in the sky with '||kohai's rain' and the emergence of 'the rice's maggots' (winged ants or termite alates, an important food source) from the moistened earth.[22] In ||kabbo's descriptions of the movements of the Milky Way the stars are animated[12] (original translation modified by author, my parentheses):

> The Milky Way must go round with the stars because it knows that it lies going round as the stars sail along. That is why the Milky Way, lying, goes along with the stars. When the Milky Way stands upon the earth, the Milky Way turns across in front because it means to wait. This is because the Milky Way knows the other stars are turning back. The stars know that the sun is the one who has turned back, he is on his path. The stars turn back and they go to fetch the daybreak so that they may lie nicely (i.e. in their 'correct' place?) as the Milky Way lies nicely. The stars must also stand nicely around. They must sail* along upon their footprints, which they, always sailing along, are following. Because they know that they are setting stars. The Milky Way lying comes to its place…in order to set nicely. It had lying gone along, because it knew that it lay upon the sky. The sky lies still, the stars are those which go along because they know that they sail along. They were setting, again they rise, they sail along following their footprints. They become white when the sun comes out. The sun sets, they stand around above because they know that they turned following the sun. The darkness comes out and the stars wax red although they had at first been white. They know that they stand brightly around so that they can sail along. Because they know that it is night and the ground is made light and they know that the stars shine a little. Darkness is upon the ground. The Milky Way gently glows…

||kabbo's observations are accurate and insightful – he describes the movements of the Milky Way and the 'other' stars as following fixed paths across a stationary backdrop of 'sky'. He notes that these bodies move in conjunction with each other and points out too how (different) stars have different colours. These observations are imbedded in anthropomorphic idiom – the stars have reason and intention – they choose their path and in doing so they take the other stellar bodies and their movements into consideration.

The stars were once people of the Early Race.[23] Some of the stories in the Bleek and Lloyd Manuscripts describe how these 'people' became the constellations and other bodies we recognise today. The two pointers to the Southern Cross, for instance, were two 'lion's men' – Early Race characters with feet like lions but who spoke like people.[24] After a series of incidents, they finally become stars.

The 'Dawn's Heart star' has been identified as the planet Jupiter.[10] Although the Dawn's Heart star is one of the 'sky's things' as he describes himself, he married an Early Race caracal woman and they had a daughter, the Dawn's Heart child. The Dawn's Heart periodically 'swallows' his child and then spits her out again. She then becomes a (female) Dawn's

Table 1. |xam Names for some celestial bodies in the Southern Hemisphere. The table is based on ref. 10 with additional names added.

|xam Name	Contemporary
Star-digging-stick's-stone or the Digging-stick's stone of Canopus	Achenar
Male Lions	Pointers to the Southern Cross
Lionesses	Alpha, Beta, and Gamma Crucis
Male Hartebeest	Aldebaran
Tortoise[1]	Betelgeuse
Female Hartebeest	Alpha Orion
Male Eland	Procyon
Eland's Wives	Castor and Pollux
Steenbok ALSO Ostrich Eggs in Nest[2]	Magellan's Clouds
Male Tortoises (hung on a stick)	Orion's Sword
Three Female Tortoises (hung on a stick) ALSO Springbok Stars[3]	Orion's Belt
Rock-rabbit's-branch-house[4]	Corona Australis
Dawn's Heart Star	Jupiter

[1] Reference 34
[2] Reference 34
[3] Reference 34
[4] Reference 22

Heart star and spits out a child of her own, another Dawn's Heart child. These three stellar bodies then 'sail' along in the sky together. Willie Koorts suggests that the two Dawn's Heart children could be Jupiter's Galilean satellites.[25]

Stars themselves and the events leading to their becoming stars are closely linked to beliefs about /*ko:ode* and !*gi*, terms for 'supernatural potency.'[13] In most Khoe-San societies the supernatural potency of girls experiencing their first menstruation is considered very strong.[26,27,28,29] In one narrative[22] an Early Race girl in a state of ritual isolation peeps out of the door of her hut and turns a group of Early Race rock-rabbit people who had been eating together just outside their house of branches into the Corona Australis. The father, mother and three rock-rabbit children became stars that sit beside the Milky Way. The stars of the Milky Way are themselves the ashes of a fire thrown up into the sky by another Early race girl (perhaps also experiencing her first menstruation and thus an initiate).[30]

The stars themselves were filled with supernatural potency that causes death and misfortune. Dia!kwain's father told him that the star !gaunu who named all the stars by singing out their names[31] used his supernatural potency to kill people by stabbing them in the chest with a magically charged object that resembled a bone needle.[23] A falling star was a sign of the physical death of a sorcerer who brings illness. The star was the sorcerer's heart. The star's light was fire and it fell into a waterhole in order to cool itself making a noise like falling rain.[32] |han≠kasso tells of stars that 'curse for them (people) the springbok's eyes' by saying 'Tsau! Tsau!'[33] He does not specify what the curse entails.

People also called on the stars for help. |han≠kasso's grandfather spoke to Canopus when it appeared in the sky and asked the star for her heart[**] – 'with which you sit in plenty' – in exchange for his, 'with which I am desperately hungry.'[33] He asks to swap stomachs, for the same reason, and then asks for her arm so that he can shoot a springbok with an arrow. The first person to see either Canopus or Sirius pointed a burning stick at the star and sang to it to open and close her eyes (i.e. twinkle) and 'come out warmly.'[22] The person then threw the stick at the star and went to sleep. ||kabbo explained that this procedure encouraged the star to rise in the night sky and put the sun's warmth into it. Like the ||kohai stars already mentioned, the appearance of Canopus and Sirius was associated with the presence of flying ants and/or termite alates. Canopus was said to 'carry rice', an expression that may imply that Canopus's appearance heralded the availability of ant and/or termite larvae.

Conclusion

The aspects of |xam starlore I have highlighted in this review are a small but important sample of Khoe-San beliefs. Celestial bodies developed from a mythological past in which stars, planets, people and animals had a common origin. Explanations of the movements of stellar bodies (e.g. sun, moon and Milky Way) are based on keen observations which are simultaneously anthropomorphic and anthropocentric in character. Stars and other entities have will and intention, even speech, and their 'behaviour' is perceived as responsive to human needs and intervention, hence the necessity for people to interact with the moon and certain stars to secure food. Certain celestial bodies are filled with supernatural potency that influence people's good fortune in everyday life.

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Endnotes:

* Lucy Lloyd translated the |xam word *!gweten* as 'sail' but it is not known if ||kabbo intended the metaphor to be nautical, or if he intended '*!gweten*' in the sense of 'soaring' or 'flying'.

** Elsewhere, ||kabbo mentions that Canopus and Sirius are female and respectfully addressed as 'grandmother'[22].

/Xam astronomical references in G R von Wielligh's *"Boesman-Stories"*

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Abstract. The primary sources of /Xam celestial narratives are the well-known works by Bleek and Lloyd. We present two new /Xam accounts, explaining the origin of the Sun and the origin of the Evening Star, as collected and retold in Afrikaans by G R von Wielligh in Boesman-Stories, Part 1. We also draw attention to English translations that we have made of parts of his work containing astronomical references.

Sommaire. Les célèbres travaux de Bleek et Lloyd constituent les sources principales des récits célestes du peuple Xam. Dans cet article, nous présentons deux nouveaux récits Xam expliquant l'origine du soleil et de l'étoile du soir. Ces récits nous ont été rapportés en langue afrikaans par G R von Wielligh dans le premier volume de son livre *Boesman-Stories*. Nous attirons aussi l'attention à la traduction anglaise que nous avons fait d'une partie des travaux de von Wielligh contenant des références astronomiques.

Introduction

G.R. von Wielligh's *Boesman-Stories*[11] (published in four parts 1919–1921) recounts narratives collected from /Xam informants by the author c.1880–1883 in the Calvinia-Bushmanland area. Part 1, subtitled "Mythology and Legends", contains a good number of astronomical references but is not included in the comprehensive southern African ethnoastronomical bibliography deposited in the library of the South African Astronomical Observatory, Cape Town.

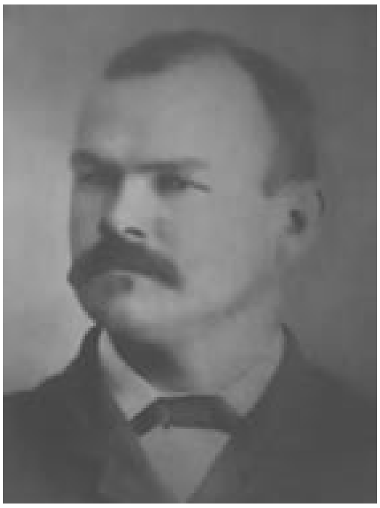

Fig. 1. G.R. von Wielligh at about the time he was Land-Surveyor General of the Transvaal. From an original found in the store room of the Surveyor General, Pretoria, photograph courtesy of Dr L.F. Braun.

G.R. von Wielligh (1859–1932)

Gideon Retief von Wielligh was born on April 1, 1859 in the Paarl district of the Western Cape. His first encounter with "the wild Bushmen" was at age 11:

> "... at that time we undertook a [trade] journey with our father through parts of Namaqualand, Bushmanland and the Hantam. During the evenings, and also during the day, many of these chaps would join us around the campfire and talk. There were still many of them that lived solely from hunting in the wilds. For a small reward they were willing to tell the little master stories, which we absorbed with mouths agape."[11] (von Wielligh 1921: Introduction)

After qualifying as a land surveyor, von Wielligh undertook surveys in the Karoo (1876–1878) and subsequently established a surveyor's office in Calvinia, south of the Hantam mountains (1880–1883), where he collected stories from /Xam shepherds.

von Wielligh and Scholarship

Since Von Wielligh's name was not mentioned in the available ethnoastronomy bibliographies at our disposal, we started this study with a general literature search and found that he was, as mentioned above, a prolific author of primarily Afrikaans fiction. It also soon became clear that his work was controversial.

It seems that he was regarded, amongst some influential academics of Afrikaans literature of his day, as a second-rate author, although C.J. Langenhoven[7] wrote a strongly-worded defence of his work. More recently, van Vuuren[9] has echoed Langenhoven's sentiments. With specific reference to Boesman-Stories, she writes that his work:

> "... demands to be reincorporated in what we consider to be the corpus of South African literature. The 'recovery' of the /Xam tales ... has important implications for a new understanding not only of our literary history, but also of South African history-writing.[9]" (van Vuuren 1995:25)

It is heartening that since van Vuuren's article, at least fourteen substantial publications, academic and literary, have appeared on San folklore. These include Bennun's *The broken string* (2004), Hollmann's *Customs and beliefs of the |Xam bushmen* (2004), Krog's *The stars say 'tsau'* (2004), James' *The first Bushman's path* (2001) and Lewis-Williams' *Stories that float from afar* (2000). In addition, *Voices from the past*, edited by Deacon & Dowson[3], contains papers presented at the Bleek & Lloyd Conference held in Cape Town in 1991. Yet, Von Wielligh is rarely mentioned, and is at best included in a bibliography. Van Vuuren speculates:

Fig. 2. Cartoon of Bushmen in a lunar crater.
Picture courtesy of The Sunday Independent, *October 15, 2000*.

"Probably the relative inaccessibility of [von Wielligh's] publications because of the medium of Afrikaans, plays a greater role here than one might expect. In the formulation by Biesele, an American, this is evident, as she says 'However, the tales are in Afrikaans ...'. (It would be an interesting exercise to translate the four parts into English, publish a new edition, and see how it is received in this extremely fast-expanding and competitive field of 'bushmanstudies'.)[9]" (van Vuuren 1995:28–29)

To this end, careful English translations of those chapters and occasional paragraphs from *Boesman-Stories*, which made any mention of astronomical phenomena, were undertaken (Appendix 1, available for download from http://www.psychohistorian.org/vonwielligh/index.html).

Comparing von Wielligh's /Xam Stories and the Bleek and Lloyd Records

Wilhelm Bleek and Lucy Lloyd interviewed a small group of /Xam in Cape Town between 1870 and 1884. The Bleek and Lloyd work, totalling almost 12 000 notebook pages, "provides a glimpse into the life-styles, language and beliefs of some of the survivors of a population that at one time inhabited the whole of southern Africa.[3]" (Deacon & Dowson 1996:1)

As mentioned, at about the same time (1880–1883), von Wielligh was collecting his material in Bushmanland. Years later, he commented on this coincidence; in a postscript to the foreword of *Boesman-Stories*, Part 2, he wrote:

"When I had almost finished writing this Part, I came upon dr W H I Bleek's Specimens of Bushman Folklore ... Reading through Bushmen Folklore I was struck by the strong resemblance between the stories he and I present. Because how is it possible that a primitive people could have distributed their folktales over so wide an area and preserved it so well? At closer inspection is appears that dr Bleek and I collected our material at about the same time and in the same area[10]." (von Wielligh 1920: iv)

In order to compare the narratives, a subject index (available in the online version of this paper) was compiled of Bleek, W.H.I. (1875) *Second Report concerning Bushman Researches*, Lloyd, L.C. (1889) *Short Account of further Bushman Material collected*, Bleek, W.H.I. & Lloyd, L.C. (1911) *Specimens of Bushman folklore*, and Von Wielligh, G.R. (1921) *Boesman-Stories. Deel 1: Mitologie en legendes*.

An examination of the index reveals the strong resemblance von Wielligh remarked on. For example, the accounts of the origin of the Moon, stars and Milky Way are similar.

However, von Wielligh recorded a unique tale of the origin of the Sun. Introducing the account, he remarked: "This story is told in different ways: what follows is as recounted by the best storyteller.[11]" (von Wielligh 1921:87) Briefly, Dancer, the Fire-Man, or the Fire-Maker, was once a man and of the ancient race. Light shone from his head, and it was he who put fire in stones, in the wood and in the clouds. Hunters would follow him to see where the game was, but sometimes he was lazy and wouldn't cooperate. Out of frustration the hunters killed him as he stood near a river. He fell into the water and his light was snuffed out. They hacked off his head and placed it on the river bank, but the light didn't return. Later, when it had begun to dry out, a woman saw the head and sent her children to throw it up into the sky, and so it became the Sun. The decapitated body is still searching for it's head, but has withered and became the crab, scuttling about at the water's edge. And the head searches incessantly for his body – in the mornings he starts searching at the mountains in the east, climbing into the sky until he comes to the mountains at the western side.

The Sun, it was said, also has two sons, Dawn and Dusk. They help him with his daily tasks, bringing him breakfast or supper, helping him out of or into bed, and so on. Dawn, the elder son, spurns the advances of a maiden (since he is happily married). The maiden's spiteful father, Wolf, murders him and skins him, but at the first incision, Dawn's sparkling heart flies out and goes up into the sky, to become the morning star. Dawn and his wife, their child, and their children's children were:

> "turned into Stars; and those Stars still follow behind their parents and are now the brightest Stars in the heavens ... [Dawn] came to fetch his wife, children and grandchildren, to live with him at the sunrise side of the sky. Though the big bright Morning Star, we must understand, is the Heart of the Dawn[11]." (von Wielligh 1921:159)

The motif of the morning star being the heart of Dawn is perhaps one of the most familiar astromyths from the Bleek & Lloyd collection, in part because the "Dawns-Heart Star" has, somewhat mysteriously, been identified as the planet Jupiter.

Von Wielligh then presents a second narrative, explaining the origin of the evening star, remarking: "This story we heard once, on the farm Zovoorbij, next to the Hantam River, district Calvinia. One evening, in 1881, there was a Bushman dance party, when one of the old guys showed his talent for story telling."

The Sun's younger son, Dusk, had big eyes so that he could see to perform his daily tasks that began at sunset and lasted until dark. Wolf's daughter , the jilted lover who was rejected by Dawn in the previous story, now latches on to Dusk, who is also happily married. His wife becomes grief-stricken, turning into the Owl, when their child is stolen by Wolf's daughter. Dusk seeks revenge and finds her at Wolf's house, but Wolf calms him with the news that his wife and child are waiting for him at a nearby cliff.

> "The two walked together, and when they stood on the edge of the precipice, Wolf pushed Dusk down the cliff. Dusk fell to the bottom. One of his bright eyes burst there, but the other flew up into the sky and became the large shiny Evening Star[11]." (von Wielligh 1921:167)

To this day, the Owl cries out at night, lamenting for her child, while Wolf each evening still tumbles Dusk down behind the western ridges.

Conclusion

These two accounts – the Sun is the Head of Dancer, and the Evening Star is the eye of Dusk – do not appear in any of the standard texts we consulted and thus expand the collection of known /Xam astro-narratives. By making the English translations of those von Wielligh's *Boesman-Stories* containing astronomical themes more readily available, we hope that others may find even more useful astronomical material.

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Comets in Bushman Paintings

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Abstract. About ten years ago I was asked to give a talk on African astronomical folklore and spent many hours reading up on the subject. My queries eventually led me to Bert Woodhouse, a member of the archaeological society and well-known recorder of Bushman paintings. He has published seven books on Bushman paintings and has a collection of over 30 000 slides covering all aspects of the subject. One section of his collection is labeled "comets" and he kindly made copies of these slides for me to use in that talk. This paper highlights those slides and discusses the objects depicted in the paintings.

Sommaire. Il y a dix ans j'ai eu à faire un exposé sur l'astronomie en Afrique qui m'obligea à de nombreuses heures de lecture sur le sujet. Mes investigations me menèrent à Bert Woodhouse, membre de la société d'archéologie, connu pour ses travaux sur les peintures des San (Bushman). Il a publié sept livres sur le sujet et possède une collection de plus de 30 000 pièces couvrant tous les aspects du sujet. Une section de sa collection est titrée *« comètes »*, et il m'avait permis d'en faire des copies pour mon exposé. Le présent exposé met l'accent sur cette section de ladite collection et je m'y étends sur les objets décrits sur ces gravures.

Bushman Paintings

Bushman paintings cover a vast range of subjects. Many depict animals, birds and fish. There are also the stick-like human figures and spiritual and shamanistic figures, many of which are still not fully understood. Some of the more modern art depicts the arrival of settlers and battles that took place between them and the indigenous peoples. Against this background it is a pleasant surprise to find that astronomical events are recorded and it is a tribute to Bert Woodhouse that he recognised them for what they are and has recorded them so carefully.

Bushmen lived close to nature and would have been acutely aware of any extraordinary happenings in their surroundings. Astronomical events such as comets, supernovae, meteors and bolides, eclipses and exceptional planetary conjunctions probably made a huge impression on these folk. One of the slides obviously shows a comet, with much detail in the head and streamers in the tail. When one takes a careful look at the other slides it would seem that most of them portray bright meteors or bolides.

Fig. 1. Probably a depiction of a meteor with a terminal burst.

It is notoriously difficult to date Bushman paintings and their ages are estimated to range from a few hundred to a few thousand years. Only some of the modern paintings, depicting scenes involving settlers, have been dated with any confidence. The Bushman paintings shown in the slides may well be the oldest recorded astronomical observations in Southern Africa.

There is a strong possibility that more astronomical objects exist in the many thousands of sites containing Bushman paintings and that, due to ignorance, have not been recognised as such by scholars.

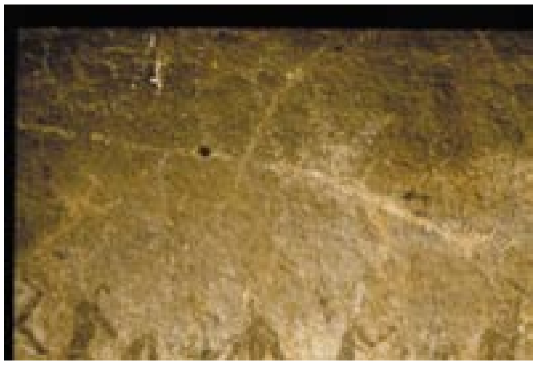

Fig. 2. An object with a double head, more commonly seen in meteors than comets.

Fig. 3. This picture may well represent an actual comet.

Conclusion

I am indebted to Bert Woodhouse for providing the slides upon which this talk was based.

Setswana Astronomical Nomenclature

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Abstract. Like many people across the globe, Africans have for many generations been awed by the night skies . Using their natural astronomical instrument, the eye, they have observed, commented on, and named celestial objects of interest to them. In anticipation of the inauguration of Southern African Large Telescope (SALT), and the very faint and distant objects it will observe, this paper revisits astronomical nomenclature of the Setswana language of Southern Africa (SA), focusing on the two brightest and nearest astronomical bodies from Earth after the Sun, the Moon and Venus.

Sommaire. Comme bien d'autres peuples de par le monde, les Africains ont de tout temps été fascinés par le ciel de nuit. Par l'observation à l'oeil nu, ils sont parvenus à identifier et à caracteriser les astres les plus importants pour eux. En prevision de l'inauguration de SALT (Southern African Large Telescope), et au vu des objets distants et à faible luminosité qu'il observera, le présent article ambitionne de brièvement revisiter le vocabulaire astronomique propre à une langue d'Afrique australe, le Setswana. Pour cela, deux corps célestes sont considéres : la Lune et Venus.

Background

For the sky and stars, there is a Setswana riddle that says, "the dress of the painter is a myriad patterns." (*Mosese ya ga Mmakgathi, maranthatha*). This demonstrates that Setswana astronomical nomenclature is woven deeply in the language and culture of the Batswana, riddled with idiom, poetry, and indirect or evasive speech. There are more telling and specific names that relate to unique stellar patterns and their seasonal appearances, *e.g.* (*Bo*) *Selemela*, *Naka*, (*Di*)*thutlwa*, and *Dikolojwane* (sometimes written *Dikolobe*), whose meanings are discussed elsewhere.

Today, the meaning or origin of some Setswana astronomical nomenclature may be debatable or open, which can lead to significantly different conclusions. For example, *Molagodimo* or *Molatladi* is said to mean the Milky Way or a rainbow. These very different physical meanings can lead to very different conclusions about the Batswana's ideas of the Milky Way or rainbow. In Setswana astronomical literature, or "Star-lore", it is commonly cited that the Batswana associated *Molagodimo* or *Molatladi* with lightning. This makes good physical sense if one uses the word's interpretation as rainbow (they both are associated with rain); however, using the word's interpretation as the Milky Way falsely leads one to fathom a rather peculiar imagination on the part of the Batswana.

The Moon

References to the Moon are deeply woven and common in Setswana. The Moon is used to represent a woman in wall murals of Batswana homes. In this case, the woman is thought to bring light to a home, but light that is not as scorching as the Sun. This is light associated with happiness, as at full Moon when kids can play outside at night.[1] A pillar, on the other hand, is used to represent a man, simply for strength. Ethno-astronomically, what is significant here is the Batswana's common and deep reference (of a woman in a house wall mural) and the comparison to or celebration of not only light but also the lower heat or radiation from the Moon, differentiating it from that of the Sun.

The Batswana's deep fascination with the Moon, such as is displayed in their wall paintings and language, must indicate some knowledge of its cycles. However, current literature suggests that though the Batswana's interest in the Moon is intense, it is primarily poetic. In other words, it is not common to see clearly cited Setswana physical understanding of the observed phases of the Moon, only poetic references to its shapes (*e.g.* as vessels [or like cow horns] carrying rain or disease). These references are seemingly not indications of any serious beliefs, but are probably what is called "Star-lore" (i.e. myths and legends) or typical indirect or poetic language of the Batswana. For example, there is a Setswana saying that "when rain falls while the sun is shining, there are monkeys having a wedding [somewhere]." It is thus important to distinguish the *physical* and *poetic* understandings, sayings and records in African astronomy in particular and Ethno-astronomy in general.

Fig. 1. A true-colour image of Venus obtained by NASA's Magellan Orbiter.[5]

The "Evening Star" and the "Morning Star"

Mercury and Venus are closer to the Sun than the Earth is, so they never appear far from it in the sky. They may appear in the west or east, with the setting or rising Sun respectively, but never opposite to the Sun in the sky. Astronomically, they are called inferior or inner planets. Venus is the brightest celestial object after the Moon and Sun, while Mercury is much dimmer and only visible a few weeks

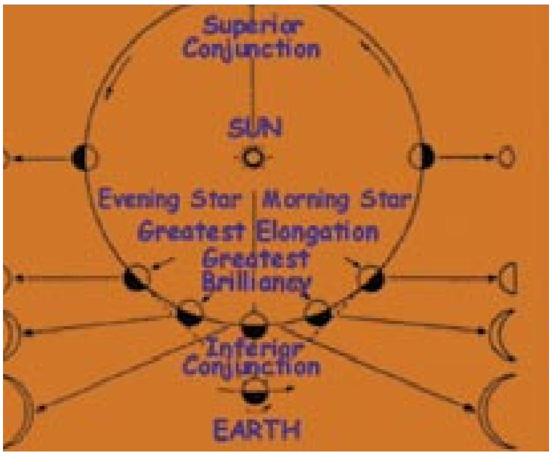

Fig. 2. The changing phase and apparent size of Venus revolving around the Sun.[4] For simplicity, the image is not drawn to scale and the earth is shown fixed with respect to the Sun.

of the year.[2;3;4] Venus is therefore the one that is commonly referred to as the "evening star" or "morning star" by many people across Africa and the globe, and not surprisingly, also by the Batswana. They call it *Mphatlalatsane*, *i.e.* the brilliant or blinding one, and *Kopadilalelo, i.e.* the seeker of evening meals.

It appears the Batswana did not independently work out that *Mphatlalatsane* and *Kopadilalelo* are the same "star", and certainly not a planet, until modern astronomical literature shed light on this topic. Also, there does not seem to be any reference to the phases (or crescent shape) of Venus in Setswana. In fact, many other people across the globe did not easily make the connection that the "evening star" and "morning star" were Venus nor did they know of its phases. It is debatable as to whether the phases (or crescent) of Venus can be seen with the naked eye. Galileo used his telescope to observe Venus (or the "evening star" or "morning star") and its phases in 1610, and he is credited with realising it is one planet. Note, however, that Pythagoras has also been given credit for this.[3;4]

According to modern orbital astronomy, the sidereal (relative to the stars) or orbital period of Venus is 225 Earth days; however, its synodic (relative to the sun as seen from a moving earth) period is 584 days. Arithmetically, 13 times 225 is about 8 times 365, which equals 5 times 584. Thus, Venus orbits the sun about 13 times in 8 Earth years, passing Earth 5 times in the process. It is the sun that is responsible for evening and day and thus the full evening-day cycle of Venus takes a synodic period of 584 days. The continuous stages as "evening" and "morning star" each average about 263 days, in between which Venus disappears on the near side of the sun for about 8 days, and on the far side for about 50 days, for a total of 584 days for a full evening-day cycle of Venus.[2;3] For a great of deal of the cycle, *i.e.* about 9 continuous months, Venus is visible from Earth just as an evening and morning star in the west and east, respectively; therefore, it is not surprising that the Batswana and many people in the world thought of its appearance in the sky as two different celestial objects. Deeper ethno-astronomical study, particularly in the context of modern orbital astronomy, should further elucidate the Batswana's regard for and knowledge of Venus and more.

Summary

Focusing on the two nearest and brightest astronomical bodies from Earth after the Sun, the Moon and Venus, I have reexamined the astronomical nomenclature of the Setswana language of Southern Africa. This account is in the context of modern physical or celestial astronomy in an attempt to make a case that Setswana astronomical nomenclature is more than just "Star-lore". Much still needs to be done in distinguishing the physical and poetic records in the study of African Astronomy, Ethno-astronomy, and, of course, "Star-lore".

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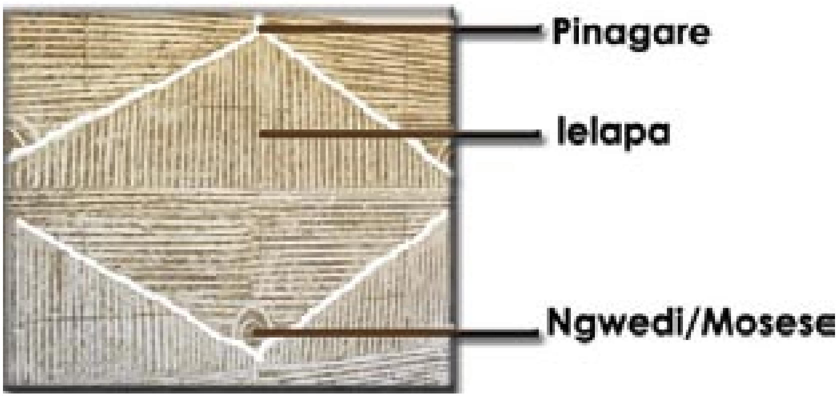

Fig. 3. A wall mural or *mokgapho* of the Batswana.[1] In the centre of the image at the bottom is a small circle depicting the Moon or *Ngwedi/Mosese* and at the top is a line indicating a pillar or *pinagare*, as labelled in Setswana.

The Making of Cosmic Africa: the Research Behind the Film

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Abstract. The multi-award winning, documentary film "*Cosmic Africa"* was released in 2003. It tells the remarkable personal odyssey of South African astronomer, Dr Thebe Medupe, who journeys into remote corners of the ancient continent to explore and shed new light on Africa's rich astronomical knowledge and sacred traditions. His quest begins to fill in the gap in historical African astronomy and also helps to bridge the future with the past and to make astronomy accessible and relevant to both Africa and the world. The film is a co-production of Cosmos Studios (USA), Aland Pictures (RSA) and Anne Rogers, the concept originator and key researcher. This paper explores the research methods used in the film and also highlights some of the subject material that was omitted from the documentary.

Sommaire. "*Cosmic Africa*", le documentaire plusieurs fois nominé a eu sa première, en salle, en 2003. Le film relate l'odyssée personnelle de Dr. Thebe Medupe – astronome SudAfricain de par les coins les plus reculés du continent Africain. Il y explore et éclaire d'une lumière nouvelle le riche patrimoine astronomique ainsi que les traditions sacrées d'Afrique. Sa quête est une contribution de plus à l'histoire de l'astronomie en Afrique. Elle suggère une réconciliation entre passé et futur, tout en magnifiant l'accessibilité et l'utilité de l'astronomie pour l'Afrique et le monde. Le film est une coproduction de Cosmos Studios (USA), Aland Pictures (RSA) et Anne Rogers, la conceptrice et chercheuse-clé. Cet article présente les méthodes de recherche utilisées lors du tournage ainsi que certains des thèmes non abordés dans le documentaire.

Aims and Objectives

The African continent, with its great variety of cultures and ancient skylore, provides an ideal backdrop to examine and unearth indigenous astronomical knowledge that, for the most part, has largely remained undocumented. Several years ago a small group of filmmakers set off to record some of this knowledge, culminating in the feature documentary film, *Cosmic Africa*.

The film was based on extensive field research that drew on the expertise of village elders, sky experts, shamans, historians, archaeologists, linguists, astronomers and anthropologists from seven countries. The vast and complex subject matter was eventually narrowed down to focus on archaeological evidence and the knowledge of three different societies: the mysterious prehistoric cattle herders of southern Egypt (Nabta Playa in the Sahara), the Dogon of Mali (settled farmers) and the hunter-gatherers of the Ju/'hoan culture of north-eastern Namibia.

Fig. 1. Ju/'hoan elders from Nyae Nyae, Namibia, recounting stories about the sky. "Anna" Tcu!Xo(*foreground/green woollen hat*)was training to become a shaman (spiritual counsellor and healer) during the time this picture was taken. *Picture credit: Anne Rogers/Cosmic Africa SA (Pty) Ltd/Cosmos Studios.*

This paper will address the various research methods used in the making of Cosmic Africa and will also highlight some of the rich and fascinating subject material that was omitted from the film.

To create an entertaining and educational film about how traditional African societies perceive the sky was a challenging and ambitious task. Our main objective was to fill in gaps in African cultural astronomy and bring it to the attention of a worldwide audience. The documentary film was released in 2003 after several years of work.

Another important aim was to bridge the past with the present by showing the relevance of Africa's mythical cosmologies and astronomical belief systems to current scientific thinking and technological advances in astronomy.

Historical Background

There is a saying in Africa that when an old person dies, a library dies. How very true this is. Prior to the actual filming process, Carina Rubin, the producer, and I were privileged to be able to travel to remote parts of Africa to interview some remarkable village elders and younger members of various African communities. Our work in the field proved invaluable.

Initially, field research was conducted in parts of Namibia, South Africa, Swaziland, Kenya, Mali, Ghana and Egypt. Apart from familiarising ourselves with the beliefs, customs and lifestyles of various communities we also visited sacred sites such as cultural shrines, burial mounds, graves and temples as well as megalithic and rock art sites.

We discovered that there was a vast amount of untapped indigenous knowledge, enough to make several films. Subject material ranged from celestial surprises such as comets, meteors and eclipses to constellations, creation myths, songs, celestial rituals, sacred festivals and legends about the sky. Other topics included the orientation and design of dwellings, the division of time, solstices, lunar and stellar calendars, the local names for celestial bodies and cardinal points. Practical aspects included navigation and how the stars, Sun and Moon are used as seasonal guides for fishing, hunting and gathering and for agricultural purposes. These research trips took place during 2000.

Eventually, we decided to film in Mali, Namibia and Egypt. This was mainly due to time limitations but also because the Dogon and San represented two very different and visually interesting African cultures. We also wanted to capture the power and history behind the ancient astronomical megaliths at Nabta Playa. Filming took place in 2001 and it was during this time that Dr Thebe Medupe, a South African astronomer, and I had the opportunity to do some additional research.

Our information was gathered from a variety of different sources – in Africa and abroad – museums, universities, libraries, cultural institutions, astronomical observatories and societies. Other sources included rock art institutes, ethnographic collections, specialist papers, journals, books and the internet. We also made a point of consulting local experts from each country and drew on the expertise of social and physical anthropologists, archaeologists, scientific historians, linguists, musicologists, astronomers and other researchers.

As we criss-crossed remote regions in Africa, we were introduced to shamans, chiefs, calendar experts, religious leaders, storytellers, blacksmiths, nomads, hunters, diviners, astrologers, sky-lore experts and other knowledgeable members of the community. It was important to hear firsthand what the people had to say and not to make broad-based assumptions. During our field research work, we prepared questions in consultation with local experts, linguists and translators.

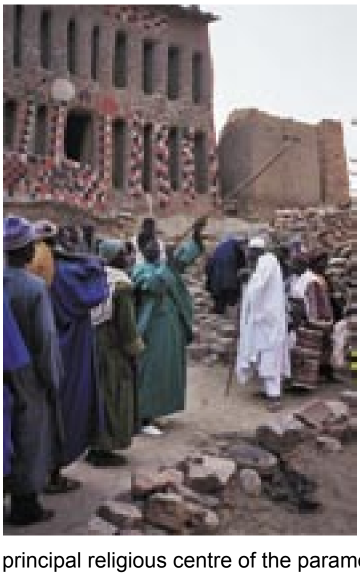

Fig. 2. The principal religious centre of the paramount Hogon of Aru in Dogon Pays, Mali. During the annual four-day Bulo ceremony sacred fertility symbols and celestial bodies are painted on the freshly cast walls of the sanctuary to obtain the blessings of the ancestors and the cosmic powers for a productive rainy season and a bountiful harvest. The Sun (*red*), stars (*black*) and the Moon (*white*) also symbolise the power of the Hogon. The ceremony is held prior to the rainy season. *Picture credit: Anne Rogers/Cosmic Africa SA (Pty) Ltd/Cosmos Studios.*

Interviews took place during the day and night with the aid of written notes, illustrations, audio recordings as well as photographic stills and video footage. Most the of the interviews were conducted in local languages and English transcripts were compiled from audio cassette recordings. At times, we also made use of special solar eclipse viewers, star charts, a telescope and a GPS.

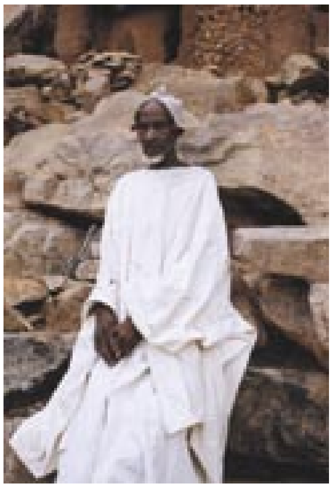

Fig. 3. Annaye Doumbo, respected Dogon elder from the village of Youga Piri (Dogon Pays, Mali). Annaye Doumbo is a “knowledgeable sky expert” and respected Dogon “spiritual” elder. *Picture credit: Anne Rogers/Cosmic Africa SA (Pty) Ltd/Cosmos Studios.*

We started by getting to know something about the people we were interviewing: where they were born, their family history, their sacred beliefs and philosophies, the names of their gods, important cultural artefacts, legends, ceremonies, rituals and social taboos.

On our first research trip to Dogon Pays in Mali, we had made prior arrangements with the head of the cultural mission in Bandiagara and a local Dogon anthropologist to accompany us to various villages. We were fortunate to link up with Annaye Doumbo, a highly-respected spiritual elder and star expert from the Aru clan. He was to play a central role in *Cosmic Africa*. As head of his village at Youga Piri, it is his role to ensure that Dogon traditions are maintained.

We discovered that Annaye Doumbo was well into his eighties. As a youth he had participated in the famous Sigi festival – a ceremony held every sixty years to renew the Dogon world. During the Second World War, he decided to leave his village and travel on foot to Ghana to avoid conscription. It took him about forty days – his route took him via Burkina Faso and sometimes he had to sleep in trees and navigate by the the stars. He performs a daily prayer to the Sun, Moon and stars. At a special time of year, when Toro Jugo – the Pleiades – rises just before dawn in June, it is a signal for the Dogon to plough and plant. He knows the precise time when this cluster of stars will appear – it is part and parcel of the agricultural calendar. Villagers are not allowed to begin ploughing until he has performed a special ritual to honour the Pleiades.

With the help of local informants and interpreters, we collected a variety of disparate skylore and astronomical knowledge from members of traditional Dogon clans, including information on their unique calendar that revolves around the phases of the Moon and market places. They have a five-day rotating week – the days are named after significant markets in their region. Their month is divided into six weeks (30 days) and begins with the new crescent Moon. Different regions have their own special markets and the days of the week are named after these places. Their new year begins in November – after the celebration of the harvest. The Moon also plays a role in certain farming practices and various rituals.

We discovered an intricate web of celestial symbolism in their rituals, language, artwork, sacred objects, festivals and ceremonies – all of which help to reinforce their sacred relationship with the earth and sky and the Dogon world. For example, during the Buro festival the stars are evoked so that the power of the Hogon – the supreme religious leader – is as strong as the stars, Sun and Moon.

As we moved from village to village, we recorded several different narratives about Orion and the Pleiades. In one version, the belt and sword of Orion form part of a powerful warrior constellation which comprises about eleven prominent stars. Another version incorporates three prominent stars in Orion's belt – these three stars are seen as mythical Nommo spirits who are also referred to as The Masters of Water. It is the Nommo who bring the rain to germinate the seeds and bring life to the land below.

Generations of Dogon farmers have noticed that when the Orion constellation rises in the east before dawn, during the months of May and June, there are very strong winds that generally herald the rainy season. Like the Pleiades, Orion is used as a practical guide for weather prediction.

During our nighttime interviews, local informants would point out prominent stars and elaborate on what they had told us during the day. The Dogon have a number of different names for Venus, depending on its station in the sky. The Milky Way is described as Amma Ajou – the road of Amma, their supreme God of creation. A celestial surprise, like a total solar eclipse, is regarded as the matrimonial union of the Sun and Moon and the symbol of love between men and women. It is Amma who through the eclipse instills love between the Sun and Moon. The Sun is described as Amma's witness and sunlight is the all-pervading presence of Amma. During an eclipse, other Dogon clans will beat metal objects and play drums. They also fire their guns into the air.

Fig. 4. Ju/'hoansi shaman preparing to demonstrate how they throw burning sticks at bright meteors. *Picture credit: Anne Rogers/Cosmic Africa SA (Pty) Ltd/Cosmos Studios.*

Fig. 5. The Este-Fanti fishermen of Ghana still use their tradtional calendar which is linked to the stars and Moon and their fishing lore. *Picture credit: Anne Rogers/Cosmic Africa SA (Pty) Ltd/Cosmos Studios.*

For the Ju/'hoansi of Namibia, unpredictable celestial events are viewed in a different light. In Nyae Nyea in a remote corner of northeastern Namibia, we visited the ancestral home of the Ju/'hoansi – a sub group of the !Kung people. Shooting stars are generally regarded as lucky omens but much brighter meteors are cause for concern. One memorable night, Kxau Tami and /Kunta Boo, two elderly shamans, demonstrated how they would throw burning sticks in the direction of a very bright meteor – as they threw the sticks into the air, they uttered swear and curse words which they said would help to divert the meteor's path and thereby prevent its dangerous potential. They believe that bright shooting stars with fiery tails are invested with very powerful !nom (extreme potency) and that they have the potential to cause sickness.

They emphasised that these meteors (fireballs or bolides) are much brighter than the normal shooting stars. "They are very bright, like the light from the Moon, and one can hear them make a noise like thunder." Shamans are highly respected in the community – they serve as healers, teachers, counsellors and storytellers. /Kunto Boo and Kxau Tami are renowned for their healing abilities and wisdom – between them they know over one hundred different songs.

Stories about the land and sky have been passed down from generation to generation. Their folklore is sprinkled with stories about the Moon. When the Moon doesn't shine, they are very frightened of lions. They sing a special song called the "Dark Moon" song to find out why the Moon is so dark. They also burn special magic sticks. "It is the lion that makes the Moon like that – it uses magic to catch the people." During a total lunar eclipse the community will sing and clap while shamans go into a trance. Both lunar and solar eclipses are associated with the trickster lion. According to legend, bad spirits or malevolent shamans can sometimes turn themselves into lions. The lion uses powerful magic and wraps its tail around the Sun to cause the eclipse.

The Southern Cross or Crux is steeped in mythology and it is also used as a fixed point to find direction. Prominent stars

Fig. 6. Dr Hassan Wario Arero interviewing two Gabra nomads at the Kalacha Oasis (Kenya). *Picture credit: Anne Rogers/Cosmic Africa SA (Pty) Ltd/Cosmos Studios.*

and planets are described in vivid detail as well as their colour. The sword of Orion is the arrow of a mythical hunter; the three stars in the belt, three zebra. Another variation of the myth is about a hunter who was walking with a bag full of ostrich eggs – the Pleiades represent the bag of ostrich eggs. The hunter took aim at the three Zebra, crept up, shot and missed. He was very angry- so he left all his possessions in the sky – the arrow, the zebra and lots of ostrich eggs!

The prominent nebula near the Southern Cross, the Coalsack, is referred to as the Old Bag of the Night. The Magellanic Clouds are described as the soft grass they use for bedding and the packing of ostrich eggs. When the Pleiades reappears in the dawn sky in June it is a sign for the annual hatching of ostrich eggs. When they rise in the evening in October and December, they herald the rains; two other bright stars, Canopus and Capella are associated with them. They pay particular attention to the Milky Way: they call it the Spine of the Night and distinguish three different positions during the course of the night. It gives them a sense of time and it also tells them about the changing seasons. They made a point of telling us that the word "spine" is used as a metaphor.

Other Highlights

On our trip to Ghana, we travelled with a local archaeologist to Lake Bosumtwi – a sacred, million year old meteorite impact crater in the heart of the Asante Kingdom. Here we met a paramount chief who showed us an intricate diagramme of the historical Akan lunar calendar that is linked to religious ceremonies and festivals. The local fishermen at Lake Bosumtwi recounted legends about the lake and sky – they use the phases of the Moon to time when the best catches will be made. Talking drums called Fontomfrom are played on a regular basis – the drums are used to recount whole tracts of ancestral history.

The Este-Fanti fishermen of Ghana's gold coast still make use of a traditional calendar where the Moon, stars and constellations are linked to their fishing lore, navigation and weather. For example, they have observed that when Antofi (the Southern Cross) rises with the Sun at the beginning of October there will be rain and thunderstorms. When Orion appears on the horizon, after being absent from the night sky for a while, they expect rough weather and do not take their boats out to sea. In the past, the community's livelihood relied on their knowledge of the stars, which has been passed down from generation to generation.

In Nairobi, we visited the National Museums of Kenya where we linked up with a Borana ethnographer who had done extensive research work in parts of Northern Kenya. Archaeological discoveries suggest that the Borana or Gada calendar may have been developed more than two thousand years ago. After conducting interviews with the Borana people we also had the opportunity to travel with museum staff and local guides into the Chalbi desert where we finally reached the small temporary settlements of the Gabra people – traditional pastoral nomads who travel vast distances with their camels, sheep and goats in search of grazing and water.

We were privileged to meet an Ayyantu – a highly respected spiritual elder who is regarded as a sky expert. He is responsible for calculating their sacred lunar calendar. He is able to recommend the best times to conduct weddings, funerals or sacred ceremonies. The Ayyantu also serves as a fortune-teller – a type of astrologer.

Through a series of interviews, we learnt that the Gabra have a complex method of reckoning time – they have two calendars – one is based on the solar year while the other is based on the phases of the Moon and the position of prominent stars throughout the year. Ceremonies and sacred rituals are very important to the Gabra and significant events like weddings and funerals and the playing of the sacred drum are linked to phases of the Moon. They rely on collective memory and divide time into seven-year cycles, with each year receiving the name of a weekday. Their seven-day week is comprised of propitious and inauspicious days. Their day begins just after the sun reaches its zenith (around 13H00), so it is actually the period between two afternoons. The world of the Gabra people revolves around a supernatural force – this force is said to influence the character of the day.

Brilliant stars or planets, such as Sirius or Venus, are named after a special sacred fire that is lit after arriving at a new settlement. A bull is sacrificed when Pleiades appears just after the first rains. The dark shape (Coalsack Nebula) near the Southern Cross is associated with a legend about a camel. The Milky Way is described as the pathway of the hyena. Songs form part of their daily life; people will sing while collecting water from wells or they will sing about the arrival of a relative or the arrival of the new Moon.

Fig. 7. Moonrise at the Nabta Playa campsite, Sahara, Egypt. *Picture credit: Anne Rogers/Cosmic Africa SA (Pty) Ltd/ Cosmos Studios.*

Other highlights included gathering information on the Herero and Swazi lunar calendars and the Ncwala (First Fruits) ceremony which coincides with the summer solstice. Unfortunately, we did not witness this elaborate ceremony in which the King of Swaziland plays a major role. The observation that the Sun does not always appear at the same place on the horizon led to an awareness of the midsummer and midwinter solstice points. Natural landmarks are generally used for these purposes but deliberately placed stone markers are also used in some parts of Africa. Our journey culminated at Nabta Playa in southern Egypt, where a small circle of stones – and other megalithic alignments – gave us additional clues as to how Africa's early sky-watchers began to track the passage of the Sun, Moon and stars.

Research Challenges

On a few occasions, we had difficulties in identifying constellations or prominent stars that were pointed out to us. For example Orion was sometimes described as a group of eleven stars but other people referred to it as just three stars. It became apparent that sky legends and descriptions of stars or constellations varied from village to village – even though some of these villages were only five kilometres apart. In Namibia, a comet was described as a "dead person" travelling in the sky while other informants said that a comet was a very good omen and that, in the past, it was greeted with singing and dancing. On several occasions, the influence of Christianity or Islam would filter through into traditional stories, providing other variants. Fortunately, on our second trip to Mali and Namibia, we were able to sort out some of these multiple viewpoints. Occasionally, we encountered problems with poor translations. We rectified the situation by involving more than one translator. Having the expertise of anthropologists and other specialists helped us enormously as they were able to save valuable time by correcting misperceptions as well as providing additional insights. We realised that it was very important to gain the trust of the community and therefore made a special point of involving local and international experts who were familiar with the region and respected by the people. This helped enormously as members of some cultures were initially reticent to part with sacred knowledge. The following experts provided us with vital background material and also accompanied us on some of our research travels. Their support and input was invaluable:

Namibia:	Dr Megan Biesele, Goodman Gwasira, Levi Namaseb and Hilda Kamuhuka
Mali:	Lassana Cisse, Dr Isaie Dougnon, Dr Ilse-margret Luttman, Keneko Pangale and Moussa Konate
Kenya:	Dr Hassan Wario Arero, Dr Paul Lane, Dr George Ubungu and Dr Robert Soper
Ghana:	Yaw Bredsa Mensa
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U S A:	The work of the late Dr Carl Sagan, Ann Druyan, the founder of Cosmos Studios and Carl Sagan's widow, Kent Gibson, Dr Keith Snedegar, Dr Phil Steffy, the Planetary Society and NASA

African Cultural Astronomy - Current Activities

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Abstract. We have reached a pivotal time in the study of the cultural astronomy of Africa. The last ten years has seen African scholars initiating projects, an increase in articles focused on African astronomy, the recognition of research in African astronomy at international meetings, and the building of a network of scholars and students. Together, let us look at what has been accomplished in African cultural astronomy and what remains to be done.

Sommaire. Nous avons atteint un temps pivotal dans l'étude de l'astronomie culturelle de l'Afrique. Les dix dernières années a vu les chercheurs africains commencer des projets, une augmentation en articles concentrés sur l'astronomie africaine, la reconnaissance de la recherche dans l'astronomie africaine lors des réunions internationales, et le bâtiment d'un réseau des chercheurs et des étudiants. Ensemble, regardons ce qui a été accompli dans l'astronomie culturelle africaine et ce qui reste à faire.

Our Legacy

Focussing on the cultural astronomy of Africa, the current research methods borrowed largely from anthropology and the theoretical assumption that African people may have sophisticated knowledge of the night sky can be traced back to the works of Marcel Griaule among the Dogon of Mali. During the 1970s, two major works were conducted among the Bamana of Mali; one by Griaule's student, Germaine Dieterlen, together with a young Malian anthropologist, Youssouf Cissae. Together they studied the writing system of one of the six power associations of the Bamana: the Komo secret society. They revealed that all the symbols written together represent the Milky Way and individual symbols include many that are related to stars, the sky and weather. The second scholar who studied the Bamana is Dominique Zahan who focussed on the Ciwara agricultural society of the Bamana. The Ciwara society is open to all and much less secretive than the Komo society. The Ciwara society entwines their knowledge of the heavens into their agricultural activities which include weather predictions, establishing dates for tilling and harvesting, and symbolic ceremonial tilling and harvest dances. Another publication of note is the study of the Mursi calendar by anthropologist David Turton and archaeo-astronomer, Clive Ruggles. They examined the social element of timekeeping that served to keep their calendar correct. These scholars' works and others mentioned are dominated by recording and analysing the astronomical knowledge of the people amongst whom they worked. There were many other works that included some astronomical knowledge of Africans but such knowledge was not the dominant focus of their and other unmentioned works.

The 1980s saw the emergence of three scholars mentored by Anthony Aveni. Suzanne Blier's studied the Batammariba of Togo and Benin, their architecture, their cosmology, and how astronomical knowledge entwines with their social, political, and architectural structures. Deirdre LaPin studied moon watching among the Ngas of Nigeria. Her film records the New Year ceremonies associated with the moon and involving rites of passage, ritual cleaning and the "shooting the moon" ceremony. Allen Roberts worked among various ethnic groups in Zaire, now the Democratic Republic of Congo. His papers present the connection between kingship and the sky, celestial names, and the preservation of history through the creation of constellations and celestial art. Laurance Doyle employed archaeoastronomical techniques to probe the calendar circle Namorotonga II in Kenya. Namorotonga II is the first sub-Saharan archaeological site studied for astronomical alignments since Great Zimbabwe. Doyle found a link between stellar alignments of the stones and those stars used in the calendar of the nearby Borana people. The works of Blier, LaPin and Roberts are similar in that they emphasise how astronomical knowledge is entwined with culture in Africa especially in relation to religion, ceremony and sociopolitical structures.

During the 1990s Keith Snedegar, using historical methods, began a long-term archival research project exploring the starlore and astronomical knowledge of the many South African ethnic groups. He has published on their starlore, calendars and rituals. In 1997, I began a four-year examination of the celestial navigation system of the fishermen of the Kerkennah Islands in Tunisia, North Africa. The fishermen use Ursa Major and Polaris for their night navigation. Kim Malville's archaeoastronomy research is on the standing stones of the Nabta Playa in Egypt. He found alignments to north, south and the equinoxes, but also to a couple of bright stars. The stones of Nabta Playa are the earliest known manmade complex aligned to celestial bodies.

This decade marks the entry of many more Africans into cultural astronomical research. Johnson Urama studies the calendar-keeping system of the Ibo of Nigeria. Damian Opata does astronomical literary analysis of the works of Chinua Achebe, and is studying the links between divination and astronomy in Africa. Barth Chukwuesi is analysing how astronomy knowledge is entwined in cultural beliefs and activities among the Ibo. Thebe Medupe (who is the focus of the film "Cosmic Africa") has collected copies of manuscripts on astronomy and other sciences written in Arabic from the libraries of Timbuctu, Mali. He is part of a team working to preserve and understand the scientific knowledge found in these documents. I supervised studies of the navigation practices of the Afar of Eritrea and the Swahili of Tanzania, and am collaborating with Felix Chami in further studies of Swahili navigation. Levi Namaseb has collected the starlore of the Khoekhoegowab people of Namibia as part of his study of their language.

Non-Africans working in African cultural astronomy this decade include Keith Snedegar who is involved in the

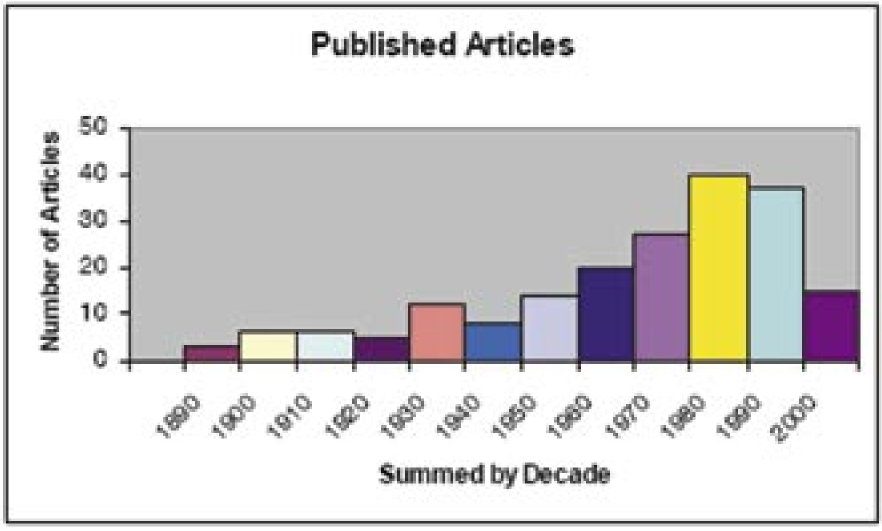

Fig. 1. Preliminary results from my book project on African Cultural Astronomy.

Timbuctu project and continues his work in the archives of South Africa, uncovering written sources of African starlore and astronomical knowledge. Patricia Hardy has unravelled the calendar system of ancient Egyptians dependent upon the appearance of bright stars using astronomy software. I am working on a detailed analysis of the many cultural expressions related to astronomy found in African cultures. My analysis and organisation of data forms the basis of a fundamental text on African cultural astronomy.

The recent research into the astronomy knowledge of Africans has become compartmentalised, that is, a particular aspect of a culture's astronomy knowledge is the focus, such as just navigation. This is very different from the broader studies of the 1970s and 1980s, and may be reflective of the training of the individual researchers. Nonetheless, the increase in the number of scholars as well as the inclusion of more African scholars has vitalised research in African cultural astronomy.

Conclusion

The year 2005 marks the establishment of a database of potential properties that might be suitable for nomination under a new UNESCO thematic initiative "Astronomy and World Heritage". Many of the active researchers focussed on Africa are working to identify properties and add them to the database. It is important that as many sites in Africa as possible be identified and suggested for inclusion in the database. The UNESCO initiative presents a unique opportunity to identify sites important for cultural astronomy research and to preserve sites for future generations of cultural astronomy researchers. Those sites included into the World Heritage List will be recognised as being of universal value to all mankind.

Acknowledgements

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Problems and Prospects in the Cultural History of South African Astronomy

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Abstract. The inauguration of the Southern African Large Telescope (SALT) is an auspicious moment for reflection on South African astronomical history, the manner in which this heritage has been represented in the past, and how it might best be represented in the future. It is now appropriate to reassess the history of European astronomy in South Africa, confronting rather than ignoring issues of national identity, scientific politics, and racism. There are also wide opportunities for scholarship on South African archaeoastronomy and indigenous knowledge systems, with potential applications to culturally relevant basic science education. In the case of astronomy, reconciliation to a rich if troubled history will only come to pass when the science is not only pursued in South Africa, but when its heritage pertains to all South Africans.

Sommaire. L'inauguration du Southern African Large Telescope (SALT) est un moment opportun pour réfléchir sur l'histoire de l'astronomie Sud Africaine: comment cet heritage a été présenté dans le passé et comment pourraitil être présenté au mieux dans le futur. Il est également temps de reevaluer l'histoire de l'astronomie Européenne en Afrique du Sud, en choisissant de confronter plutôt que d'ignorer les questions d'identité nationale, de politique scientifique et de racisme. Il y a également de vastes possibilités de recherches universitaires en archéoastronomie et en savoirs endogènes à l'Afrique du Sud; toutes riches d'applications dans des formations de base aux sciences qui soient culturellement adaptées. Dans le cas de l'astronomie, la reconciliation avec une histoire riche et trouble ne se fera pas que quand la science sera continuée audela de l'Afrique du Sud, mais également quand son heritage appartiendra a tous les Sud Africains.

Introduction

The inauguration of the Southern African Large Telescope (SALT) is an auspicious moment for reflection on the history of astronomy in South Africa, the manner in which this history has been represented in the past, and how it might best be represented in the future. To begin, I will suggest that there is much to be learned about indigenous African astronomical practices. This research is important in its own right, but has even greater potential value in the advancement of culturally relevant basic science education and what may be called scientific reconciliation. I will also advocate a historiography that embraces rather than avoids the issues of identity, politics, and racism in the modern South African astronomical community. The character of national institutions such as the Union/Republic Observatory and the South African Astronomical Observatory (SAAO), popular attitudes – Black and White – toward astronomy, the political dynamics of international collaboration, and the transition from fundamental astronomy to astrophysics – all offer illuminating case studies of how the science was practiced and perceived. In other words, historians have plenty of opportunity to explore the manifold constructions of human meaning in South African astronomy, and should not content themselves with the representation of this rich scientific enterprise in the form of personal anecdotes or the dry chronicles of data collection.

For many readers, the shape of South African astronomy has been defined by Moore and Collins' popular *Astronomy of Southern Africa*, an engaging narrative that has yet to be superseded.[1] Although their historical account is very attractive on a certain level, it suffers in two respects: it treats the history of astronomy in South Africa as if it were essentially separate from the history of the country as a whole; and it gives the impression that before the arrival of Europeans, Africans themselves scarcely ever looked up. Moore and Collins grant indigenous African astronomical knowledge all of one and a half pages in a rather hasty introduction; after that, their narrative does not pertain to the majority population in the least. One may intuit the difference between the 1970s (when *Astronomy of Southern Africa* was published) and now by picturing B.J. Vorster at the inauguration of the SAAO in 1973 and Thabo Mbeki at the inauguration of SALT in 2005. The transformation in political culture is obvious enough. What of the history of astronomy? By and large, recent scholarship has not taken up the challenge.[2]

Fig. 1. President Thabo Mbeki at the SALT inauguration in 2005. Photographer Nic Aldridge © *The SALT Foundation*.

Archeoastronomy

Appropriately, the challenge of representing astronomy in the context of South African history begins with the externalisation of political power – not, however, among the telescopes of Sutherland but among the ruins of Mapungubwe. The National Park and World Heritage Site at Mapungubwe, in Limpopo Province, protects the site of the capital of an African state that flourished in the thirteenth century A.D.[3] The African polity centred on Mapungubwe presumably developed temporal and spatial ideologies involving the sky. In the milieu of numerous other world societies, E.C. Krupp has discussed the relationship between state formation and official ideologies legitimising the elite status of leadership by establishing a connection between human affairs and the cosmos. The claim of interaction with heavenly supernatural forces invests the ruling class with divine authority over society. It is common for such a claim to be expressed in the spatial organisation and ritual architecture of a community.[4] This is where archaeoastronomy, the study of astronomical features in material culture, comes into play. To date, no site in South Africa has been surveyed specifically for its archaeoastronomical potential, but Mapungubwe should be at the top of the list. The segregation of the elite compound on the summit of Mapungubwe hill from the common residential area below suggests an ideology of social control. The artifacts of gold and textile production are also indicative of a sophisticated culture, one that would utilise a systematic calendar. It would be reasonable to look for structures on Mapungubwe hill aligned in directions of the solsticial sunrise and sunset. An alignment with the heliacal rising of the star Canopus is another possibility. Historical peoples, including the Venda, who are culturally descendent from those who inhabited Mapungubwe, ritually observed the summer solstice sunrise and heliacal rising of Canopus as calendrical markers.[5]

The second item on any prospective survey list should be the Iron Age village which Tim Maggs identified with the Sotho tradition of Ntsuanatsatsi.[6] Situated a kilometre west of a prominent hill in the grassy highveld of the Free State, the stone-walled ruins face eastward. The place-name, Ntsuanatsatsi, attested to as early as the 1830s, means "sunrise" in the Sesotho language. For local Bafokeng and Batlokwa clans the hill is reputed to have been where the first ancestors rose from the earth. Chiefs are said to have held the councils on top of the ridge across from the hill in former times. Their ability to gauge the annual motion of the sun by the sunrise locations on Ntsuanatsatsi hill may have contributed to the prominence of these early Sotho leaders. A critical study should model the sunrise phenomena with respect to the hill as observed from different structures in the village.

Fig. 2. Mapungubwe Hill. *Courtesy of South African National Parks.*

As of now, there has been no conclusive evidence for intentional astronomical alignments anywhere in southern Africa because no one has done the necessary fieldwork. Even at Mapungubwe and Ntsuanatsatsi negative results are quite possible, but given that archaeoastronomical surveys have identified such alignments in nearly every other cultural region of the world, it would be extraordinary not to find signs in southern African material cultures. This collaborative research among archaeologists, astronomers, anthropologists and historians remains a major desideratum.

Scholarship on astronomical traditions among historical African peoples is another area largely unexplored. While the everyday experience of "African Time," lax attitudes toward punctuality, may dampen belief in African calendar systems, in fact there is a wealth of evidence for astronomical time reckoning among southern African peoples.[7] Oral literature, that is to say, folktales, proverbs, praise poems, and the wisdom of grandmothers has memorialised this body of indigenous knowledge. It survived fairly intact up to a half century ago; in the present day it is poorly documented and very much endangered. Temba Matomela of the Iziko Museum, Cape Town, has made a pioneering effort to record oral Xhosa folk astronomy. Supported by a National Research Foundation (NRF) grant he has conducted fieldwork in the Eastern Cape, seeking knowledgeable informants. One of his chief conclusions to date is that much more work needs to be done in this time-consuming research.[8]

Indigenous Knowledge and Science Education

Why is the study of African archaeoastronomy and astronomical tradition important? Surely, the recovery of cultural heritage is important in itself, but another part of the answer is that this heritage could provide a foundation on which culturally relevant basic science education may be constructed. For according to the constructivist interpretation of science, knowledge resides in the minds of individuals yet these individual "knowers" can best express themselves within their own socio-cultural context. That is to say, as the knowers themselves are participants in a culture, their scientific knowledge is necessarily embedded and expressed within that cultural matrix. The science classroom, then, is not simply a place where a body of value-free knowledge is transmitted from teacher to learner; it is a place of acculturation. (One might note the phrase "culture of learning" often used in South Africa.) Europeans and North Americans tend to forget that their cultural history is intimately bound with the history of Western science–figures such as Nicholas Copernicus, Isaac Newton and Albert Einstein as they represent culture icons as well as great scientific thinkers.

What of African science studies, particularly at the elementary level in the rural classroom? Far too often the body of knowledge regarded as having the greatest viability – that is to say, the Western scientific tradition – imposes an alien cultural and historical order upon the learners. Unless there is a perceived local heritage in a scientific discipline, as there often is with medicine for instance, the learner receives no positive social reinforcement in the study of that discipline. African educationalists such as O.J. Jegede suggest that greater emphasis be placed on the indigenous knowledge base with which a science learner identifies.[9] Rather than subjugate the indigenous system to a dominant Western paradigm, the educational objective should be to bring about *collateral learning* by which both approaches are in a real sense validated.

The challenge for science educators is to appreciate how learners are processing information and what elements interact to advance the understanding of science concepts within African contexts. A crucial step toward this end would be a more complete record of and greater appreciation for indigenous knowledge systems. Secondly, a "boot-strapping" approach to sustainable, locally controlled science study – being applied elsewhere in Africa – is worth considering for South African education.[10]

European Astronomy in South Africa

The recovery and appreciation of African indigenous knowledge should by no means denigrate the exceptional record of European astronomy in South Africa. Indeed, many scholars – Brian Warner being among the most outstanding – have given fulsome attention to European astronomers of the early period.[11] The eighteenth and nineteenth centuries are a sort of golden age for the historians, particularly on account of the attractive individuals who make convenient objects for study. Who could not become enamoured with the heroism of La Caille, the gentlemanliness of Herschel, the determination of Maclear, and the collegiality of Gill? The apparent magnitude of these great personalities may have dazzled researchers somewhat, but in large measure recent scholarship has attained a high standard.

Even so, the period 1880 – 1914 is in need of fresh attention. As H.M. Astronomer at the Royal Observatory, Cape of Good Hope (RO Cape) for much of this time, David Gill was the actor at centre stage, yet there has been no large scale historical study of his scientific career since George Forbes' 1916 biography. This work, founded though it is on a healthy cross-section of Gill's correspondence, reads like pious hagiography. An indefatigable observer, a scientific friend to all, a cultural connoisseur and supporter of deserving civic institutions, as well as a faithful imperialist, Forbes' portrait depicts the very model of a British patriot-scientist so necessary to be imagined in the middle of World War I.[12] Ninety years later, this representation is sorely out of date.

Not that there is any question of Gill's significance. His advocacy of celestial photography and scientific collaboration was of vital import. Gill transformed the RO Cape from a colonial institution into a world-class factory observatory, having a large and efficient staff working on multiple research programmes in collaboration with international partners. By doing so, he substantially achieved South Africa's placement within the realm of an emerging global astronomical community. RO Cape became the leading centre of southern hemisphere astronomy and would remain so for decades after Gill's departure. Gill's energy also led to the establishment of the Geodetic Survey of South Africa, the South African Association for the Advancement of Science, and the Union Observatory in Johannesburg. But there were limitations to Gill's creative force. The great Carte de Ciel sky-mapping project, of which Gill was a chief instigator, got bogged down in the inefficiencies of its least productive members. Also, being in the employ of the British Admiralty, Gill was somewhat conservative in his view of astronomical research. When the future dean of American astrophysicists, H.N. Russell, met Gill at Cambridge, he recognised in Gill's fundamental astronomy the kind of scientific drudgery he did not want to take on.[13] Much of the next generation of researchers, would, like Russell, turn to the "new astronomy."

And then, of course, Gill retired to Britain. One might wonder if astronomy in South Africa was done, at least at the research level, exclusively by visitors. Their stays could be awfully extended, but in the end they would go home. The identity of astronomers in the generation following Gill was anything but securely South African. For instance, the correspondence between R.T.A. Innes and A.W. Roberts reveals that late in the 1920s they considered themselves Scotsmen first, even as Innes was director of the Union Observatory and Roberts was serving in the South African senate.[14] Between the wars the country could boast of two major observatories (not to mention the observing stations established by American universities), but neither RO Cape nor the Union Observatory could be called national institutions.

Just when truly South African astronomers emerged, rather than foreign astronomers in South Africa, is not a trivial question to ask. The policy of Spencer Jones and John Jackson of hiring South Africans for RO Cape technical positions should receive more attention, as should the careers of these individuals. Noteworthy was Reginald de Kock, hired as a "computer" in 1941, but who was better known for variable star observations conducted on his own time.[15] By far the more prominent was Alan Cousins, who in 1947 earned a position on the strength of his technical experience and would establish an international reputation in the standardisation of photoelectric photometry.[16]

Fig. 3. The 1.0-m telescope at the opening of the SAAO in Sutherland in 1973. *Courtesy of the SAAO*.

Those who were employed in higher education rather than the observatories found it difficult to establish a footing as research astronomers. The case of Arthur Bleksley at the University of the Witwatersrand is instructive. Active in the theoretical study of Cepheid variation, and having been a visiting scholar at Leiden University, Bleksley was poised to establish himself within the international astronomical fraternity in the late 1930s. However, his research career stagnated; after World War II he focussed his efforts on teaching and the popularisation of astronomy. Perhaps his great achievement was bringing the Johannesburg Planetarium to the Wits campus.[17]

Although professional astronomy long remained the preserve of visiting scientists, since the 1910s there has been a grass-roots amateur movement that embraced both the Afrikaans and English-speaking communities. Perhaps the rise of a national culture of astronomy owes more to the Astronomical Society of Southern Africa (ASSA) than to any professional institution. A comprehensive history of the ASSA has yet to be written. It will be important to ask about the membership profile. What sort of person becomes an active member? Have regional differences been significant? Who have been the leaders? And what personal and scientific networks have developed among amateurs and professional astronomers? South African amateurs have distinguished themselves especially in the observation of comets and variable stars. The line between professional and amateur could be blurred by the likes of Cousins and de Kock. More recently, Danie Overbeek was an outstanding example of what South African amateurs can achieve in terms of their observational record and international reputation.[18] It is telling that professional astronomers have enthusiastically held office in the ASSA. Nonetheless, the exuberance of amateur astronomy within the white population begs the question of how black South Africans engaged the modern science.

Astronomy and Black South Africans

The attitudes of black South Africans toward astronomy in the twentieth century have received no real scholarly attention, yet this background is necessary for a full appreciation of the status of the science in contemporary South Africa. To pretend that the modern science being conducted in the country had no relationship with the majority population would have breathtaking implications. There are clear signs that blacks had a healthy curiosity about modern astronomy even before World War I, and despite considerable discouragement in the segregation and apartheid eras, valued the science.

The great Motswana journalist and political activist, Sol Plaatjie wrote on astronomical topics in his newspapers *Tsala ea Becoana* and *Tsala ea Bath*. The object of special interest was Halley's Comet on its return in 1910. The comet also had a symbolic presence in his novel, Mhudi, and continued to have such a hold on the writer's imagination that he named his third son Halley. Plaatjie's writings on the comet and astronomy generally have yet to be interpreted.[19] At all events, he was not alone.

Apparently, the earliest book length treatment in a southern African language is the 1910 Sesotho publication, *Tse Leholimo le tse Lefatse* (*The Heavens and the Earth*), based on a series of articles in the Morija Sesotho newspaper which ran two years previously. The author was Samuel Duby, a missionary at Morija in Lesotho.[20] It is telling that Duby's only secular work was this introductory astronomy text. Being neither an astronomer nor a science teacher, Duby must have been motivated by local demand for scientific information. Although the mission context of *Tse Leholimo* is evident through its many biblical citations, its scientific content was garnered from fairly trustworthy contemporary publications such as John Thornton's *Advanced Physiography* and Francis Brunnow's revision of *Brinkley's Astronomy*. *Tse Leholimo* provides a good description of the solar system, explains eclipses, and discusses stellar astronomy. Some of the astronomical terminology was problematic in translation, but Duby utilised the indigenous names of planets and conspicuous asterisms. It is easy to imagine Basotho literati such as Thomas Mofolo partnering with Duby on the composition of this extraordinary work.

Today, *Tse Leholimo le tse Lefatse* is a rare book. One of the few extant copies is in the university library at Fort Hare. The story of science instruction, including astronomy, at this most famous of historically black institutions awaits its chronicler.[21] What cannot be denied is that mathematical and physical sciences were taught to a high standard. By the 1940s Fort Hare graduates were returning to their alma mater as lecturers. A.M. Phahle in physics and J.A. Mokoena in mathematics were two of the most remarkable. Mokoena even became head of department. Sadly, the expropriation of higher education by means of the Extension of University Education Act of 1959 ended the South African careers of many black academics. Phahle migrated to the U.K., whereas Mokoena later taught at the University of Zambia.

Scientific training was not a priority of "Bantu Education". That a widespread receptivity to fields such as astronomy quietly survived decades of governmental suppression deserves serious investigation. Surely it can be no coincidence that the first black South African astronomers appeared when the first opportunities to receive professional training emerged in the 1990s as the apartheid regime gave way to a non-racial democracy. Thebe Medupe and Menzi Mchunu are two pioneers of this generation of scientists.[22] Both illustrate a determination to succeed in addition to scientific inquisitiveness. As a boy Medupe built his own telescope out of scrap parts. His parents valued education enough to sacrifice for his private schooling. He excelled in science, earned his PhD., and is now senior lecturer in the University of Cape Town Department of Astronomy. Mchunu walked 16km to his high school, studied at the University of Zululand on something less than a shoestring budget, and was the first recipient of a SALT Postgraduate Fellowship, which sent him to Rutgers University in 2001. More recently he has been a PhD. student and member of the Stardust research group at the University of Missouri.

Fig. 4. The 1.9-m telescope at SAAO in Sutherland. *Courtesy of the SAAO*.

The Importance of the Post-War Period 1948–1968

Somewhat insulated from the socio-political issues that would buffet the country after World War II, professional astronomers in South Africa looked optimistically to the future. As David Evans described the scientific prospects, southern hemisphere astronomy was a "ripe harvest waiting to be reaped" and South Africa was the promised land whose day was nigh.[23] In the Post-War period, the positional astronomy that had been the mainstay of research at RO Cape was clearly a thing of the past, although certain large programmes had yet to be completed. Richard Stoy's tenure as H.M. Astronomer (1950–1968) marked a transition in the research programme to astrophysics, while at the Radcliffe Observatory in Pretoria the 1948 installation of a world-class 1.9 metre telescope heralded a new age of productivity. The Radcliffe trio of A.D. Thackeray, Adriaan Wesselink, and Michael Feast produced first-rate research, particularly on the radial velocities of B-stars as markers of galactic rotation and on RR Lyrae stars in the Magellanic Clouds as markers of the cosmic distance scale.

In the late 40s and early 50s, there was considerable international enthusiasm. Visiting astronomers such as Bart Bok found Harvard University's Boyden Station in Bloemfontein to be an observational Mecca, and Indiana professor John Irwin enthused about the advantage of having more photometric nights in Pretoria than were possible at most observatories in North America.[24] Indeed, in galactic astronomy and photoelectric photometry South Africa played an important international role. And yet, a major investment in instrumentation and personnel never materialised. As it happened, just the opposite occurred. Harvard reduced its presence at Boyden, leaving the management of the observatory to a loose consortium which allowed it to drift into obscurity and near death. The Yale-Columbia telescope was moved to Australia's Mt. Stromlo. The Lamont-Hussey Observatory became quiescent after Richard Rossiter's retirement in 1952. As late as 1963 there appeared to be real hope that the European Southern Observatory would be located in South Africa, but when the decision was made in November of that year, European astronomers preferred a site in the Chilean Andes.[25] For astronomers from the United States the general lesson of South Africa was the need to develop a national observatory at Kitt Peak, Arizona.

Meanwhile, the future of the Royal Observatory at the Cape was in doubt. The British Admiralty, which had administered the institution since its founding in 1820, wished to divest itself of the observatory. A merger with the Greenwich Royal Observatory in 1960 provided some short-term advantages for RO Cape, but substantial new funding and instrumentation were not among them. When Stoy and Evans, the director and chief assistant, resigned their positions at RO Cape in 1968 it was a clear sign that South African astronomy was in a state of uncertain transition.

The personal decisions of Stoy and Evans had been preceded by that of Adriaan Wesselink. When he left the Radcliffe Observatory for a post at Yale University he cited health concerns; privately his opposition to apartheid had been a factor. He worried that race relations were going to be worse before they got better.[26] It remains an open question how much the country's political climate – at its personal, institutional, and national levels – rather than scientific factors contributed to the relative decline of South African astronomy in the 1960s, but by the end of that decade it was apparent that the country's standing within the international astronomical community was not what many scientists had hoped for fifteen or twenty years earlier. A full and nuanced account of what happened and why awaits future treatment. Many sensitive primary sources are still not readily available. Thackeray's confidential papers relating to the Radcliffe Observatory, for instance, will not be accessible to researchers until 2028.[27]

SAAO and SALT

It could be argued that with the establishment of the SAAO in 1972 South Africa finally had a national astronomical institution. What sort of national community had been institutionalised is still to be adequately described. In some important respects, notably staffing and funding – the British Science Research Council contributed funds for Observatory operations until 1985 – the SAAO was a continuation of the RO Cape by a different name. Because the history of SAAO lies within living memory, the collection of oral history interviews would be of great value in understanding the human and institutional dynamics of the place. One theme of such an investigation could be the efforts to maintain scientific productivity with aging instrumentation and non-cutting-edge technology. It would be facile to claim that the pariah status of the apartheid regime hobbled astronomical research. A judicious study of trends in scientific productivity, funding, and international cooperation would go far to clearing up misperceptions of a precipitous decline. Even so, any fair treatment of South African astronomy in the last quarter of the twentieth century must contextualise the science within the racial and political crises the country was going through. By the early 1990s it was apparent to Bob Stobie, the new director of SAAO, that South African astronomy might not be internationally competitive unless it had a new generation large telescope. It is remarkable that construction of that instrument, SALT, would be approved by the cabinet of President Nelson Mandela. Undoubtedly, the political dispensation after 1994 transformed the prospects of South African astronomy. SALT may be seen as a prestige project; it may also have been an act of national scientific reconciliation.

In the case of astronomy, reconciliation will only fully come to pass when the science is not only pursued in South Africa but when it pertains to South Africa; when black South Africans take their place in the astronomical community (and when indigenous African cosmologies are viewed as aspects of a positive heritage, having a standing analogous to Greek and Roman mythology in the Western tradition). The collateral benefits of SALT and NRF initiatives in education and community outreach are significant beginnings. What should not be lost in the mix is that no one group owns the sky, and never has; it has always belonged to everyone's heritage. For the student of South African astronomical history only the most inclusive of attitudes can grasp its broad horizons.

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The Political Uses of Astronomy

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Abstract. In its first twelve years of rule the African National Congress (ANC) Government spent more on astronomy than all governments combined between 1910–1993. Three factors drove this unexpected development: (a) national prestige; (b) dignity of the continent of Africa; and (c) Black dignity. Both astronomy and astronautics project an image of modernity – the cutting edge of high technology. When the Government supports initiatives such as SALT, SKA, the proposed national space agency, and microsats, it does so because it perceives these as having a political importance far beyond their intrinsic importance to astronomy. These project "soft power" – an image of modernity to foreign powers and foreign investors – which contribute to their intangible perceptions of South Africa. Astronomers need to encourage this trend by both greatly increasing public outreach programmes and by making representations to the media, Parliament, and other public authorities, on issues such as light pollution.

Sommaire. Durant ses douze premières années au pouvoir, le Congres National Africain (ANC) a - dans le domaine de l'astronomie - dépensé plus que tous les gouvernements de la période 1910–1933 réunis. Trois facteurs ont sous-tendu ce choix : (a) le prestige national; (b) la fierté de l'Afrique et (c) la fierté du peuple noir. Tous deux réunis, l'astronomie et l'astronautique projettent une image de modernité, d'avant-garde technologique. Dans son choix de soutenir des projets tels que SALT, SKA, la future Agence Spatiale et le lancement de micro-satellites, le Gouvernement Sud-Africain agit en saisissant pleinement la portée politique desdits projets, au-delà de leur impact intrinsèque en astronomie. Ces projets distillent fortement une image de modernité auprès des puissances et des probables investisseurs étrangers. Ladite image modelant fortement leurs perceptions de l'Afrique du Sud. Les astronomes se doivent de soutenir cette tendance en accentuant les campagnes de vulgarisation aupres du public ainsi que leurs contributions dans les media, au parlement et auprès d'autres instances publiques sur des questions telles que la pollution due à l'éclairage urbain.

Introduction

When the historic liberation movement the African National Congress (ANC) came to power in 1994, its election campaign made no mention of astronomy.

Of all 490 MPs, the only one who claims an interest in astronomy is an honourable member of the Official Opposition. The sole leading member of the ruling party and its allies who shares our passion is Dr. Bernie Fanaroff, with a Cambridge doctorate in radio-astronomy. But throughout the 1990s he was deployed away from science, on economic and crime-combatting strategy.

Yet in its first decade of rule the ANC has spent more on Astronomy than all governments combined between 1910–1990. This symposium is held to coincide with the official inauguration of SALT, and to remind us that the Government has committed serious resources to our bid for the SKA.

What Caused These Unexpected Developments

Three factors caused these unexpected developments:

- national prestige;
- dignity of the continent of Africa; and
- Black dignity.

These have led to unexpected expenditure on four projects: the Timbuktu Manuscripts Project, the PBMR Project, the Southern African Large Telescope (SALT) and the Square Kilometre Array (SKA).

Both astronomy and astronautics project an image of modernity – the cutting edge of high technology. Left to itself, international news coverage focuses on what sells – crime, war, the grotesque, and the gruesome. When the S A Government supports initiatives such SALT and SKA, the proposed national space agency, and ZA SAT, it does so because it perceives these as having a political importance far beyond their intrinsic importance to us. These project an image of modernity to foreign powers and foreign investors. They project a perception that South Africa is part of "us" and not part of "them". Such perceptions encourage global powers and companies to assume that they can find partners here and do business here. Such perceptions mean that when we have conflicting interests on some issues, these are seen as differences between friends, not a showdown with an enemy.

How Astronomy and Astronautics May Maximise This Trend

This political scientist tried four practical ways to help astronomy. I joined those who lobbied between 1991-1994 to create a Department of Science and Technology. Later, I urged South African Astronomical Observatory (SAAO) Director Bob Stobie to establish a full-time, salaried post for public education and outreach in astronomy. Subsequently, I helped him draft paragraphs towards a political case for SALT and SALT Collateral, which he incorporated into the SAAO proposal. Most recently, I helped Dr. Peter Martinez draft paragraphs towards the political case for a national space agency, which cabinet has accepted.

We can persuade Government that astronomy and astronautics have six political uses:

- Firstly, as mentioned, projecting a perception of modernity;

- Secondly, Science and Technology (S&T) are healing in the context of party politics: bipartisan, and nation-building; an aim that we can all work on together.;
- Thirdly, astronomy can help with drawing people towards the S&T needed to solve South Africa's "human resources catastrophe", to attract youth into SMET – science, maths, engineering, and technology;
- Fourthly, astronomy trains students in scientific method and laboratory technique. Even though few students will later get posts in astronomy, their training and skills are applicable to all other R&D careers;
- Fifthly, astronomy generates spin-offs, such as software to count stars in an image, applied to count breast cancer cells in microscope samples; and finally:
- Astronomy and astronautics can reinforce our existing foreign policy aims. The economies of scale make regional and continental organizations optimal vehicles for comsats, metsats, tele-education and similar satellite applications. This strengthens continental unity, and its economic growth, and strengthens the African Union and NEPAD.

What Are the Optimal Strategies to Sustain This State Commitment?

First, like for example the Botanical Society, and the Mountain Club, SAAO and ASSA should be making more presentations to Parliament, Cape Town Metro, and the media over light pollution, science education, and similar issues.

Second, ASSA should encourage the masters students of the National Astrophysics and Space Science Programme (NASSP) to join, to grow its youth cohort, and jointly with SAAO's resources, seek to draw a wider range of South Africans into astronomy.

Third, SAAO and ASSA should urge that the proposed national space agency take the lead in public outreach for S&T, with astronomy prominently in its programme. This NSA should, like NASA, seek the budget to encourage high school S&T clubs and events.

Fourth, India is the world leader in a space programme appropriate for developing countries. Its dedicated 1.9t Edusat should be the model for an Afro-Edusat under African Union auspices, which India has already proposed. IBSA (India-Brazil-South Africa) is another appropriate vehicle for both astrophysics and satellite applications projects, with a focus on tele-education.

Fifth, SAAO and ASSA should propose to the DST support for a Decade of SALT and SALT Collateral.

What Would Government be Receptive to in Exchange

First, wider engagement with the voters and taxpayers. Past practice is that SAAO-Observatory has one open night per month, the second Saturday. SAAO-Sutherland had one open night per year.

Both SAAO Observatory and SAAO Sutherland has to be open by demand, approaching the cloudless proportion of our 365 nights per year. Obviously this cannot be done by drafting professional researchers on a roster, and is beyond the current number of volunteer amateurs. It requires seeking a budget for a team of paid astronomy educators, speaking the major local languages in each centre.

Second, we need to organise greater coordination and synergy between SAAO, ASSA, the MTN Sciencentre (ideally if it relocated to a venue more accessible by public transport), the Cederberg Amateur Observatory, and the country's two Planetariums.

Third, since South Africans are great party animals, it is overdue for SAAO and ASSA to add to Dark Sky Nights some Star Party events in all the major centres.

An Africanised Study of Astronomical History in the Northern Cape, South Africa, for Purposes of Secondary and Higher Education Programmes in Tourism Management

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Abstract. Dr M.J. Hoffman, Head of the Department Physics, University of the Free State (UFS), presented a paper at the Duineveld Secondary School in Upington, to enhance the idea of a natural observatory centre in the Northern Cape. Quite aptly, the National Institute for Higher Education: Northern Cape (NIHE) also invited a renowned African astronomer, Dr T Medupe, to address their graduation ceremony in 2005. However, Dr Albert Strydom, Programme Head of Tourism Management at the Central University for Technology, Free State (CUT), is very much aware of the delicate nature of this type of high scientific profile in Tourism Management. It is foreseen by Dr Kallie de Beer, Director of Distance Education, that teaching and learning in this field will predominantly be conducted via Open and Distance e-Learning (ODeL). Consequently, it is also important to understand the philosophy of ODeL within global and Africanized perspectives. Astronomy, in this case, offers excellent examples of Africanised science in practice to add scientific value to tourist packages in the Northern Cape. (www.saao.ac.za/assa/aahs).

Sommaire. Dr. M.J. Hoffman, chef du Dpt. De physique à l'université du Free State a présenté à Upington, l'idée d'un centre culturel voué aux sciences de l'Univers dans la province Sud Africaine du Northern Cape (NC). Dans la foulée , l'organisme chargé des études superieures de ladite province a invité l'astronome Africain Dr. T. Medupe, pour une communication lors de la céremonie de remise des diplômes en 2005. Dr. A Strydom, responsable de la formation au management du tourisme à l'institut universitaire de Bloemfontein (NC), souligne quant à lui la délicate tâche de prise en compte du profil scientifique dans le management du tourisme. Dr. K. de Beer, Directeur du Dpt. de la formation à distance (NC) souligne que la formation dans le domaine susmentionné se fera principalement via les nouvelles technologies de l'Information (NTIC). Par conséquent, il est tout aussi important de comprendre la philosophie des NTIC selon une perspective globale et africanisée. L'astronomie, en la matière, fournit d'excellents modèles de science pratique et mise en contexte, pouvant ajouter une valeur scientifique à l'offre touristique dans la province du Northern Cape.

Introduction

The Northern Cape is the largest geographical province of South Africa. It is served by the National Institute for Higher Education (NIHE), (University status) offering tertiary education in collaboration with the University of the Free State (UFS), the Central University of Technology, Free State (CUT), the University of South Africa (UNISA), the Vaal Triangle University of Technology (VUT) and the University of the Western Cape (UWC). Due to the fact that the establishment phase has only been in Kimberley since 23 June 2003, it inter alia envisages to offer a National Diploma in Tourism Management. Dr M.J. Hoffman, Head of the Department Physics, UFS, presented a proposal at the auditorium for tourism at the Duineveld Secondary School in Upington for the establishment and expansion of a natural observatory centre for the Northern Cape at SAAO or Sutherland or Augrabies. Hoffman is also an astronomer who regularly presents public lectures at the Boyden Observatory in Bloemfontein.

Quite aptly the NIHE invited an astronomer, Dr Thebe Medupe, to address their graduation ceremony in 2005. Dr Medupe also emphasised the importance of this field of study in the Northern Cape. Dr Albert Strydom, Programme Head of Tourism Management at the CUT, is aware of the delicate nature of this type of high scientific profile in Tourism Management. With the scientific prerequisites of this generation, tourism falls in the category of international space research. For example the USA spacecraft Discovery could use the extra long landing strip in Upington as an emergency back-up.

While the NIHE and Higher Education Institutional (HEIS) partners will be offering contact lectures as well, it is foreseen that the predominant character of this HEIS will be that of a virtual university which is conducted by Open Learning and Distance e-Learning methodology (ODEL). Therefore it is also important to understand the philosophy of Open Learning (OL) within global and Africanised perspectives. Astronomy in this case offers excellent examples of Africanised science in practice when it is said that Native Africans learn by imitation. They observe their fathers and accomplished leaders during their apprenticeships. General principles have been passed down from generation to generation.[15] The !Kung San, Southern Africa's original people of the Kalahari Desert, resided all over the Republic of Botswana, Namibia, the Northern and Western Cape and Free State provinces of the Republic of South Africa. They are typical of the hunter-gather mode of existence – in which modern people spent most of their time – and are compared with the most advanced space projects of the National Aeronautics and Space Administration (NASA). One of NASA's former scientists, Carl Sagan,[15] describes the formidable forensic tracking skills of the San as "science in action". Modern space scientists do exactly the same when they try to analyse a crater on the Moon, Mercury or Triton by its degree of erosion. However, they do not perform their calculations using Maxwell's equations only or do quantum mechanics from scratch. Instead, they figure out all the tracking protocols since the beginning of mankind according to "Nature's rules". Like the !Kung tracking protocols for example. How they scrutinised footprints of fast moving animals, their accuracy of inductive and deductive reasoning; the wind that blows away the footprints. These methods are identical to what planetary astronomers use in analysing craters, other things being equal, depth-to-diameter.

Tourism Management Courses

Fransie Coetzee, a journalist of *Die Volksblad*, a daily newspaper in the Free State and the Northern Cape, wrote an article on the possibilities for amateurs in astronomy in the clear night skies of Upington in the Northern Cape.[14] Although many a foreign visitor to the Northern Cape has remarked on the dark night skies of this province, hardly any acknowledgement has been given in national tourist brochures about this wonderful eco-tourism possibility. However, recent quality publications such as Products Of Southern Africa[11] gives great prominence to the Southern Cross constellation in the southern hemisphere. Sky Guide Africa South[12] inter alia quotes Nobel prizewinner in physics, Steven Weinberg, as saying that " Astronomy … provides a unique bridge between the sciences and the public". The official travel guide of the Northern Cape[10] now refers tourists to the Karoo Hoogland Tourism[6] (URL: www.karoohoogland.co.za) for visting the SA Astronomical Observatory in Sutherland.

2.1 Tourism Management Courses at Duineveld High School; Upington

Tourism management has been established since 1997 as a career course at this school due to the growing importance of this discipline in the Northern Cape, especially in national, provincial and cultural tourism. It includes Mathematics and Geographical tourism, time zones, international icons and outcomes in technology. It is the first school in South Africa to accommodate its own Tourism Centre with state of the art technology as well as an auditorium. Co-operative Education (experiential learning) forms part of the curriculum.

Hoffman of the Boyden Observatory and other colleagues of the (UFS) regularly make use of the Duineveld facilities. Hoffman and Flanagan envisage a tourism and educational dream for the Northern Cape.[4] Various star gazing tours are now starting to take off to explore the night skies of this province. For the romantics, they can have moonlight dinners on the salt pans!

2.2 National Institute for Higher Education: Northern Cape (NIHE)

The NIHE is a totally new concept for higher education in South Africa. Due to the sparse population in the largest geographical province in South Africa, the Northern Cape, the Department of Education (DoE) established a National Institute for Higher Education in Kimberley instead of a fully fledged university. Higher education institutions (HEIS) which historically offered tertiary education in the Northern Cape via first, second and third generation distance education methodologies, were requested to form the core of the NIHE. The following higher education institutions are possible "partners" within the NIHE:

- The University of the Free State (UFS);
- Central University of Technology, Free State (CUT)
- Vaal Triangle University of Technology (VUT)
- The University of the Western Cape (UWC); and
- The University of South Africa (UNISA)

The NIHE requested that Tourism Management should be accredited with one of the HEIS partners. Although there has not yet been a response to this request, the fact remains that NIHE is already advertising for prospective students in this field of study. The aim of this paper is not to propagate a Higher Diploma in Tourism Management, but to introduce only one prominent aspect, namely astronomy, as a possible field in such a modular curriculum, that could be offered by means of Open and Distance Education e-Learning (OdeL) methodology.

Fig. 1. An illustration of a possible Natural Observatory Centre for the Northern Cape. Such a centre can serve as a landmark for a tourism industry that takes advantage of the cosmic landscape and very dark sky of the Northern Cape. Diagram obtained from final year B.Arch. project of Marie-Louise Flanagan, University of the Free State.

Open Distance E-Learning Methodology

Open and Distance e-Learning (ODeL) will be the logical method for teaching courses in Tourism Management in the Northern Cape due to the great distances between towns and cities, especially from the main campuses of the University of the Western Cape (UWC), UNISA in Tswane, the University of the Free State (UFS) the Central University of Technology: Free State (CUT) in Bloemfontein and the Vaal University of Technology(VUT) in the Vaal Triangle near Vereeniging. Modules specifically formulated for tourist possibilities in the case of Astronomy, can be downloaded or offered via internet and satellite linkages..

Other examples are already in existence. The University of Stellenbosch (US) already offers courses at Upington via satellite technology and could easily be expanded to widen access for other Higher Education partners. (Also note the satellite offerings of the Universities of Pretoria,

Stellenbosch and North West at the EDU-Park in Polokwane as far away as the Limpopo Province.
UNISA has several regional learning centres in the Northern Cape which are served by interactive video conferencing facilities from the main campuses in Florida, Johannesburg and in Tswane, Gauteng. Linkages between the UFS's research in astronomy at the Boyden Observatory and the National Institute for Higher Education: Northern Cape (NIHE) are also possible for the distribution of services via the interactive video conferencing facilities of NIHE to the rest of the Northern Cape. NIHE is housed in the former Provincial Government buildings of the Northern Cape, from which the Premier had interactive video linkages with the respective sub-regions. These communication lines are compatable with those of UNISA, UWC and the CUT. The CUT is currently establishing its programmes on Web CT (6). Students and researchers in the Northern Cape can already download course material in several technology modules via the internet.

Outcomes

Co-operative Education or so called experiential learning in Tourism Management is a fait accompli for CUT students. Students are placed by the Director: Co-operative Education at various travel agencies, guest houses and government parastatals in jobs as tour operators or guides to complete their "practicals". The ideal is also to equip those students who are placed in the Northern Cape with knowledge of the South African Large Telescope (SALT) in Sutherland, as well as the history of the San people who used scientific ways and means to predict the weather conditions from the stars and the moon the night before their hunting expeditions. They should also know about the Upington Airport, which can be used by the space shuttle Discovery for a back-up landing strip in case of foul weather conditions in the United States. Students in Tourism Management have to be literate in astronomy, especially in the Northern Cape. They should also know about plans for the world's largest radio telescope, The Square Kilometre Array (SKA) (www.ska.ac.za) as well as the existence of another seven observatories in their province. Bushmen paintings also reflect the oldest astronomical recordings in Southern Africa while it is important to study indigenous SeTswana astronomical nomenclature. Scientific knowledge may therefore be essential for students in Tourism Management in the Northern Cape. Tourist guides who organise tours for amateur astronomers will also have to be aware of international political aspects of SALT, for example, that the 91 mirrors are of Russian origin and that South Africa and Russia have signed a scientific agreement for co-operation for space research and possible launching sites at the Overberg testing range.[14]

For SALT to become a tourist attraction of note, it needs to be accessible to the market. Case studies world-wide indicate that successful tourism in an extensive area like the Northern Cape is dependent on the principles of packaging, clustering of tourism products in order to create a diverse offering and the development of theme-specific tourism routes.[17] Therefore SALT may only be included in packages, tour itineraries, routes, tourism clusters and brochures if it is really accessible to tourists. This accessibility must, of course, take place within acceptable parameters of noise (radio) pollution, light pollution and air pollution.[16] According to media reports, the Karoo Hoogland municipality area expects 30 000 tourists to Sutherland annually due the publicity SALT is generating.[14] The highway from Cape Town to Gauteng via Kimberley has been renovated inter alia for star-gazing opportunities.[14] Although it all sounds like moonshine and roses, this province is one of the poorest of all, eigth from the top in South Africa. The infrastructure is far from "first world" and the majority of the people are not at all wealthy. Consequently, there exists tension among the inhabitants as to how best money should be spent.[14]

Africanisation

ODeL methodology is closely linked to space technology in instructing and training students via satellite and the internet. In this case it would be used for Tourism Management. Curricula, however, have to be customised to provide for Indigenous Knowledge Systems (IKS) which are part of the UFS Programme of Africa Studies (cf. Indilinga, 2005). In this case it would deal with pre- and post-colonial knowledge about scientific astronomy. Astronomers can encourage assimilation of traditional knowledge into modern systems as far as possible and, on the other hand, can provide a language and grammar for indigenous people through which they can access modernity. This will assure the scientific integrity of the tourism enterprise in the Northern Cape. In this sense, SALT and space technology in the Northern Cape will provide a sense of pride in their past and engender respect for indigenous-peoples, and will also "enable people in indigenous mind-sets to make a better transition into the world of Science, Engineering and Technology" (SET).[9]

Ethno-astronomy also becomes very important for the SeTwana peoples of the Northern Cape due to the writings by French missionaries about the SeTwana's beliefs concerning the origin of mankind at Ntsuantsatsi in the Eastern Free State. Although the Free State is an adjacent province to the Northern Cape, the pre-colonial SeTwana people were not divided by artificial borders. They are still one nation right across the Kalahari into the Republic of Botswana. Dr Jarita Holbrook, of the Bureau of Applied Research in Anthropology at the University of Arizona, warns against the over simplification of endogenous knowledge of Africans. SeTswana nomenclature for the study of astronomy tells it own history in Southern Africa.[7]

Entrepreneurs have already taken the gap in Africanising their products, for example Stellekaya, the wine cellar in Stellenbosch who sponsored the wine for the AAHS symposium in Cape Town. They literally formed their name by a combination of stars and housing; "stella" is "home of the stars" and "iKaya" means house.[8] Tourism is stimulated by this kind of endigenous art of the trade.

Biblical Perspectives on Astronomy

It would be incomplete to refer to the historical uses of astronomy in the Northern Cape without referring to the predominant Biblical perspectives of the core population. Missionaries like Moffat brought Christianity to the Northern Cape before the arrival of the Dutch-speaking Voortrekkers during their trek from the Cape Colony into the hinterland of Southern Africa in 1838. Moffat's daughter Mary was married to the famous discoverer, David Livingstone, who was the first white man to view the Victoria Water. However, Biblical history is intrinsically linked to the introduction of European culture into Africa. The SeTswane Bible was the very first Bible to be translated into an African language. It was printed at the Moffat Missionary Station in Kuruman in the Northern Cape.

Without denigrating the San peoples' indigenous knowledge of astronomy, academic researchers should most definitely take Biblical facts into consideration when analysing the true history of the Northern Cape. Some early astronomers in the Southern hemisphere even linked the crucifixion of Jesus Christ with the Crux Australis, "cross of the South."[11] Surely the European descendants who were pioneers of the Northern Cape also used navigation skills incorporating this constellation's inclination from the perpendicular or planted their vegetables according to the phases of the moon. There is a time and a season for everything done under the sun (Eccl. 3). God originally made the sun, moon, and stars to regulate times and seasons on the eternal Earth.[2] (Dake[2],1949: 51).

Conclusion

SALT will most definitely not operate in isolation from other academic or industrial establishments. Otherwise it will lose some of its value. Such a large technology research project cannot be done without taking into consideration the real life situation on planet earth. Peoples of the Northern Cape (SeTswana and ! Xhoi San) were deprived of development by the former political dispensations, namely colonialism and apartheid. This should be taken into account by the developers of space technology in their homeland. Researchers have to take notice of indigenous cultures as well as modern developments, without losing their own perspective on Space Science, Engineering and Technology (SET).

Knowledge can also not be hidden from the media, who use the very same space technology to communicate via the internet as well as other means and who create daily news reports. Subsequently, the people of the Northern Cape must be included along with modern science, by the HEI's. Only then will tourism managers be equipped to link SALT, one of the largest telescopes in the world, with the network of higher Scientific, Engineering and Technological (SET) research to create better living conditions on earth. Not only is this part of globalisation, but it will specifically benefit the peoples of the Northern Cape at large.

The Square Kilometre Array (SKA), the International Radio Telescope for the 21st century – should it be built in the Northern Cape – will crown this province as the astronomical tourist Mecca of the world!

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The Discovery of the Nearest Star

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Abstract. Proxima Centauri, the closest star to us after the Sun, is part of a triple system whose other two members constitute the double α Centauri. In the 1830s, the latter was the subject of the first successful stellar parallax measurements made in Cape Town by Thomas Henderson. Proxima was found in 1915, at the Union Observatory in Johannesburg by R T A Innes, as a faint star with a high proper motion similar to that of α Cen. Its parallax was measured independently over the following two years by J G E G Voûte at the Cape and by Innes himself, unknown to each other. Innes, on the basis of his rather rough result, declared it to be closer than α and named it 'Proxima Centauri', but the truth of its proximity was only established rigorously in 1928 by H A Alden, based on observations at the Yale Southern Station in Johannesburg.

Sommaire. Proxima du Centaure, l'étoile la plus proche de nous après le soleil, fait partie d'un système triple dont les deux autres membres forment le doublet α du Centaure. Dans les années 1830, ce doublet a fait l'objet de la première mesure réussie de parallaxe stellaire par Thomas Henderson depuis Cape Town. En 1915, Proxima a été découverte par R T A Innes à l'observatoire de l'Union comme une étoile de faible magnitude ayant un mouvement propre rapide similaire a celui de α du Centaure. Durant les deux années suivantes, sa parallaxe a été mesurée d'une manière indépendante par J G E G Voûte au Cap et par Innes lui-même. Sur la base de résultats plus qu'approximatifs, Innes plaça l'étoile à une distance plus proche de nous que α du Centaure et la nomma ainsi 'Proxima du Centaure'. Mais la position réelle de l'étoile a été établie rigoureusement en 1928 par H A Alden en se basant sur des observations faites depuis Yale Southern Station à Johannesburg.

Alpha Centauri

Permanent southern hemisphere observatories were established under official auspices in the early 19th century at Cape Town (1820) and Paramatta in Australia (1821). In addition, the British East India Company placed one on St Helena to determine the star positions needed for navigation by their own commercial fleet. In 1833, their observer, Lieutenant Manuel Johnson (1805–1859), informed the second HM Astronomer at the Cape of Good Hope, Thomas Henderson (1798–1844), of his finding that Alpha Centauri had a large proper motion.[14]

Henderson[14] proceeded to make frequent observations of the declination of α Cen with a Jones mural circle and his assistant, Lieutenant William Meadows, of its Right Ascension with a Dollond transit. The mural circle used by Henderson was defective, as the six individual microscope readings did not agree, but their average was found to yield consistent measures. On investigation some years later, one of its bearing surfaces was found to be slightly loose on its axle, causing a minute flop on rotation.

Henderson stayed just over a year in Cape Town. On returning to England, he reduced his declination data promptly but was slow in obtaining the R.A. result and seems to have put the whole matter aside until jolted into action by his friend and rival, the German astronomer Friedrich Wilhelm Bessel, who had been active while he was dallying. Starting in September 1834, Bessell had monitored the position of 61 Cyg, another high proper motion star, using his 'Great Fraunhofer Heliometer' at the observatory in Königsberg (now Kaliningrad in Russia). By virtue of making many observations each night and by observing on a great many nights, Bessel obtained a value for the parallax of 61 Cyg of π = 0.31" ± 0.02" arcsec. His formal error was about one fifth of that later reported by Henderson, the improvement being directly attributable to the superiority of the heliometer method. His result was communicated promptly to the Royal Astronomical Society in London.[3]

Henderson's own parallax paper was read to the Society two months after Bessel's, in January 1839.[5] α Cen had a parallax π = 1.16" ± 0.11" arcsec.

Previous claims to have discovered finite stellar parallaxes had all been demonstrably false. The results of Bessel and Henderson had therefore to be examined in detail and were the subject of a highly critical report compiled by Rev Robert Main (1808–1878) on behalf of the Society.[11] Bessel's work was deemed rigorous and highly reasonable. Henderson's, on the other hand, was questioned because the R.A. figures were not as significant as the Declination ones. Bessel, as a result, was considered to have made the first believable observation of stellar parallax and was accordingly awarded the Society's accolade, their Gold Medal.[7] His discovery created a sensation because, though parallax is directly predicted by Copernican theory, it had never previously been detected. In 1842, Henderson[6] read a second and final paper on the parallax of α Cen, based on a more extensive series of measurements carried out by his successor at the Cape, Thomas Maclear (1794–1879) with a replacement mural circle. The results now found general acceptance.

Several decades later, David Gill (1843–1914), the fifth HM Astronomer at the Cape, used a heliometer with W L Elkin (1855–1933) to determine a more accurate parallax for α_2 Cen of π = 0.75" ± 0.01", essentially the modern value.[4]

A High Proper Motion Object

In 1915, Richard Thorburn Ayton Innes (1861–1933), the director of the Union Observatory in Johannesburg, blinked a plate of 1910 with one of 1915 taken with the Franklin-Adams camera. He examined an area of 60 square degrees around α Cen, taking about 40 hours to do it, and found a star with a proper motion of 4.87” per year, similar to that of α Cen, and just over 2 degrees away from it. He published his result promptly in a Union Observatory Circular.[8]

Fig. 1. J G E G Voûte from a group photograph taken at the Royal Observatory, Cape of Good Hope, in July 1914.

Though keen to measure the parallax of his large proper motion star, Innes did not then have suitable facilities. He ordered from T Cooke and Sons a micrometer eyepiece to be fitted to the Observatory's 9-inch telescope. This was in place only in May 1916.

He cannot have been too pleased when in April 1917 he received a letter from J G E G Voûte (1879–1963), a Dutch volunteer assistant of private means at the Royal Observatory in Cape Town. He told Innes that he had started observing the new star photographically for parallax in February, 1916.

Fig. 2. R T A. Innes, c 1905 (*SAAO Collection*).

Voûte's results were published first.[13] The value he gave for Innes's star in his paper was: $\pi = 0.755'' \pm 0.028''$, with a proper motion of 3.76” per year. He pointed out that its implied absolute magnitude made it the least luminous star known. The evidence at that stage clearly did not suggest that it was any closer than α Cen.

Innes was concerned to establish his priority. He made a preliminary announcement of his (then incomplete) parallax results on 3 July 1917 at a meeting of the South African Association for the Advancement of Science. Partly based on Voûte's data, Innes obtained the value of 0.759” for the parallax of the star and, without a proper discussion of the probable error of the measurement, drew the unjustifiable conclusion that his star was closer than α Cen and therefore must be the nearest star to the Solar System.

When he published his result, Innes suggested: “If this small star had a name it would be convenient – it is therefore suggested that it should be referred to as Proxima Centaurus’.[10]

The current value for the parallax of Proxima quoted in *The General Catalogue of Trigonometric Stellar Parallaxes*[12] is 0.770” and that for the two components of α Cen is 0.750”. Voûte's value, with probable error 0.03”, was obviously nearer the correct one than Innes's.

In 1918, Innes was given the South Africa Medal of the South African Association for the Advancement of Science for his work on double stars and the discovery of Proxima Cen.[2] In 1923, he was awarded an honorary Doctor of Science degree by Leiden University.

The first accurate set of proper motions for Proxima Cen was obtained by Alden[1] at the Yale Southern Station in Johannesburg, using their 26-inch refractor. At last, Proxima was proved to be the closest star but, even so, the significance of the result was not very high. At least, it was good enough to prove that Innes's lucky guess was correct.

Because of its closeness, Proxima has been the subject of many research papers. Its parallax and proper motion have been investigated on several occasions. Many searches for nearer stars have been made, but Proxima still holds the record.

Acknowledgements

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Abstract

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Some Glimpses into the Past at the Johannesburg Observatory

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SUMMARY

This presentation is illustrated with some of the many pictures appearing in the author's book *Living amongst the stars* which it is hoped will be published in the near future. It starts with the work done by David Gill at the Royal Observatory, Cape Town, on astrophotography, leading to J.C. Kapteyn's contribution to the *Cape Photographic Durchmustering* and the subsequent friendly relationships with observatories in the Netherlands. The opening of the Transvaal Meteorological Department in 1905 is illustrated leading to the first astronomical ventures. By 1910 the observatory was committed to southern sky mapping and continued along this path until 1938. The successive telescopes are illustrated. The presentation continues with sketches of the Union and Republic Observatory directors and shows some of their contributions to astronomy and timekeeping. Co-operation with Leiden Observatory is shown at the Broederstroom annexe.

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Cet exposé a pour illustrations quelques unes des nombreuses images apparaissant dans l'ouvrage de l'auteur intitulé « *Living amongst the stars* », à paraître. Il débute par le travail d'astrophotographie de David Gill à l'Observatoire Royale du Cap. Travail ayant mené aux contributions de J.C. Kapteyn dans le cadre du « *Cape Photographic Durchmustering »* qui se sont prolongées en des relations d'échanges avec divers observatoires en Hollande. En 1905, l'établissement du Département de Météorologie du Transvaal permit les premiers pas en astronomie. En 1910, l'observatoire était voué à la cartographie du ciel austral et ce jusqu'en 1938. Les télescopes successivement utilisés sont présentés. L'exposé se poursuit avec les portraits des directeurs de l'observatoire ainsi que certaines de leurs contributions en astronomie et en mesure du temps. La collaboration avec l'observatoire de Leyde est présentée dans l'annexe titrée Broederstroom.

Contributions from the First Half-Century of African American Astronomers with a Focus on Solar Physics

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Abstract. It has been exactly half a century since the first African American received a PhD degree and successfully entered into a career in astronomical research. Since that time, a total of twenty scientists have followed in the wake of this trailblazer. Exactly half of these chose to spend a major portion of their career in the fields of solar and stellar physics. The contributions of the solar physicists have had a profound impact on our understanding of the sun, stars, and their immediate environments. In this paper I will review the scientific contributions of these scientists and develop the historical and social context their work.

Sommaire. Cela fait exactement un demi-siècle depuis le temps du premier Africain Américain à avoir obtenu un Ph.D et poursuivi une brillante carrière de recherche en astronomie. Depuis lors, un total de vingt scientifiques ont suivi la trace de ce pionnier. Exactement la moitié d'entre eux ont choisi de poursuivre la majeure partie de leur carrière dans les domaines de la physique du Soleil et des étoiles. Les contributions des physiciens du Soleil ont eu un profond impact sur notre compréhension du Soleil, des étoiles et de leurs environnements immédiats. Dans cet article, j'examine les contributions de ces scientifiques et explore le contexte historique et social de leur travail.

Introduction

Africa's contribution to astronomy extends beyond her shores. The full contributions of the African diaspora to humanity's advancement in the fields of astronomy and astrophysics must take into account those individuals dispossessed of their African homeland in centuries past but not of their African heritage or identity. A particularly prolific group has been the African American astronomers.

The early history of African American intellectuals in the West is characterised by their struggle to persevere in an environment where they were generally considered to be mentally inferior to whites, regardless of the thoughts they possessed. Moreover, their general station in life subjected them to daily humiliation, emasculation, and abhorrence. There were those who did persevere, however, and were able to achieve intellectually despite these circumstances.

One of the earliest known exhibitors of Black African mental prowess in the Americas was Thomas Fuller (1710–1790). Fuller was known to be capable of instantaneous unit conversions for any intervals of time or space. He could also calculate in his head the values of a geometric series to the seventh power. Fuller was born in West Africa and sold into slavery at the age of 14. It is suggested that he possessed his calculational abilities prior to arrival in the Americas.

A more well-known early African American intellectual, generally considered to be the first African American with a serious interest in astronomy, is Benjamin Banneker (1731–1806). Banneker was known to have taught himself mathematics and astronomy, and successfully predicted the solar eclipse of April 14, 1789. By 1791, he had created and published an almanac for Pennsylvania, Delaware, and Maryland.

The first African American to achieve the PhD degree was Edward A. Bouchet. Dr. Bouchet was actually the sixth American of any race to earn a PhD. He obtained his in the field of Physics from Yale University in 1876. The topic of his dissertation was geometrical optics. Dr. Bouchet also has the distinction of being the first American PhD recipient to *not* receive a faculty position. This did not occur again until 1954.

The first African Americans to become modern, professional astronomical researchers appeared in the second half of the 20th Century. Among the early pioneers, these individuals overwhelmingly focused their research activities on the study of the Sun and its influence on the interplanetary environment. Below, we introduce the reader to the African American researchers in the field of solar physics.

Profiles of Contributors

The Sun is unique among all stars by being the only one close enough to the Earth for us to observe the details of its surface phenomena. Because of this, it serves as the only existing astrophysical plasma laboratory wherein observation prevails over speculation. The realm of solar physics involves studies covering four regions of the Sun and its atmosphere: (a) the solar interior; (b) the near-Sun atmosphere; (c) the solar wind and interplanetary environment; and (d) the extension to stars of discoveries made in the solar context.

Of the approximately twenty African-Americans who have become astronomical researchers, half have studied solar and stellar physics. Coincidentally, all of the first four fall into this category. In the following sections, we present profiles of three of these African-American astronomy pioneers. We also present brief profiles of three young solar scientists who are blazing a trail of success in their own right.

Early Pioneers:

Dr Carl A. Rouse

After earning a PhD in Physics from the California Institute of Technology (Caltech) in 1956, Dr Carl Albert Rouse became the first African American to successfully enter into a career as a professional astronomical researcher. Dr Rouse's PhD research was in the field of particle physics. After graduate school he took a position as a scientist at the Lawrence Livermore National Laboratory (LLNL) where he studied screened Coulomb interactions utilizing quantum mechanics theory.

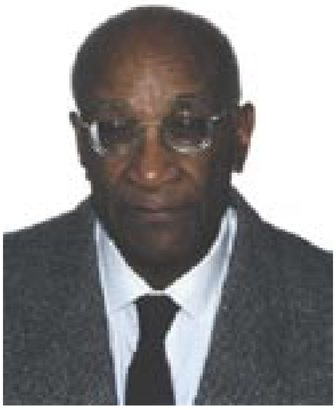

Fig. 1. Dr Carl A. Rouse, the first African-American to successfully enter into a career as an astronomical researcher. Dr. Rouse created detailed theoretical models of the solar interior and was the first person to solve the Saha Equation for the solar interior.

Dr Rouse's interest in astrophysics was initially aroused from an interest in variable stars. He wondered how a star's internal structure depended upon the details of ionisation and excitation within its interior. While it is easy to ask this question, finding the answer is extremely difficult. Modelling the interior of a star is no simple task. The supercomputer resources of the U.S. government laboratories had been previously utilised to model a computationally intense astrophysical situation of great interest, the collapse of a massive star and its subsequent explosion as a supernova. Dr Rouse realised that supercomputers could possibly allow him to calculate the equation of state of the solar core. Utilising the supercomputer resources at LLNL, Dr Rouse created detailed models of the solar interior and was the first person to solve the Saha Equation for the solar interior.

In a burst of scholarly productivity between 1961 and 1969, Dr Rouse published nine single author scholarly articles on the theoretical physics of screened Coulomb interactions and six single author articles developing his models of the solar interior. This early solar work culminated in 1969 resulting in an article in the prestigious British journal *Nature*. One of his most interesting ideas regarding the solar interior was that the Sun's core was not composed primarily of hydrogen or helium as commonly accepted, but that it was composed of a high-Z element with iron being the likely candidate.

Since this early work, Dr Rouse has continued to develop models of the solar interior utilising new supercomputer resources as they become available. In the 1980's he considered the solar neutrino deficit with his models. He has also incorporated into his models the latest data from helioseismology observing instruments. Over his career, Dr Rouse has published a total of 43 single author scholarly articles in refereed journals. Born in 1926, Dr Rouse turned 80 years old in 2005 and enthusiastically continues his work.

Dr Arthur B.C. Walker, II

Dr Arthur Bertram Cuthbert Walker, II, received a PhD in Physics from the University of Illinois in 1962. Like Dr Rouse before him, Dr Walker's PhD research was in the area of particle physics. He carried out research in nuclear physics and meson physics, particularly, the photoproduction of π mesons. Immediately after graduate school, he entered the United States Air Force with the rank of 1st Lieutenant. His interest in space physics was initiated there when he utilised his ample talents as a detailed experimentalist to build instruments for rocket probes and for a satellite experiment to measure protons and electrons trapped in the Earth's magnetosphere.

Dr Walker's interest in solar physics began at the Aerospace Corporation where he accepted a position in 1965 upon completion of his military obligation. With collaborator Dr H.R. Rugge, Dr Walker developed the first satellite borne X-ray spectrometer and carried out a series of pioneering studies of the X-ray spectrum of the sun. Dr Walker's innovative Bragg crystal spectrometers were flown on the Air Force OV1-10 and OV1-17 satellites and resulted in the first astronomical identification of X-ray dielectronic recombination lines and established the importance of radiative decay of metastable levels and of autoionising levels respectively in high temperature astrophysical plasmas. These studies also helped establish the temperature, composition, and dynamic nature of the sun's corona, and provided basic insights into the interaction of matter and radiation in diffuse million degree plasmas.

Fig. 2. Dr Arthur B.C. Walker, II, one of two African-Americans to successfully enter into a career as an astronomical researcher in 1962. Dr. Walker was the most accomplished among African American astronomers. He pioneered key technologies to astronomical observation, was a pioneer of X-ray spectroscopy, was the mentor of America's first woman in space, was the mentor of five current solar physicists, and was the mentor of two current African American astrophysicists.

In 1974, Dr Walker accepted a position as a member of the Physics Department at Stanford University. He continued to perform pioneering research and blossomed as a mentor. He and his student Sally Ride (America's first female in space), performed a comprehensive analysis of the role of dust and of the ionisation state on the interstellar medium absorption of X-rays. The two developed the first comprehensive model of the interaction of X-rays and the interstellar gas resolving several controversies over the composition of this fundamental component of the galaxy. Later, realising the potential of a new technology developed by his Stanford colleague, T.W. Barbee that permitted the fabrication of synthetic mirrors that selectively reflect X-rays of a specific wavelength, Dr Walker and his student, Joakim Lindblom, with their collaborator Richard Hoover of the Marshall Space Flight Center (MSFC), pioneered the application of these "multilayer mirrors" to astronomical observations. In 1987, they obtained the first high-resolution thermally-differentiated images of the solar atmosphere. This technology has now become standard in solar EUV imaging.

Dr Walker stands out among African-American astronomical researchers by being the only one to have produced a successful African-American astronomical researcher, Dr Hakeem M. Oluseyi. Dr. Walker was also the PhD mentor for five current solar physics researchers. Four of these are experimentalists and one is primarily a computational physicist. Five of Dr Walker's former students now serve as professors in American colleges and universities. Dr Walker passed away on April 29, 2001, but his contributions to astronomy continue through the work of his students and the impact of the technologies and spectroscopic techniques he pioneered, which are still in use today.

Fig. 3. Dr George R Carruthers, the 4th African American to successfully enter into a career as an astronomical researcher. Dr. Carruthers is best known for inventing an instrument which was placed on the moon in 1972 and observed the earth and the cosmos.

Dr George R. Carruthers

Dr George R. Carruthers received a PhD in Physics from the University of Illinois in 1964, becoming the 4th African American astronomical researcher. Dr Carruthers is best known for being the principal inventor of the Lunar Surface Far Ultraviolet Camera/Spectrograph that accompanied the Apollo 16 mission to the moon in April 1972. Positioned on the moon's surface, the camera allowed researchers for the first time to examine the Earth's extended atmosphere in the ultraviolet. The scientific results from this camera also included the first cosmic detection of molecular hydrogen. Dr Carruther's camera also represented the first observatory to be placed on a celestial body other than the earth.

Dr Carruther's began building instruments for space missions in 1966 and has since instrumented numerous sounding rocket missions, space shuttle missions, placed an instrument on Skylab, and as recently as 1999 provided an instrument for the ARGOS satellite. Today Dr Carruthers is concerned with Sun-Earth connection science. He holds two patents for his astronomical ultraviolet imaging technologies.

Young Contributors:

Following in the wake of the great African American solar astronomers mentioned above are three young solar physicists who are developing outstanding careers in their own right. Like the three pioneering scientists profiled above, this group consists of one scientist who is primarily a theorist and two who are primarily experimentalists; however, all three utilise observations and data analysis in their science.

The first is Dr Alphonse Sterling. He received his PhD in Physics from the University of New Hampshire in 1988. His research has focussed on the study of spicules, the primary discrete structures comprising the solar chromosphere. More recently he has begun to study giant explosions at the Sun's surface known as "coronal mass ejections." Dr Sterling is the author or co-author of over one hundred scientific publications.

Next is Dr Leonard Strachan. He received his PhD in Astronomy from Harvard University in 1990. His research has focussed on developing techniques for extreme ultraviolet spectroscopic study of solar plasma outflows. He has been a co-investigator of the Spartan Ultraviolet Coronal Spectrometer (UVCS/Spartan) team. Dr Strachan is also the author or co-author of over one hundred scientific publications.

Finally, there is Dr Hakeem Oluseyi. He received his PhD in Physics from Stanford University in 2000. His research has focussed on the development of instrumentation for the study of hot astrophysical plasmas. He has participated in rocket flights with the late Dr Arthur B.C. Walker, II; is currently a member of the instrumentation development team for the proposed Supernova Acceleration Probe satellite; and is in the process of developing his own solar rocket programme. Dr Oluseyi is the author of over 45 publications and holds eight technology patents.

Clearly, the pioneering African American solar physicists have been among the most accomplished of African American scientists. The current generation appears well-positioned to continue this legacy.

Fig. 4. (a) Dr Alphonse Sterling of NASA's Marshall Space Flight Center; (b) Dr Leonard Strachan of the Smithsonian Astrophysical Observatory; and (c) Dr Hakeem M. Oluseyi of the University of Alabama and the National Space Science and Technology Center.

Astronomy at Unisa

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Abstract. In 1873, the University of the Cape of Good Hope, an examining body with the power to grant degrees, was established in Cape Town. In Act 12 of 1916, it was transformed into a new federal university, effective from 02 April 1918. The name of the institution was changed to the University of South Africa (Unisa) and its headquarters was moved to Pretoria. In response to pressure from unattached students from all races to obtain qualifications without attendance at a university or college, in 1947 Unisa started teaching some subjects internally. With over 200 000 students registered in distance degree programmes in 2005, Unisa is the largest tertiary education institution on the African continent. Examinations are arranged at centres conveniently located throughout the world. Astronomy has been offered at Unisa since 1923. In 1960 Mr J Wolterbeek was appointed as the first full-time lecturer in Astronomy, and in 1972 the 9-inch Reunert Telescope, donated to Unisa by the Republic Observatory, was installed in a roof-top observatory on the new Theo van Wyk building on Muckleneuk Ridge. A new observatory, containing a 14-inch computer-controlled Schmidt-Cassegrain reflector, was inaugurated in 1992. Unisa currently offers a BSc major in Astronomy, post-graduate tuition up to the PhD level and is part of the National Astrophysics and Space Science Programme (NASSP) consortium.

Sommaire. L'université du Cap de Bonne-Espérance, fondée au Cap en 1873, est un établissement d'enseignement supérieur ayant l'autorité de délivrer des diplômes. Elle a été transformée en une université fédérale par l'Acte 12 de 1916 devenu effectif le 02 avril 1918. L'établissement a été renommé Université d'Afrique du Sud (Unisa) et son siège social a été déplacé à Pretoria. En 1947, à la suite de pressions exercées par des étudiants de toutes races pour l'obtention d'une formation à distance, l'Unisa a commencé à enseigner quelques matières par correspondance. En 2005, avec plus de 200 000 étudiants enregistrés dans des programmes de formation à distance, Unisa est le plus large établissement d'enseignement supérieur sur le continent africain. Les examens sont organisés dans des centres repartis dans le monde entier. L'astronomie a été introduite à l'Unisa en 1923. En 1960, Mr.J. Wolterbeek a été le premier à être nommé Maître de Conférence en astronomie, et en 1972, le télescope de 9 pouces offert à l'Unisa par l'Observatoire de la République a été installé au-dessus du nouveau bâtiment Theo van Wyk. Un nouvel observatoire, équipé d'un télescope Schmidt-Cassegrain robotisé de 14 pouces de diamètre a été inauguré en 1992. Aujourd'hui, Unisa délivre le diplôme de Maîtrise en astronomie, des bourses d'études doctorales, et fait partie du programme national d'astronomie et sciences spatiales (NASSP).

The University of the Cape of Good Hope

The campaign for a university in Cape Town opened in March 1873.[1] To prevent the University of London from securing control of tertiary education in southern Africa, the editor of *The Argus* newspaper in Cape Town wrote an editorial in which he called for speedy action to create "a Cape university with power to grant degrees under charter from the crown." An eight-member commission was set up by the Cape government to report on the form that such an institution should take. The commission sought the opinions of all prominent teachers in the colony before recommending an examining body, along the lines of London University, which set syllabi, conducted examinations and held graduation ceremonies. Act 16 of 1873 created the University of the Cape of Good Hope, which was governed by a 20-member council. Edward James Stone Esq., M.A., F.R.S. was appointed to the council and is one of the 14 names listed on the minutes of the first council meeting held on 1st September 1873. In August 1877 the University of the Cape of Good Hope was granted a Royal Charter by Queen Victoria.

The University's BA degree was a composite arts and science degree until 1883, after which it could be taken in literature and philosophy, or in mathematics and natural science. The MA degree was divided into three departments: language and literature, mathematics and natural philosophy, and physical sciences. A considerable expansion of the groups and subjects offered took place over the years. Because the University only set the syllabi and marked the exams, the teaching was done at separate colleges set up for this purpose.

Sir David Gill, Her Majesty's Astronomer at the Cape Obser-vatory from 1879–1907, was appointed to the second university council in 1880 and was awarded an honorary degree by the University in 1905. On the recommendation of Gill, an honorary doctorate in science was awarded to the amateur astronomer Alexander W Roberts in 1899.

Unisa

The University of South Africa (Unisa) formally came into being on 02 April 1918 following Act No. 12 of 1916, which decreed that it be recognised as the successor to the University of the Cape of Good Hope. Unisa established its headquarters in Pretoria rather than Cape Town. Two other Acts of 1916 transformed former colleges of the University of the Cape of Good Hope into universities: the South African College became the University of Cape Town and the Victoria College was transformed into the University of Stellenbosch.

In 1918 external students were regarded with little favour and it was hoped by many that these students would eventually disappear from the university scene. However, by 1945 the situation had changed dramatically. Although some external students were attending recognised teaching institutions, the great majority of students were affiliated to correspondence colleges. There was immense pressure from unattached students of all races to obtain qualifications without attendance at a university or college. Correspondence colleges had been set up to cater for their needs, and by 1945 there were over 20 such businesses in existence. Studying via Unisa offered an opportunity for self-improvement to those who

Fig. 1. A panoramic view of the Unisa buildings (excluding the tower on the extreme right of the picture) on the main campus in Pretoria (c.2000).

could not afford to attend a teaching university or university college. Many older men and women who, for one reason or another, had found it necessary to discontinue their studies after leaving school were now in full-time employment and hence welcomed the Unisa examinations as a way of obtaining graduate qualifications. In particular, servicemen returning from the Second World War saw the advantage of "learning while earning."

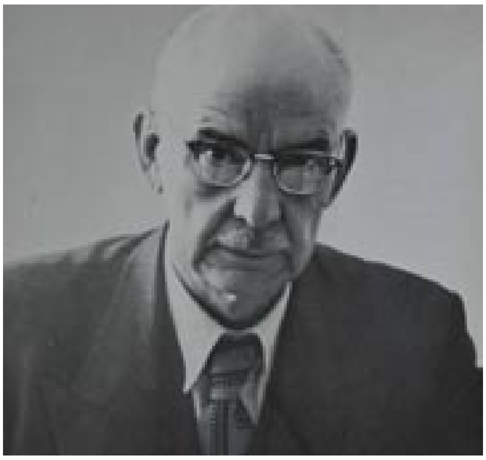

Fig. 2. Prof A J H van der Walt was appointed as the Director of the Division of External Studies in 1946. Later, he became the first Principal and Vice-Chancellor of Unisa.

The University decided to offer tuition from within, and to this end, set up a Division of External Studies in 1946. Prof A J H van der Walt was appointed to the post of Director of the Division. Initially, the division was going to run for one year, and its fate was going to be assessed at the end of the period. The work of the new Divison of External Studies was limited to one lecturer per subject in the faculties of Arts, Law and Commerce. On 16 October 1946, Mr J.H. van der Merwe joined the staff as a Senior Lecturer in Mathematics. He was responsible for all the Mathematics, Applied Mathematics and Statistics courses. Because of the success of the Division of External Studies, in 1953 Prof van der Walt was given the title of Principal and the authority to unite the teaching and administrative sections of Unisa. With the passing of Act 54 of 1955, the Principal of the university became the Vice-Chancellor, and the Division of External Studies simply a division of studies. Unisa still offers education via correspondence and currently has over 200 000 registered students over a broad range of subjects in Arts, Law, Commerce and Science amongst others.

Astronomy Courses

Astronomy has been offered at Unisa since 1923. The syllabus for Astronomy, as presented in the 1923/24 Calendar of the University, is listed below. The material is mathematical in nature, typical of classical astronomy courses at that time. From 1930 onwards, Courses I and II consisted of two papers each, with a slight change in the syllabus, but using the same textbooks. From the 1930s through to 1962, Astronomy was offered through the services of Mr H. Long, a land surveyor working in the Eastern Cape.

First course.- Spherical trigonometry. Diurnal motion. Co-ordinates of stars. Apparent annual motion of the sun. Mean and sidereal time. Equation of time. Methods of determining time, latitude, and azimuth. Instruments of a fixed observatory, such as transit-circle, equatorial heliometer, and their adjustments. Refraction and effects on right ascension, declination, distance of two stars. Parallax. Determination of position of first point of Aries. Kepler's laws and their application. Mean and true anomaly. The planets (descriptive, e.g. masses, time of revolution, etc.)

Second course. Theory and practice of interpolation. Method of least squares. Precession, nutation, and aberration. Eclipses and occultations. Determination of sun's distance. Determination of orbit of a planet. Libration. Determination of a parabolic orbit. Tisserand's criterion.

Suggested books: Ball, *Spherical Astronomy*; Newcomb, *Spherical Astronomy*; Chapman, *Astronomy for Surveyors;* Plummer *Dynamical Astronomy;* Klinkerfues, *Theoretical Astronomy.*

Unisa currently offers nine undergraduate astronomy modules which can be taken as part of a BSc majoring in astronomy. The emphasis of the course material has changed from the rather old-fashioned concentration on positional astronomy to courses on modern astrophysics. Students can register for individual modules for non-degree purposes subject to having passed the necessary maths and physics prerequisite modules. Several South African universities that do not offer astronomy give credit towards a BSc degree for any of the Unisa modules that students pass. Hons, MSc and PhD degrees are also offered by Unisa. MSc and PhD degrees, which consist of submitting a dissertation, can be done by correspondence (i.e. remotely from the university) provided the candidate can find a suitable local supervisor.

Unisa is part of the National Astrophysics and Space Physics (NASSP) consortium. Ms Alet de Witt, a student from the first NASSP Hons class in 2004, has recently completed her MSc on "Shock excited 1720 MHz OH masers in Herbig-Haro Objects" and is registered for her PhD.

Staff

In order that Prof van der Merwe, the Head of the Mathematics Department and the Dean of the Faculty, could go on long leave, Mr J. Wolterbeek was appointed as a Locum Tenens on 1 March 1960. His primary responsibility was to mark 2nd and 3rd year mathematics assignments on Calculus and Analysis. During the year, a teaching post for astronomy was created and Wolterbeek was the successful applicant. On 1 October 1960 he was appointed to a full-time post of Lecturer in Astronomy within the Department of Mathematics at Unisa.

Wolterbeek was born in the Hague, Netherlands, on 27 April 1930. He went to school in the Hague, matriculating in July 1948. He continued his studies at Leiden University where he obtained his BSc (or Candidates as it is known there) in 1952 majoring in Mathematics and Astronomy, and then registered for an MSc in Astronomy. For the practical part of these studies he worked under Prof van der Hulst on the 21 cm line of neutral hydrogen, and he spent from September to November 1955 studying double stars in Toulouse, France. Wolterbeek was awarded his MSc (or Doctorandus) and a Mathematics Teaching Diploma (for High School) in December 1956. From April 1957 to January 1959 he was conscripted into NATO's Signal Corp in the Netherlands. He joined the Leiden Observatory on 15 January 1959, moving to the Leiden Southern Station at Broederstroom (near Hartebeestpoort Dam) in May of that year, and then to Unisa in early 1960. Wolterbeek was promoted to Senior Lecturer in September 1991.

A second full-time astronomy lecturer, Dr Peter D Bennewith from University College, London, started at Unisa on 1 February 1975. He immediately set about upgrading the 2nd and 3rd year courses by including more astrophysics in the syllabus. Bennewith also introduced an Honours paper in Astrophysics in 1976.

Bennewith resigned from Unisa in 1983, leaving at the end of May of that year to return to the UK. He was succeeded by Dr W F Wargau who had been an Assistant Professor (Wissenschaftlicher Angestellter) at the University of Erlanger-Nurnberg in Germany. Wargau arrived in November 1983 to his position as Senior Lecturer in Astronomy within the Department of Mathematics.

Dr Barbara Cunow joined the astronomy section of the Maths Department from July 1994 to January 1995 as a temporary lecturer. From May to November 1995 Cunow again visited the department, this time on a scholarship for her senior Doctorate, which was financed by the Ministerium fuer Wissenschaft und Forschung des Landes Nordrhein-Westfalen, Germany. She obtained her Diplom in Physics from Muenster University in 1989, and her PhD in Astronomy from the same university in 1994, her thesis dealing with the photometry of galaxies. In January 1996 Cunow was appointed as a Lecturer in the Department of Mathematics, Applied Mathematics and Astronomy to replace Wolterbeek, who had retired.

Fig. 3. Dr Barbara Cunow from the Astronomy section of the Department of Mathematical Sciences adjusting her telescope at one of our public viewing evenings.

Walter Freidrich Wargau (1948–1996) died in Schwabach, Germany on 6 November 1996. He had attended an astronomical conference in the UK, and was visiting family and post-graduate students in Germany when he was taken critically ill as a result of chronic active hepatitis which he had contracted in 1978. His position was filled by Dr Derck P Smits, from HartRAO, who took up a post of Associate Professor on 2 Feb 1998.

Observatories

Unisa started to migrate to its present main campus on Muckleneuk Ridge in 1972. The Maths Department took up residence in the newly erected Theo van Wyk building during August. The new building made it possible for the Astronomy section to expand its activities. As mentioned above, a 9" (288-mm) refractor made by Sir Howard Grubb in 1907, known as the Reunert telescope, had been donated to Unisa in 1968 by the Republic Observatory where it had become redundant. The history of this telescope has been chronicled by Hers.[2] Under the supervision of Wolterbeek, the dismantled instrument was installed on the roof of the new building in a protective brick housing with a retractable metal roof where it stands to this day. The roof-top observatory was completed in the second week of September 1972 and immediately drew large numbers of visitors. Besides viewing evenings for the public, the telescope was also used to teach astronomy students some of the practical aspects of observational work, and by Wolterbeek for observations of double stars.

In a memo to the Registrar of Finance dated 13 May 1987, Wargau requested funds to build and equip a small but modern observatory which could be used for training students in professional techniques. Many years of planning and toil culminated in the official opening of the new Unisa Observatory in August 1992. The Observatory contains a

35cm (14") computer-controlled Schmidt-Cassegrain telescope mounted on a fixed pillar. A practical module was launched in 1993 on 2nd year level (AST255), and an advanced practical at 3rd year level (AST355) in 1994. Mrs V. Pieters, a BSc and Hons graduate from Unisa, based her Masters dissertation on work carried out at the Observatory. She completed her MSc thesis entitled "Aperture Photometry at the Unisa Observatory: System Evaluation via Light Curves of Eclipsing Binaries" by the end of 1993.

Acknowledgements

Much of the general material about Unisa and the University of the Cape of Good Hope prior to 1973 have been gleaned from the comprehensive history of Unisa called *Spes in Arduis* by Boucher.[1] Details regarding the early years of the Mathematics Department were obtained from the personal recollections of Mr Wolterbeek.

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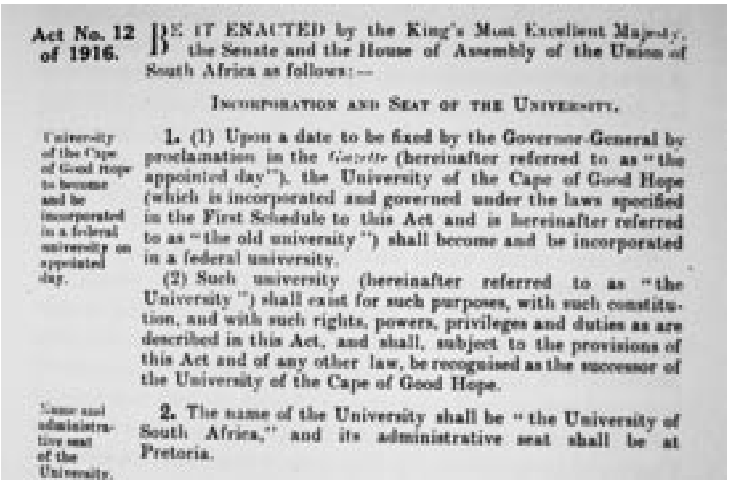

Act No. 12 of 1916.

BE IT ENACTED by the King's Most Excellent Majesty, the Senate and the House of Assembly of the Union of South Africa as follows:—

INCORPORATION AND SEAT OF THE UNIVERSITY.

University of the Cape of Good Hope to become and be incorporated in a federal university on appointed day.

1. (1) Upon a date to be fixed by the Governor-General by proclamation in the *Gazette* (hereinafter referred to as "the appointed day"), the University of the Cape of Good Hope (which is incorporated and governed under the laws specified in the First Schedule to this Act and is hereinafter referred to as "the old university") shall become and be incorporated in a federal university.

(2) Such university (hereinafter referred to as "the University") shall exist for such purposes, with such constitution, and with such rights, powers, privileges and duties as are described in this Act, and shall, subject to the provisions of this Act and of any other law, be recognised as the successor of the University of the Cape of Good Hope.

Name and administrative seat of the University.

2. The name of the University shall be "the University of South Africa," and its administrative seat shall be at Pretoria.

Fig. 4. A copy of Act 12 of 1916 which transformed the University of the Cape of Good Hope into a new institution called the University of South Africa.

Forty Years of Radio Astronomy at Hartebeesthoek

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Abstract. In 1961 an 85-foot (26-metre) diameter radio antenna was erected at Hartebeesthoek near Johannesburg, as NASA's Deep Space Instrumentation Facility 51. A young South African engineer employed there soon initiated a radio astronomy research programme to use free time between tracking spacecraft. On the closure of the facility by NASA in 1974, it was re-constituted as a radio astronomy observatory operated by the CSIR. In this paper, we highlight various strands of the forty year history of radio astronomy at Hartebeesthoek. We also cover some of the perhaps surprising spinoffs that it has generated, both scientifically and practically. Some of these hark back to measurements taken by the Abbé de la Caille at the Cape in the 1750's, and to the reasons for establishing a Royal Observatory there in the 1820's.

Sommaire. Pour le suivi de ses sondes spatiales, la NASA etablit en 1961, à Hartebeesthoek – non loin de Johannesbourg – une antenne radio de 26 m de diametre. Un jeune Ingénieur Sud Africain, alors employé sur le site initiera un programme de recherches en radioastronomie durant les heures d'inactivité de l'antenne. A l'arrêt des activités de la NASA en 1974, le site fut reconverti en observatoire pour la radioastronomie , sous la tutelle du C.S.I.R. Sud Africain. Le présent article éclaire sur certaines des retombées scientifiques et technologiques dudit observatoire. Certaines de ces retombées ramènent aux observations faites par La Caille au Cap autour de 1750 ainsi qu'aux raisons ayant motivé l'érection d'un observatoire astronomique au Cap autour de 1820.

Themes Within the History of Radio Astronomy at Hartebeesthoek

Multiple strands can be found in the history of radio astronomy at Hartebeesthoek. That it began was the consequence of political decisions relating to the superpowers' space race. New discoveries in radio astronomy steadily expanded the science potential of a 26-m antenna located in southern Africa. Here we note some of the people who made it happen, new techniques and technologies that were developed, and representative science outputs that were the result. Scientific and practical spinoffs followed as it developed.

The Political Environment around Hartebeesthoek

From the beginning of the space race the United States needed a station in southern Africa to track its spacecraft. As the capacity to send spacecraft beyond Earth orbit developed, a "Deep Space" tracking facility in this area became a necessity. The South African Council for Scientific and Industrial Research (CSIR) entered into an agreement to operate a facility on behalf of the Jet Propulsion Laboratory (JPL) for the US National Aeronautics and Space Administration (NASA). The National Institute of Telecommunications Research (NITR) of the CSIR was tasked with operating the 85 ft. (26-m) antenna built for this purpose at Hartebeesthoek, 60 km west of Johannesburg (Fig. 1). One of the South African engineers involved was George Nicolson, who soon started using the antenna for radio astronomical research[21] when it was not tracking spacecraft.

By 1974 NASA was in the post-Apollo era. Having now a new tracking station in Madrid with a 210 ft. (64-m) antenna providing greater capability, it was able to close the Hartebeesthoek station, which had become an increasing political embarassment in the era of apartheid. After the NASA withdrawal, Nicolson, together with a team of one engineer and six technicians, was given the task of transforming the facility into a radio astronomy observatory within the CSIR. The Department of Physics and Electronics at Rhodes University, the only other group actively involved in radio astronomy in South Africa, was given a 20% share of the observing time available on the telescope.

Fig. 1. Hartebeesthoek in 1961, during the inauguration of the 85 ft. radio antenna. Note the original aluminium mesh surface and prime focus 960-MHz receiver.

In 1988, the Foundation for Research Development (FRD) was established within the CSIR, and what was now the Hartebeesthoek Radio Astronomy Observatory (HartRAO) was transferred to it. National politics were transformed by the election of a democratic government in 1994. The new Department of Arts, Culture, Science and Technology (DACST) inherited the FRD, which mutated into the National Research Foundation (NRF), and in 2002 DACST split, the NRF coming under the new Department of Science and Technology (DST). All these political events influenced developments at Hartebeesthoek.

The People Driving Science Through New Techniques and New Technologies

During the NASA period, Nicolson developed a novel noise-adding, gain-stabilised radiometer for mapping the Milky Way and for flux measurements on radio galaxies.

Multiple copies of this continue in use at the observatory today.

The technique of very long baseline radio interferometry using pairs and then arrays of telescopes began in 1967. Nicolson participated in the first southern intercontinental Very Long Baseline Interferometry (VLBI), in which signals from an object are recorded simultaneously at each telescope, the data later being cross-correlated using a computer.[22] This provides a "virtual telescope" as large as the separation between the antennas, with a consequent improvement in angular resolution of many orders of magnitude compared to a single antenna.

In the post-NASA era, young graduates from local universities were recruited by Nicolson to assist with technical developments and to start up new research areas. Peter Mountfort and Justin Jonas (Rhodes University) developed the HP1000 mini-computer-based control system for the radio telescope in the late 1970's, and used it to map the continuum radio emission from the southern sky.[11] Michael Gaylard (ex-Rhodes University) started up spectroscopic observing[7] in 1980, using a 256-channel autocorrelation spectrometer built by Guy Woodhouse (University of the Witwatersrand) as an MSc project. Claire Flanagan[5] (ex-Rhodes University) completed a single-channel pulsar timer whose construction was initiated by a visiting Swiss engineering student. Don Bramwell developed queue-scheduling software for the mini-computer system, to permit unattended single-dish observing. The replacement of the mini-computer control system by a linux-based PC network from the late 1990's was led by Jonathan Quick (ex-University of the Witwatersrand) supported by Andrew Goertz (Greybe) (on sabbatical from the European Synchrotron Research Facility, Grenoble), Gaylard, Beate Woermann and Sarah Buchner (all ex-Rhodes University).

Radio Astronomy with a 26-Metre Antenna

In 1932 Karl Jansky discovered the first source of radio continuum emission from beyond the Earth which he showed to be associated with the Milky Way. Nicolson's first project[19] in 1963 was to map the continuum emission from the southern Milky Way at 960-MHz (Fig. 3). This was followed in the 1980's and 1990's by the much more ambitious 2300-MHz map of almost the whole southern sky by Jonas, Baart & Nicolson[12], for which Nicolson's gain-stabilised radiometer was crucial.

Fig. 2. George Nicolson in the Hartebeesthoek control room in 1962.

Hey reported the detection of the Sun's radio emission by military radars in 1942. Owing to their distance, no other normal stars are detectable with a 26-m centimetric antenna. Interacting binary stars may, however, produce strong radio emission, one such star being Circinus X-1. First discovered as an X-ray source, it also produces radio flares with a 16.6-day period. Nicolson[23] obtained accurate ephemerides for the flares through long-term monitoring with dual-beam Dicke-switched receivers at 5000– and 8500-MHz.

The first galaxy beyond the Milky Way from which radio emission was detected was M31, the Andromeda galaxy, by Hanbury Brown and Hazard in 1950. While this is a "normal" galaxy like the Milky Way, it was later found that there are "active" galaxies from which radio emitting jets emerged. In 1966, Nicolson began a major programme to monitor variability in extragalactic radio sources at 2300-MHz. This revealed significant variability in objects with flat radio spectra.[20] They were the target of the first southern hemisphere VLBI, which was carried out between Hartebeesthoek and Woomera in Australia in 1971 (Legg *et al.*[14]). The aim was to determine the sizes of sources and to look for evidence of changing size and superluminal motion in the jets. The long baselines to South Africa from other continents provide very high angular resolution for such studies. This has led to frequent experiments particularly with Australia, as part of the Australia Telescope Long Baseline Array (AT-LBA), and with Europe, HartRAO having become an associate member of the European VLBI Network (EVN) in 2001. Evolving technology now permits radio sources to be mapped in exquisite detail on a scale of a thousandth of a second of arc. HartRAO was a key southern hemisphere station in the networks supporting the Japanese VLBI Space Observatory Programme (VSOP)[10] using the first orbiting radio telescope.

In 1955 Burke and Franklin discovered that planets in the solar system produce radio emission. The impact of comet Shoemaker-Levy 9 on Jupiter in July 1994 provided a unique opportunity for Derck Smits[18] (ex-UCT, now at UNISA) to measure the disturbance to that planet's radiation belts and their recovery, which took more than a year, through monitoring at 5000– and 8500–MHz.

Radio emission and absorption lines from interstellar molecules were discovered by Weinreb in 1963, the first molecule found this way being the hydroxyl. An interesting use of sensitivity of the hydroxyl molecule to background

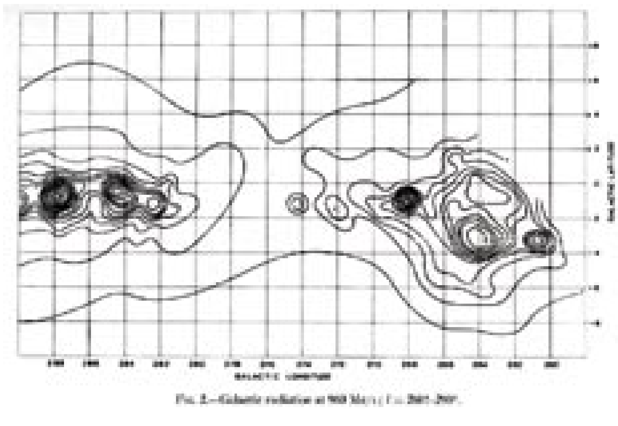

Fig. 3. Radio map of the southern Milky Way at 960MHz in the first radio astronomy paper from Hartebeesthoek, by Nicolson[19] in 1965.

radiation was in obtaining a distance estimate to the Puppis A supernova remnant by Woermann, Gaylard & Otrupcek.[27] Puppis A can be seen at L= 260.7°, B= –3.2° in Nicolson's original publication (Fig. 3).

Photo-ionised nebulae around OB stars are a significant source of the continuum radio emission in the Milky Way. They comprise most of the strong sources lying near L= 0° in Fig 3. The ionised hydrogen also emits a comb of recombination lines across the radio spectrum. This was first detected by Dravskikh and Dravskikh in 1964. The first spectroscopic publication from Hartebeesthoek, in 1984, reported the detection of recombination lines from the faint Barnard Loop in the Orion region by Gaylard.[6] A surprising later result was their detection in the Gum Nebula by Woermann[26] in her PhD research.

The cosmic microwave background was discovered by Penzias and Wilson in 1965. An unexpected application of the 2300-MHz map of the southern galactic emission[9] was its value in the removal of foreground radiation from the Milky Way in studies of the cosmic microwave background (CMB) radiation.[8] Similarly, Gaylard and Woermann's work on the Barnard Loop and the Gum Nebula assisted in separating out thermal and non-thermal foreground emission for correcting CMB maps.[4]

Much of the spectroscopic research at Hartebeesthoek focussed on masers – stimulated emission from molecules – whose existence had been discovered by Weaver *et al.* in 1965. Initially labelled "Mysterium" this emission was soon identified as coming from hydroxyl in clouds near newly formed stars. Ground state hydroxyl emission at 1665-MHz was the first maser targeted at Hartebeesthoek, using the new 18-cm wavelength receiver, by Cohen, Baart & Jonas[3] in 1988. Batrla *et al.* discovered bright methanol masers at 12178-MHz in 1987. A new receiver was soon built using off-the-shelf amplifiers designed for domestic satellite receivers, and southern surveys and monitoring were initiated in 1988 (*e.g.* Kemball, Gaylard & Nicolson[13]). Even brighter methanol masers at 6668-MHz were discovered by Menten in 1991, and Canadian post-doc Gordon MacLeod and Gaylard rapidly embarked on the first southern searches for these, using a new receiver built for the purpose (*e.g.* MacLeod, Gaylard & Nicolson[17]). Johan van der Walt at the Potchefstroom University (now NorthWest University) seized the opportunity presented by the methanol masers for studying star formation. Most recently this led to the PhD by Sharmila Goedhart, which included the startling discovery of periodic variations in some of these masers.[9] Smits[24] also used the Hartebeesthoek telescope to good effect in searching for and monitoring excited-state hydroxyl masers in the 4.7– and 6–GHz transitions.

Neutron stars are the collapsed remnants of stars. They may emit strong, beamed radiation from above their magnetic poles. This is observed as a string of pulses, which led to such objects being named "pulsars" when they were discovered by Bell and Hewish in 1967. Monitoring of a set of 28 pulsars at HartRAO began in 1984. The "Vela Pulsar" (B0833–45) exhibits sudden jumps in rotation rate ("glitches") every few years. It became the target of a campaign of daily monitoring. The first pulsar publication from HartRAO reported the July 1985 glitch and the second the 1988 "Christmas Eve" glitch, found by automated glitch detection software developed by Flanagan.[5] This pulsar is located within Nicolson's first 960-MHz map (Fig. 3), at L= 263.5°, B= –2.8°. The pulsar itself is not seen in the map, but the large remnant of the supernova that produced the pulsar is evident. Collaboration with the University of Nigeria at Nsukka produced PhD's by Johnson Urama and Augustine Chukwude and a series of publications on the long-term behaviour of pulsars (*e.g.* Urama & Okeke[25]).

Radio Astronomy Spinoffs

A by-product of VLBI is that accurate positions are determined for the participating telescopes. With rapidly improving technologies this led to two spinoffs. The first is astrometric VLBI, which was developed to obtain very accurate positions for extremely compact radio sources. Following the acquisition of a hydrogen maser frequency standard in 1985 and a Mark III VLBI terminal, HartRAO was used for its extension to the south.[16] A dichroic reflector was developed to allow simultaneous 13-cm and 3.5-cm observing, which permits the correction of atmospheric and ionospheric effects. This advance led to the radio source-based International Celestial Reference Frame (ICRF) replacing the optical FK5 reference frame from 1998.[15] This type of astrometric function was a key motivator in the establishment of the Royal Observatory at the Cape in 1820. Radio astronomy has now replaced optical astronomy for this purpose; the radio reference frame is accurate to the order of the 0.001seconds of arc compared to the optical accuracy of 0.1 – 1arc seconds. Regular 24-hour experiments using the Hartebeesthoek antenna help to maintain and extend the radio reference frame.

The second spinoff is geodetic VLBI, in which the VLBI technique is used to study the dynamics of the Earth. The first experiment involving Hartebeesthoek used the 18-cm wavelength receiver and took place in 1980. This determined the position of the antenna to an accuracy of several metres, an order of magnitude better than the position measured in the 1970's as part of the NASA Deep Space Network. However, the techniques employed to improve astrometric VLBI also radically improved the geodetic accuracy. The telescope positional uncertainty was reduced to 10 cm in the 1986 campaign[1] in which German PhD student Axel Nothnagel played a leading role at HartRAO, and has continued to shrink with further technology improvements. As the 20-year mark arrives for these weekly experiments, the telescope's positional uncertainty has shrunk to less than 1 mm. The telescope is moving north east at 25 mm per year, a direct measurement of the current motion of the African tectonic plate on which it is the only such telescope. A practical consequence of this precise position determination is that from January 1999 the 26-m telescope became the reference point for the co-ordinate system of South Africa when the national coordinate grid was transformed from Clarke 1880 to WGS84, creating the Hartebeesthoek 94 datum.[28] We are reminded of De La Caille's 1750 measurement of the arc of meridian at the Cape and the determination of the longitude of Cape Town, and the subsequent work of Cape Observatory astronomers Maclear, Herschel and Gill in geodesy and surveying.

Geodetic VLBI also measures Earth orientation and rotation rate – in other words, Earth time (UT1). Ludwig Combrinck took on leadership of the spinoff Space Geodesy programme.

He was instrumental in getting a refurbished but disused NASA satellite laser ranger (SLR) set up at Hartebeesthoek, and in getting a network of Global Positioning System receivers operating across southern Africa as part of the International GPS Service (IGS). These two systems make use of the absolute position established by the radio telescope. The co-located SLR measures the orbits of various satellites to an accuracy of centimetres. The functions of these satellites include precise positioning, navigation, gravity field measurement and sea surface height measurement. The SLR at HartRAO fills a huge hole in coverage by the global SLR network, providing a major improvement in orbit solution accuracy. The GPS base stations in South Africa and neighbouring countries provide an inexpensive way of propagating accurate position measurement. This in turn has spinoffs, for example in measuring the atmospheric water vapour content,[2] which has implications for weather modelling.

Conclusions

The 26-m antenna and the uses to which it is put have been radically transformed since its construction in 1961 for the purpose of tracking spacecraft exploring the solar system. The antenna has been used to make a wide range of astronomical discoveries, and a new branch of science has sprung up that capitalises on the precisely determined location for the antenna. The three current research instruments are shown in Fig. 4, together with the people who make them work.

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Fig. 4. Hartebeesthoek in 2003. The entire staff are seen here, with the GPS basestation antenna in the left foreground. The Satellite Laser Ranger is in the right background. The 26-m antenna is seen with four panels missing during its third resurfacing, with solid aluminium panels. The antenna was converted from prime focus to Cassegrain in 1964.

Scientific Astronomy by the Neolithic People of the Cape

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Abstract. The poster on this subject displayed at the AAHS sought to prove that the neolithic peoples of South Africa were able to predict and verify the day of an equinox and determine the E–W line by means of specialised bored stones, examples of which are extant in the museum at Genadendal. This then meant that the observing sites could be accurately located with observations of 2 or 3 equinox sunrises or sunsets.The method is so unexpected and simple that this note will describe it in more detail, in a manner suited to non-specialists. It can be performed by children.

Sommaire. Le poster sur ce sujet, exposé lors du *AAHS* ambitionnait de montrer que les peuples du Néolithique de l'actuel Afrique du Sud savaient prédire et vérifier l'avènement de l'équinoxe ainsi que déterminer la direction Est-ouest à l'aide de pierres spécialement taillées dont des exemplaires sont conservés au musée de Genadental. Cela signifiait que les sites d'observations pouvaient être localisés en observant 2 ou 3 levers ou couchers de Soleil durant l'équinoxe. La méthode est si inattendue et simple qu'il nous est possible de la décrire, ici, de façon détaillée et accessible aux non-spécialistes. Des enfants pourraient aisément la reproduire.

Introduction

A while before this Archeoastronomy Symposium, a local historian, Dr Cyril Hromnik, gave a talk to the local amateur astronomers, describing his observation that small stone structures in the "veld", south of the SALT telescope, were actually observatories or shrines, since if an observer was present at dusk or dawn on an equinox, the sun would rise exactly over a tor or col (koppie or nek) on the horizon. He invited those present to investigate this on the following equinox by accompanying him. This I did, which led to a poster exhibit which shows how it could have been done in a very simple manner, by neolithic hunter-gatherer people. Dr Hromnik inclines to a "diffusion" explanation, since this method was also used in India, with which he is well acquainted.

The local hunter-gatherers were, however, very knowledgeable about the stars, giving the bright circumpolar star α and β Cen and Achenar the names !Kwe, meaning the "bored stones" which were their incunabula. The sun was regarded as a special gift of the main god and his wife who kept it burning overnight.

Their stories or myths were recorded by Dr Bleek and Lucy Lloyd about 170 years ago in Cape Town.

The Method

A ball about 10-cm in diameter is positioned at the top of a stake about 1½ to 2m high above the ground, with an open view to the east and west and a level surface extending about 5-m around. The shadow of the ball cast by the Sun should be marked from dawn to dusk on a day close to a solstice (summer or winter) i.e. about 21 June or 21 December. The mark can be made on a solid surface by chalk, charcoal or old ballpoint pens inserted into the ground, being the centre of the shadow. By joining the marks, a pronounced curve is produced. The procedure can be repeated monthly and it will be noticed that the curvature decreases until it becomes a straight line on the day of the equinox.

The important days for marking out the path of the shadow, at half-hour or hourly intervals, are the 20th, 21st, 22nd and 23rd of the month for the March and September equinoxes. A cord stretched between the end points will clearly show the slight curvature, or lack thereof. The straight line will correspond to the date of the equinox and will yield the exact East-West direction. After the equinox date, the curvature reverses. The curve can be thought of as a round-bottomed "V".

Fig. 1. A practical demonstration of the path of the sun's shadow. The equinox is on the left, summer solstice is on the right.

Each V-shaped curve is a branch of a hyperbola. It points away from the Sun in summer and towards the Sun in winter, becoming a straight E–W line on the equinoxes.[1]

This experiment has been done at latitude 34° south. The slopes of the curves will be very different at higher latitudes; they become circles at the poles (summer only!)

Conclusion

The simplicity and accuracy of the method must surely demonstrate how obelisks were used in Egypt, and lingams in India, to indicate true E–W, the length of the year and the arrival of an equinox. A year is the number of days between three successive equinoxes, namely 179 days (September to March) and then 186 days (March to September).

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The Nature of the Dawn's Heart Star

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Abstract. One of the most developed San narratives is that of the Dawn's Heart, who had a close relationship with his daughter, the Dawn's Heart Child. The Father was identified as Jupiter with the Child (or Dawn's Heart Star) being Regulus. Both these identifications have been questioned before. This paper investigates naked-eye observations of one (or possibly two) of Jupiter's moons as an explanation for the Dawn's Heart Star. Some linguistic evidence is found for the San distinguishing between the planets and that good conditions and a keen-eyed observer is necessary for naked-eye visibility of Galilean satellites but that it is indeed possible, supporting the present hypothesis.

Sommaire. L'une des légendes les plus élaborées du peuple San est celle du "Coeur de l'Aube " qui, selon ladite légende, fut très proche de sa fille, "La Fille du Coeur de l'Aube". Des tentatives ultérieures d'identification encore fortement débattues ont vu en le père, la planète Jupiter et en la fille, l'étoile Regulus. Le présent article explore la possibilité d'observations à l'oeil nu de l'un (ou deux) des satellites de Jupiter comme plausible explication à la légende susmentionnée. Deux faits sont à relever à l'appui de notre hypothèse : des preuves linguistiques indiquent que les San savent identifier les planètes. En plus, de bonnes conditions de visibilité ainsi qu'une acuité visuelle suffisante permettent l'observation a l'oeil nu de certains des satellites de Jupiter.

The Legend of the Dawn's Heart Star

Hewitt[7] explains at length how this long, complex story links Earth/Sky, Day/Night and Culture/Nature. This narrative concludes where the Dawn's Heart left his wife, the Lynx and went back into the sky to live with his daughter, the Dawn's Heart Child, also called the Dawn's Heart Star.

In simplified form, Von Wielligh deciphers this cryptic tale:

> "(Lynx) could now again look after her own child; and that daughter had children, and the children also had children. Everyone was turned into Stars; and those Stars still follow behind their parents and are now the brightest Stars in the heavens…. (Wolf) murdered (Dawn) and started to skin him. But just as he cut open the body, the sparkling Heart flew out and went up into the sky, and from then on was the Morning Star. It was then that he (Dawn) came to fetch his wife, children and grandchildren, to live with him at the sunrise side of the sky. Though the big bright Morning Star, we must understand, is the Heart of the Dawn."[14]

It seems that Bleek and Lloyd's San informant physically pointed out the Dawn's Heart Stars to him who, with the help of an astronomer (possibly George Maclear and/or Finlay) identified it as Jupiter and…

> "… the child was identified with a small star standing close to Jupiter in the sky. At the time when we asked it was Regulus."[4]

Possible Explanations

Snedegar[11] urges that Bleek's interpretation of Jupiter is wrong and that the Dawn's Heart Star must be Venus on the grounds of a Jupiter/Venus conjunction on 15 October 1873. Planetarium software shows that on this date, Jupiter and Venus indeed were 20 arcminutes from each other in the morning sky. However, about four months before, on 26 June 1873, Jupiter passed within a lunar diameter of Regulus.

From a linguistic point of view, as pointed out in private communication with van Vuuren[13] and Hollmann[8], it is clear from Bleek[2] that the /Xam had different words for the planets of Jupiter, Venus and Mars, suggesting different objects.

The /Xam divided all stars into night stars and day stars, with their "morning star", Jupiter, being a day star par excellence[7]; and Venus, a night star.

Fig 1. Quite early on in the project, in June 1872, //Kabbo told the story of the Dawn's Heart to Lucy Lloyd.

Two sources offer another possible explanation. After quoting Bleek[4]:

> "The 'Dawn's-Heart' (the star Jupiter) has a daughter, who is identified with some neighbouring star preceding Jupiter (at the time when we asked, it was Regulus or Alpha Leonis). Her name is the 'Dawn's-Heart-child', and her relation to her father is somewhat mysterious. He calls her 'my heart', he swallows her, then walks alone as the only Dawn's-Heart Star, and, when she is grown up, he spits her out again. She then herself becomes another (female) Dawn's-Heart, and spits out another Dawn's-Heart-child, which follows the male and female Dawn's-Heart."

… van Reenen[12] made three remarks:

> "Firstly … that Dr. Bleek was not completely sure which star was associated with the planet Jupiter. Secondly, we must deduce that the Dawn's Heart and his child are heavenly bodies that are always close together, otherwise such an intimate relationship would not have been attributed to them. Thirdly, it must be suspected that the phenomenon described here, must have repeated itself

regularly to have made such a lasting impression."

Van Reenen suggests that the reason for Bleek not understanding what his Bushman informant was trying to show him was because he was unable to see what was being pointed out to him. Van Reenen closes by stating how this is an example of the Bushmen describing their observations of the movements of Jupiter's moons in their characteristic poetic manner.

The second source, A.R. Willcox,[16] echoes van Reenen when writing:

> "… can hardly be other than their explanation of the disappearance of one of Jupiter's moons as it passes behind the planet in temporary occultation and then reappears, but even the brightest moon can be seen by very few, if any, people of other races without optical aid."

Both van Reenen and Willcox are suggesting what is a present-day legend – that the Bushman had superior eyesight and were able to see some of Jupiter's moons with the naked-eye. Proving this today is not easy, although, Von Wielligh[15] highlights this special ability repeatedly. They did indeed require remarkable powers of observation for some daily tasks that ensured their survival in a land of harsh conditions. Some of the edible roots that they dug up for medicine, food and water only revealed very subtle visible clues aboveground and their outstanding tracking abilities astounded many.

Naked-eye Galilean Satellite Visibility

Although rare, some occasional naked-eye sightings of Galilean satellites have been recorded over time. The following table gives the visual magnitudes and maximum angular separations from the centre of Jupiter at mean opposition.[6]

Jovian Satellite	Brightness	Maximum Separation
I – Io	4.8 Mag	2.3'
II – Europa	5.2 Mag	3.7'
III – Ganymede	4.5 Mag	5.9'
IV – Callisto	5.5 Mag	10.3'

When only considering separation, the traditional naked-eye test for visual acuteness, the 3.5 arcminute binary Epsilon Lyrae, suggests Europa should even be possible.

Without the glare of Jupiter, all four moons are bright enough to be easily visible from a dark site, but due to their proximity to bright Jupiter, the aberrations of the eye cause spikes and flares, hiding the moons. Some observers (*e.g.* Baum[1] and Denning[5]) developed observing techniques to counteract these aberrations while those blessed with more perfect eyes get by without these "tricks".

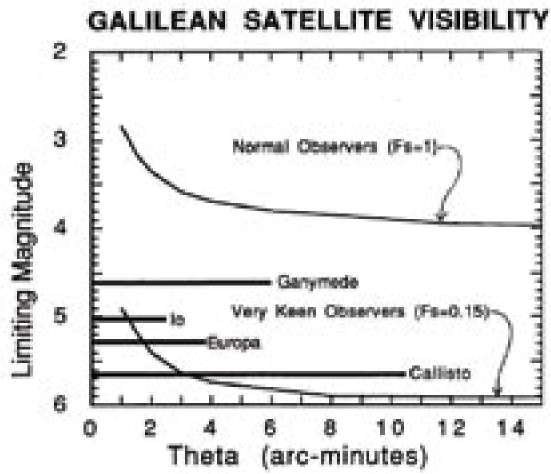
See[10] made a series of observations and Whitmell[17] collected nine cases of naked-eye sightings of Jovian satellites. Common elements to these accounts were:

- Satellite III was most commonly observed (nearly all the cases) followed by IV (three accounts) and one case of II.
- A hint of twilight or some moonlight seemed to help reduce Jupiter's glare;
- Excellent atmospheric conditions; and
- Three observers were known to possess exceptionally keen eyesight.

Fig 2. The naked-eye appearance of Jupiter and its satellites Ganymede (*right of planet's image*) and Callisto (*left*) as sketched by Richard Baum in 1975 on September 10th (*top*) and 12th. (April 1976, *Sky and Telescope*, 235)[1].

In a paper entitled "Glare and Celestial Visibility", Schaefer[9] developed a model for observing faint objects in close proximity to a bright one. He specifically deals with the case of Galilean satellite visibility.

This graph from Schaefer[9] represents two extreme cases of an observer with average eyesight ($F_s = 1$) and an exceptionally keen-eyed observer ($F_s = 0.15$, someone who can see a 7.7–mag star without optical aid). For the moons to be visible for a particular person, the moon's horizontal line must be in the region to the upper-right of the observer's threshold curve. The model shows that normal sighted people cannot see the moons, but the very best observers can see all four.



This also gives an idea of the good conditions required for this observation, certainly not possible from our light-polluted city-skies today. It also suggests good seeing conditions, similar to that commonly found in the arid areas where the /Xam lived.

Conclusion

The explanation for naked-eye observations of one, and possibly two of Jupiter's Galilean satellites for the Dawn's

Heart Star thus seems plausible, but assumes that a fair percentage of the /Xam had above-average eyesight or they, knowingly or unknowingly, developed a technique to enable them to see this. Since they had this unique legend, directly connected to a particular observation, it gave every /Xam a perfect motive to seriously attempt to observe the Dawn's Heart Star for themselves. The semi-desert conditions where they lived definitely provided optimal conditions for this rare observation.

If the present hypothesis is correct, it explains why the /Xam ignored Venus to be the Dawn's Heart since it does not occasionally sport any "children" the way Jupiter does. This theory is further backed by some linguistic support.

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Advice to Contributors

The purpose of this publication is to provide a forum for communication among space scientists in Africa. In addition to recording the activities of the Working Group, *African Skies/Cieux Africains* features articles on current research developments in the space sciences in Africa as well as educational material intended for general readers and science educators. Contributions relevant to these themes will be considered for publication in *African Skies/Cieux Africains*. Shorter communications will be considered for publication in the News, Letters or Announcements sections of *African Skies/Cieux Africains*.

The official languages of *African Skies/Cieux Africains* are English and French. Contributions in either of these languages are acceptable. Authors fluent in both these languages are encouraged also to provide a translated one-page summary of their contribution. Papers in Arabic are also acceptable provided that (i) they are accompanied by a summary in one of the two official languages and (ii) a camera-ready copy of the Arabic text is submitted.

Contributions may be submitted by electronic mail, fax, or post to the address inside the front cover. Line drawings and photographs may be submitted for publication. Where possible, electronic copies of illustrations should also be submitted. Line drawings submitted electronically should preferably be in PostScript format. Photographs or other images should be scanned at the highest possible resolution to produce images in a common graphics image format.

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