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monthly notes of the astronomical society of southern africa

Vol 71 Nos 5 & 6 June 2012

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monthly notes of the astronomical society of southern africa

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Vol 71 Nos 7 & 8 (Aug 2012 issue), 01 Jul 2012
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SKA Announcement

South Africa gets the majority share of the SKA with the lion's share of the dishes and dense aperture array destined for the Northern Cape Province. Some dishes and the low-frequency array will be built in Western Australia.

Picture credit: Jive Media and SKA South Africa

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Monthly Notes of the Astronomical Society of Southern Africa
Vol 71 Nos 5 & 6 June 2012

assa news

Annual Report of the Comet and Meteor Section for 2011

T P Cooper, Director

Summary of observed meteor showers

Observer (no. of showers observed)	Showers Observed and duration	Total Time hrs
Mary Fanner (2)	Gamma Normids (7.4), delta Pavonids (5.0)	12.4
Tim Cooper (2)	Eta Aquariids (2.0), alpha Circinids (4.2)	6.2
Tony Jones (1)	Alpha Centaurids (5.0)	5.0
Karen Koch (1)	Alpha Centaurids (4.8)	4.8
Total		**28.4**

Five meteor showers were observed by four individuals totalling 28.4 hours observations.

Notes on some specific showers observed:

Alpha Centaurids – the shower was observed by Karen Koch and Tony Jones

Gamma Normids – observed by Mary Fanner, who found peak activity of nine gamma Normids in 1.9 hours observation with LM=5.5 on the night of March 13/14.

Delta Pavonids – observed by Mary Fanner seeing 11 shower members in 5.0 hours under LM=5.3 on the nights of April 4/5 and 5/6.

Eta Aquariids – Tim Cooper managed observations on the only clear morning, that of May 4, seeing 13 eta Aquariids in 2.0 hours with LM=5.4.

Alpha Circinids – a possible repeat outburst of this shower, observed in 1977, was predicted by Peter Jenniskens. Tim Cooper detected no shower members amongst 22 meteors in 4.2 hours observation.

Summary of observed Fireballs

2011 saw a total of eight fireball reports. The full details have been submitted for publication in *MNASSA* as a separate article. The observed events are summarised in Table 1.

Summary of observed Comets:

Five comets were observed in 2011 by four individuals as shown in Table 2.

C/2009 F4 McNaught – imaged by Tim Cooper

Table 1

Date, 2011	Time, UT	Observer	Location	V mag
May 6	22h31	Simon Walsh and others	Waterberg, Limpopo	-5
July 20	16h28	Louis Piovesan	Estcourt, KZN	-5
August 18	16h25	Sarah Coronaios	Makhado, Limpopo	-7
August 19	19h07	Lourens van Niekerk and Andrew Morgan	Makhado and Tuli Wilderness Area	> -5
August 23	20h15	Peter Herbert	Seapoint, W Cape	> -3
August 27	04h00	Laurence Matthews	Barrydale, S Cape	-4
September 23	17h13	Constant Volschenk	Observatory, Gauteng	-3
October 21	17h15	Jessy de Kock and Brandon Talbot	Peninsula, W Cape	-5

Table 2

ICQ Observer Code	C/2009 F4	C/2006 S3	C/2009 P1	213P	C/2011 W3
BEG01			●		●
COO02	●	●	●	●	●
STR03			●		
WAKxx			●		
KORxx			●		●
TOUxx			●		

Key to observers in Table:

BEG01 = Mike Begbie
STR03 = Magda Streicher
KORxx = Kos Coronaios
COO02 = Tim Cooper
WAKxx = Nigel Wakefield
TOUxx = Oleg Toumilovic

C/2006 S3 LONEOS – imaged by Tim Cooper

C/2009 P1 Garradd – was well observed by Magda Streicher, Nigel Wakefield, Mike Begbie and Tim Cooper, photographed by Kos Coronaios and Oleg Toumilovic, sketched by Magda Stricher and CCD imaged by Tim Cooper.

213P van Ness – was imaged by Tim Cooper

C/2011 W3 Lovejoy – observed by Mike Begbie and Tim Cooper, photographed by Kos Coronaios

Summary of Asteroid observations

The following asteroidal occultation events were attempted:

TYC 1275-01666-1 by (559) Nanon on 2011 March 16 – cloud reported by Nigel Wakefield.

TYC 0807-00901-1 by (7) Iris on 2011 April 25 – cloud reported by Nigel Wakefield and Tim Cooper

All observers of comets, asteroids and meteors, are heartily thanked for their contributions. ☆

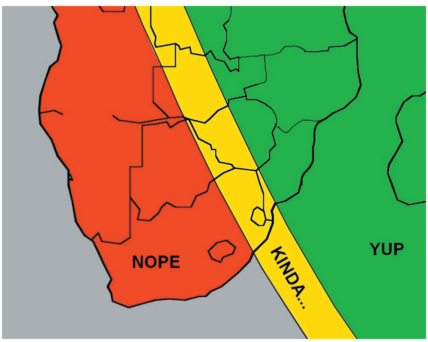
Transit of Venus from South Africa in 2012

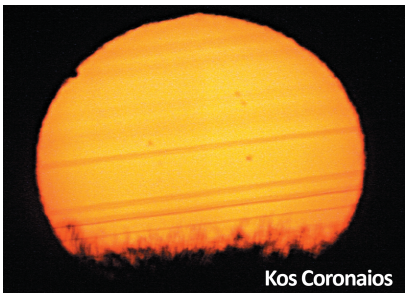
Case Rijsdijk

Transits of Venus are rare events, at best two per lifetime! Only seven of these rare events have been witnessed since the invention of the telescope. The previous Transit of Venus took place on 8 June, 2004, (see *MNASSA* Vol. 63, Nos 7 & 8, August 2004) which was preceded by the pair of appearances on 9 December 1874 and 6 December 1882. The next pair will occur on 10-11 December 2117, and in December 2125.

The Transit map clearly shows the marginal visibility from South Africa, but some of our members did manage to get some sort of image at sunrise on 6 June.

Liezl Botha managed to photograph it from Umdloti beach in Durban. It is a is truly amazing image as the Sun was below the horizon, but atmospheric refraction allowed her to capture a part of Venus' disk as it left the Sun's disk (see upper left). Compare this with Kos Coronaios' image taken from just south of Louis Trichardt as the Sun was rising. Again Venus can just be seen in the upper left of the solar disk on the way out and any chance of timing the internal egression and possibly capturing the 'Black Drop Effect' had gone. As Kos Coronaios commented, "The external egression could hardly be seen. Timing an event such as this with the solar disk only a couple of degrees above the horizon, atmospheric refraction, turbulence from the Earth's atmosphere as well as imperfections in the viewing apparatus all play a massive role, making it just about impossible". ☆





Africa celebrates SKA bid outcome

"We have always said that we are ready to host the SKA, and the world has listened to us," Ms Naledi Pandor, South Africa's Minister of Science and Technology said at a crowded media briefing on 25 May 2012 in Pretoria. Earlier that day the SKA Organisation announced that a majority share of the iconic SKA telescope would be built in South Africa, with the lion's share of the dishes and dense aperture array destined for the Northern Cape Province. Some dishes and the low-frequency array will be built in Western Australia.

"I am ecstatic! I'm happy for our scientists, I'm happy for our country, I'm happy for Africa!" Minister Pandor added. "We've done it! Who would have thought?"

This announcement coincided with the celebration of Africa Day. The African SKA site proposal had been endorsed by the African Union, both in 2010 and earlier this year. In a follow-up statement President Jacob Zuma added "South Africa is confident that the country will deliver on the expectations of the continent and world".

"We've been waiting for this decision for a very long time - it has been a long, hard road at times," said Prof Justin Jonas, Associate Director: Science and Engineering, SKA South Africa. "I think that this is an excellent outcome for the global SKA project, and now we can move into the really exciting phase - the detailed design and building of the SKA."

Prof Jonas, who is also at the Physics Department at Rhodes University, has been a key role player in developing and defending South Africa's SKA site bid since 2001. "The announcement that a major share of the gigantic SKA telescope will come to Africa is a fantastic outcome for the continent," he said. "It maximises South Africa's scientific and engineering contribution and means that all the work we've done up to now - and everything we do from here onwards - will contribute to the SKA."

Since the announcement that South Africa, along with its eight SKA partner countries in Africa, will host the entire mid-frequency dish array and dense aperture array of the iconic SKA telescope congratulatory messages have been pouring in from around the globe praising the hard work of the South African SKA team and the unwavering support for Africa's site bid from the South African government.

In their announcement, Members of the SKA Organisation acknowledged that Southern Africa was identified as the preferred site for the SKA by the independent SKA Site Advisory Committee, but added that the majority of the Members were in favour of a dual-site implementation model - an inclusive approach that was

Ms Naledi Pandor and Prof Justin Jonas.

deemed to be scientifically justified, as well as technically and financially viable.

"I always knew that our bid was very competitive. After we were shortlisted for hosting the SKA in 2006, we worked even harder to fine-tune our site bid and we presented an exceptionally viable and robust implementation plan for the SKA," Prof Jonas added. "We chose our site very carefully - remote enough to do the science, but not so remote that infrastructure development and operations becomes too difficult and too expensive. These were deliberate and calculated decisions based on thorough analysis of the requirements of the SKA - and it paid off!"

Professor Jonas is very excited about the implications of the SKA site decision for the role that South Africa's MeerKAT telescope will play in the future of the SKA. "The decision recognises MeerKAT as a key instrument that will make up one quarter of SKA Phase 1 mid-frequency array, and the science planned for SKA Phase 1 is very similar to the MeerKAT science case - just much more ambitious," he explains. "Our researchers and students who participate in the MeerKAT surveys have a huge advantage. They are well placed to enter SKA Phase 1. They have the opportunity to become science leaders in future SKA projects."

Up to 2016 South Africa will be constructing the 64 MeerKAT dishes in the Karoo and construction on 190 SKA Phase 1 dishes should start more or less when MeerKAT is complete. "The design of the SKA dishes is not yet final, but they should look similar to the Gregorian-offset dish design chosen for MeerKAT," Prof Jonas expects.

The next step for the SKA is a detailed design and pre-construction phase (2013 - 2015) followed by the construction of SKA Phase 1 - making up about 10% of the total instrument. Scientists should be able to use SKA Phase 1 for research by 2020. By that time construction on SKA Phase 2 should be underway (2018 - 2023) with full science operations commencing by 2024. ☆

Q & A - SKA site bid announcement

Justin Jonas

On 25 May 2012 the Members of the SKA Organisation announced that the SKA telescope would be split over Africa and Australia, with a major share of the telescope destined to be built in South Africa. Prof Justin Jonas, Associate Director: Science and Engineering at SKA South Africa answers some FAQs regarding the outcome of the SKA site bid and the future of the SKA.

How important is the SKA site bid outcome for South Africa? What does it mean for the country?

This is a very significant moment for South Africa, and Africa as a whole. It is also an important milestone in the international SKA project - the overall winner here is global science. For South Africa and our African partner countries this represents a new era, where Africa is seen as a science destination and takes its place as an equal peer in global science.

What do you think differentiated South Africa's bid from Australia?

The higher elevation of the South African site (1 000 m) is an advantage for the mid-frequency telescope, hence the allocation of this segment of the SKA to South Africa. The SKA Site Advisory Committee (SSAC) report can be found at www.skatelescope.org

Did the Astronomy Geographic Advantage (AGA) play a critical role is South Africa's successful bid for the SKA?

The AGA act provides protection for all astronomy activities within designated areas within the Northern Cape Province. It provides long-term protection of the radio spectrum in these areas, which is critical for the SKA to achieve its scientific goals. The AGA act was an important factor in South African SKA proposal.

How will the SKA be split between Africa and Australia? Is this feasible, given the distance between the two continents?

The SKA consists of two quite distinct components: one working at low frequencies and one working at mid frequencies. The two components use very different antenna technologies and operate independently. For this reason it is quite easy to separate the SKA into these two components, and build them on separate sites. Even if the SKA had been allocated to one country the two components would have been separated by quite a large distance.

What are the potential advantages and disadvantages of a dual site?

Firstly, there is no detriment to the science, and for Phase 1 there may even be advantages because of the use of existing investments at both sites. Management will be slightly more complicated, but the SKA Organisation is already distributed across many countries. The implementation cost will inevitably be higher because of some duplication of infrastructure and differential construction and operations costs between the countries, but this may be offset by greater participation and hence Membership contributions.

How will be components of the SKA be split across both continents?

SKA **Phase 1** (about 10% of the total SKA)

South Africa: South Africa's precursor array - the 64-dish MeerKAT telescope - will be integrated into Phase 1. An additional 190 mid-frequency dish-shaped antennas, each about 15 m high will be built.

Australia: Australia's 36-dish SKA Pathfinder (ASKAP) will be integrated into Phase 1. An additional 60 mid-frequency dish-shaped antennas, each about 15 m high, will be built, as well as a large number of small, low-frequency antennas - each about 1,5 m high.

SKA Phase 2

South Africa & African partners: Telescope will extend to long baselines of 3 000 km or more. A total of about three thousand mid-frequency dishes, with the highest concentration in the Northern Cape, South Africa, but some dishes in Namibia, Botswana, Zambia, Mozambique, Kenya, Ghana, Madagascar and Mauritius. In addition, a large number of flat mid-frequency antennas, each about 60 m in diameter (number to be determined).

Australia: Telescope extends over a baseline of 200 km. Up to 10 times more of the low-frequency antennas - each about 1.5 m high.

What about the cost? How much will each contribute? Will the cost of building the telescope increase due to the split?

Capital and running costs for the SKA will come from contributions from all of the Members of the SKA Organisation. The split in costs will depend on the number of Members, currently eight, that join the Organisation. In the SKA Phase 1 era they may be a saving on costs because the split site scenario allows the use of existing infrastructure on both sites. In the Phase 2 era there will be a need to build duplicate infrastructure, but the cost of this has not yet been determined with any accuracy. The increase is expected to be a relatively small fraction of the total cost.

What are your plans for the SKA site in South Africa? What will it include?

Currently the South African SKA site

is being developed for the MeerKAT precursor telescope. The infrastructure that is already developed, and will be developed over the next few years, will be used for both the MeerKAT and SKA Phase 1. This infrastructure includes electric power from the national grid, data connections to major academic networks, and buildings to support the construction and operation of MeerKAT and the SKA.

What role do the international partners have in the project – how do they contribute? What kind of support are you looking for from the international community?

The SKA is a global project and depends fundamentally on support from all of the Members of the SKA Organisation. The SKA will not only consist of the antennas to the two sites, but very importantly consists of a distributed network of staff, institutions, data networks and computing facilities located in the Member countries. Capital and operations costs will be covered by contributions from the Members.

Who is now going to lead the SKA project?

The SKA is a global project and it will be managed by the SKA Organisation which is a company registered in the UK. All of the Members of the Organisation will participate in the management, development and construction.

What is the budget for the SKA? How much will South Africa be putting towards it, and how will project financing be divided amongst the countries participating?

The current estimated capital cost of the SKA is 1.5 billion euros. The contributions from the Members are yet to be negotiated, and will depend on the number of new countries that become Members of the SKA Organisation.

Current Members of the SKA Organisation (May 2012):

* Australia: Department of Innovation, Industry, Science and Research
* Canada: National Research Council
* China: National Astronomical Observatories, Chinese Academy of Sciences
* Italy: National Institute for Astrophysics
* New Zealand: Ministry of Economic Development
* Republic of South Africa: National Research Foundation
* The Netherlands: Netherlands Organisation for Scientific Research
* United Kingdom: Science and Technology Facilities Council

What kind of impact will the SKA have on the development of science and technology in Africa?

The SKA has already had an impact through the MeerKAT project and the human capital development project that is managed by the SKA South Africa project office. The MeerKAT has provided African academia and industry with challenges that have improved their competitiveness, and the human capital programme has increased the numbers of students taking degrees up to the PhD level in physics, mathematics and engineering. Being much larger, the SKA will take this to the next level.

What kind of experience does South Africa have that it can apply to the SKA? Is it equipped to handle such a large, high-profile and high-tech research project?

South African industry has a long and excellent track record in managing and executing large projects, both locally and abroad. Sasol is perhaps a good example of this, but there are many others in the mining, defence, energy, construction and manufacturing sectors.

Does the SKA project create any specific opportunities for increased collaboration with the other BRICS countries?

China is already a Member of the SKA Organisation, and India has a long involvement in the SKA and will likely become a Member in the future. Russia and Brazil have both shown interest in the SKA, and may join at a later date. We are currently working very closely with our Indian colleagues of high performance data process and computing systems, and have engaged with Chinese industry with regard to the construction of dishes.

What is so special about the Karoo region? Why build the SKA there?

It is a radio quiet region, being in a remote area with sparse population and no economic activity other than low density farming. It is also a dry, high plateau providing good atmospheric and tropospheric conditions for mid-frequency observations. Although it is remote, it is well serviced with basic infrastructure such as utility grid power and roads.

What makes the SKA different from other radio telescopes?

The SKA will be about 50 times more sensitive than any other existing radio telescope. It is not fundamentally different from existing instruments, but it will make use of the most advanced technologies available to provide the most favourable cost/performance ratio.

What will be the main research areas of the SKA?

The SKA science objectives are outlined at www.skatelescope.org/the-science/. They key science programmes are all transformational in that they will provide answers to fundamental questions in physics, astronomy and cosmology. It will focus on addressing questions that can only be answered using a radio telescope. Scientists expect that the SKA will make new discoveries about the universe that we had not imagined.

What will SKA actually look like?

The SKA will consist of thousands of different types of antennae spread out over large areas. Some will be shaped like dishes, while others will look like flat tiles and TV antennas. Artist's impressions of what the dishes will look like are available at www.skatelescope.org/media-outreach/images (www.skatelescope.org/media-outreach/images/).

Construction of the telescope is set to begin in 2016. What preparations need to be made in the next four years?

The next step for the SKA is a detailed design and pre-construction phase (2013 - 2015) followed by the construction of SKA Phase 1 - making up about 10% of the total instrument. Scientists should be able to use SKA Phase 1 for research by 2020. By that time construction on SKA Phase 2 should be underway (2018 - 2023) with full science operations commencing by 2024.

What is the life expectancy of the SKA?

At least 50 years.

Press releases and statements from SKA South Africa www.ska.ac.za/media/releases.php
Photos www.ska.ac.za/media/visuals.php
MeerKAT www.ska.ac.za/meerkat/index.php
SKA international - photos, videos, artist's impressions www.skatelescope.org ☆

NSTF Award for Dr Amanda Weltman

Congratulations to Dr Amanda Weltman on her NSTF-BHP Billiton Award, which she received on Thursday, 21 June at the Annual NSTF Awards Dinner. She received the TW Kambule Award as an Emerging Researcher for an outstanding contribution to SETI through Research and its Outputs – over a period of up to six years after award of a PhD or equivalent in research. The award was sponsored by the NRF.

Her award was for the development of the Chameleon Mechanism, a novel theory which has provided a locally testable theory explaining the mysterious force causing the universe to accelerate – so-called Dark Energy. This theory suggests the existence of 'chameleon particles' which change their mass depending on their surroundings.

Last year, on 27 September 2011, Amanda was awarded the Royal Society of South Africa's Meiring Naude Medal during the Societie's Annual Dinner. And earlier, in 2009, she was the recipient of the "Best emerging young scientist" award in the DST's South African Women in Science Awards. ☆

Early Days of Satellite Tracking in South Africa

Greg Roberts *grr@telkomsa.net*

Prolegomena

Putting a satellite in orbit is only half the job. For the satellite to be of any use it is necessary to recover information from the satellite which means one needs to know where the satellite is at any instance. This is known as satellite tracking and can be done in various ways.

If the satellite is carrying an active payload it will use radio transmissions to beam data to suitably equipped receiving stations. However, the majority of objects that achieve orbit are passive – i.e. they do not carry radio transmitters which means they have to be tracked by other means. In the first few decades of the Space Age this was achieved by optical methods whereby the satellite reflected sunlight and could be seen moving against the backdrop of the more distant stars. Using these stars as a reference framework, and knowing the observation time to a high degree of accuracy, it is possible to get positional data in the form of Right Ascension/ Declination or azimuth/elevation as a function of time. With suitable software it is possible to compute an accurate representation of the satellites orbit which allows one to predict where the satellite will be at some future time.

South Africa, on account of its favourable geographical position, has always been in the position to play a major role in the early stages of missions. In most cases South Africa was the first major land mass over which a newly launched satellite would pass if launched from the United States. It was therefore natural that various tracking facilities would be installed in South Africa for this purpose.

As an avid amateur satellite tracker since 1957, these tracking stations were my idea of heaven! During Easter of 1966 myself and a colleague, Arthur Arnold (1940-2012), visited several of these facilities where I took a fair number of photographs when allowed. Since these show part of the history of satellite tracking in South Africa, I have been persuaded that it would be of historical value if this was placed on record. Several articles on this subject will thus be prepared, covering the following facilities:

- The Baker-Nunn camera (BNC) at Olifantsfontein
- The French tracking station (CNES) at Paardefontein
- The STADAN/MINITRACK facility at Hartebeesthoek
- Amateur satellite tracking - MOONWATCH and the Durban Satellite Tracking Station

Editor's Note *– In the course of this year and next, MNASSA will publish each of them, so as to have a complete record of this activity.*

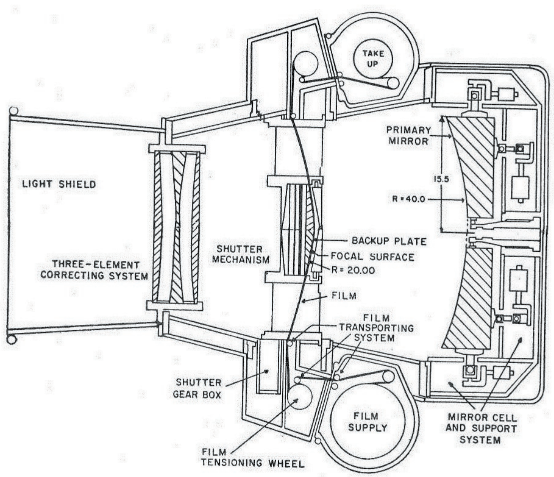
The Baker-Nunn Camera (BNC)

To give an idea of the technology of the time and how problems were solved, it is of interest to give some details of what the BNC was and how it was operated.

The BNC was designed by Dr James G Baker, who was considered to be the world's leading authority on optical systems for astronomical cameras, under the direction of Dr Fred L Whipple specifically for satellite observations. It is a modified Super-Schmidt camera operating at F/1 with a focal length of 500 mm and 500 mm aperture. For its time it was a formidable project as the largest Schmidt camera operating at F/1 till then was only 200 mm in diameter and had a single corrector element. Baker completed the optical design in July 1956 and in November 1956 a contract was signed with Perkin-Elmer Corporation of Norwalk, Connecticut who were the only firm to bid for the contract to supply 12 cameras. It turned out to be a lot more complicated and expensive than originally anticipated!

The Pyrex primary mirror has a spherical curve and is used in conjunction with a corrector lens which is made of three elements of which two are positive and the other negative. The focal surface is approximately spherical and photographic film is stretched under tension over a specially designed Pyrex spherical surface. Along the tracking axis the field of view is 30° and perpendicular to this it is 5°.

Eastman Kodak supplied the initial 55 mm wide ID-2 photographic film used and a contract for 40 000 feet of film was placed. As photographic emulsions improved other emulsions were used. With an image scale of approximately 406 arc sec/mm, the camera could photograph a basketball at a distance of 1 600 km or reach around magnitude +14 with a 20 second exposure.



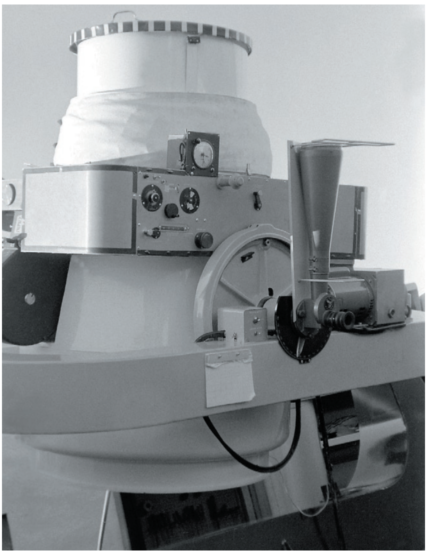
Optical/mechanical layout of the Baker-Nunn camera – from Cospar Information Bulletin #25, Oct 1965: "Manual for the Establishment of an Optical Tracking Station".

After consultations between Whipple and Dr J.Allen Hynek and Joseph Nunn the mount was decided upon and the contract for the camera mount was awarded to Boller and Chivens, Inc. of South Pasadena, California in October 1956.

The BNC could operate in three modes:

1. The camera remains stationary and the satellite leaves a track on the recording film. This was generally used when the satellite was as bright as magnitude +7. As the satellite trails along the film the image is interrupted into six segments by a rotating barrel shutter and the time of the central (third) break was recorded.
2. The camera tracks along a great circle arc that approximates the apparent motion of the satellite so that it appeared stellar-like and the star images as segmented trails being chopped with the barrel shutter so as to provide time identifiable points, and
3. The camera executes an oscillating movement so that the camera could alternate between being the first and second modes.

The camera was mounted on a gimbal triaxial mount which permits the long axis of the film to be orientated along the expected path of the satellite. A special prediction program was required to take into account the three axis system. The camera could move along a great circle track with an angular velocity of 0 to 2 deg/sec (7 000 seconds of arc per second of time) which is equivalent to crossing the sky from horizon to horizon, through the zenith, in 93 seconds.



Baker-Nunn camera pointing to the zenith inside its triaxial mount with a 5-inch Apogee finder telescope mounted on the side. The top of camera has a thermal blanket wrapped around it. Photo: Greg Roberts

Baker-Nunn camera shortly after installation. Note the Norrman clock on the left hand side. Photo: Peter Smits

The total exposure time of each frame could be set to 0.2, 0.4, 0.8, 1.6 or 3.2 seconds and the value chosen depended on the apparent angular velocity of the satellite and its brightness. A number of successive exposures (usually from 4 to 10 with an average number of 7) were taken. The interval between exposures were five times the selected exposure period of an individual frame.

Using standard astrometric practices, satellite positions were determined using the stellar background. Star positions were defined by the SAO Star Catalogue which was especially compiled for satellite tracking in 1966. It was a combination of several star catalogues so the accuracy was not consistent. It contained 258 996 stars with epoch B1950. This catalogue is still in use today although the current version has many errors corrected and is now for epoch 2000. The average positional accuracy of observations was about 4 arc seconds with a timing accuracy of 1 ms or better.

The manufacture of these cameras was regarded as one of the finest achievements of American industry. Twelve were constructed, almost simultaneously, without the construction of a prototype. The first one completed had to work and no major changes could be made.

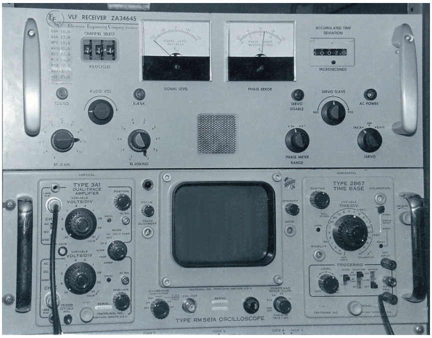
Time Determination

Originally accurate time was provided by a Norrman crystal clock constructed by Norrman Labs in Williams Bay, Wisconsin.

Norrman crystal clock. The cathode ray tube used to give a high resolution time display is obvious. Photo: Greg Roberts

The original high frequency of the crystal oscillator was divided into lower frequencies, the most important one being 60 Hz. This drove a rotating disk at 1 rps from a 60 hertz synchronous motor to give the time presentation. In addition an alternating current of 100 Hz was used to generate a circular sweep on an oscilloscope. The electronic beam rotated at 1 rev per 10 ms and the oscilloscope electron beam was pulsed on and off in synchronization with the time and electronic markers indicated intervals of 1 and 0.1 ms.

The controlled 60 hertz from the time unit was also used to run the slave camera in



Part of the EECo time system which used VLF time stations – in this photo the receiver is set on 21.4 kilocycles. Photo: Greg Roberts

the camera which could be synchronized to the master clock to within 0.1 ms. The same frequency (boosted by a power amplifier) was used to run the motors for the camera shutter and the tracking motion of the camera.

Before 1965-1966 the Norrman crystal clocks used were checked daily against WWVH from Greenbelt, Maryland, USA on high frequency (HF) using 10, 15 and 20 MHz. Typical accuracy was only of the order of 1.5 to 2 ms of time as a result of the large uncertainties in the propagation times of HF radio signals bouncing off the ionosphere.

During the period Jan-March 1963 the prototype of a more accurate time system, developed by Electronics Engineering Company (EECo), was tested at Olifantsfontein. It received signals from all the major Very Low Frequency (VLF) stations transmitting time signals. These tests established the feasibility of operating the timing system indefinitely in synchronism with a VLF time standard transmission.

In 1965 the timing system was replaced by the more accurate/reliable system built by EECo. A portable quartz clock accurate to 5 parts in 10^{10} visited each BNC station about twice a year to check the time system and the VLF signals were monitored to check the clock rates. This improved the timing accuracy to 0.3 ms or better.

When the NASA laser tracking equipment was installed around 1974 the timing accuracy improved to within 0.1 ms as the master clocks at all laser stations (which included South Africa) were controlled by a rubidium standard.

Orbit Computations

Prof Leland Cunningham of the University of California was employed as a consultant and developed a theory to deal with satellite orbits based on the Earth's gravity. This theory was programmed to run on an IBM-704 electronic computer at the Smithsonian Astrophysical Observatory (SAO).

Initially orbital predictions were done at SAO and transmitted by radio teletype. Subsequent to this several improvements were made and by mid 1974 it was decided to install minicomputers at all sites. The computer chosen was a DATA GENERAL minicomputer with a thousand 16-bit-word memory and a floating point processor. Data input/output was provided by a teletype, a high speed paper tape reader and punch as well as a cathode-ray-tube display and a three drive Linc tape magnetic storage system.

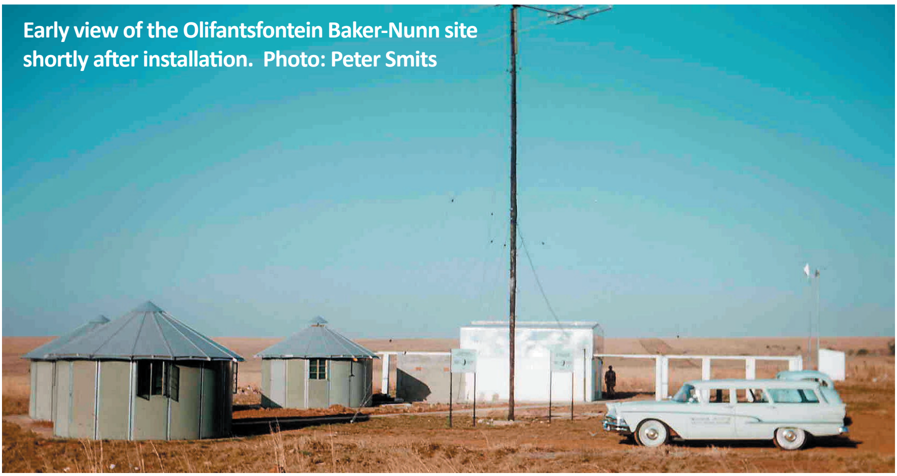
Olifantsfontein (Station 9002)

Once the camera and timing system had been decided upon it was now necessary to decide where to place the BNCs. Sites were chosen in Spain (San Fernando), South Africa (Olifantsfontein), Iran (Shiraz), India (Naini Tal), Japan(Tokyo), Australia (Woomera), Hawaii (Maui), United States (Organ Pass and Jupiter), Curacao, Peru (Arequipa) and Argentina (Villa Dolores).

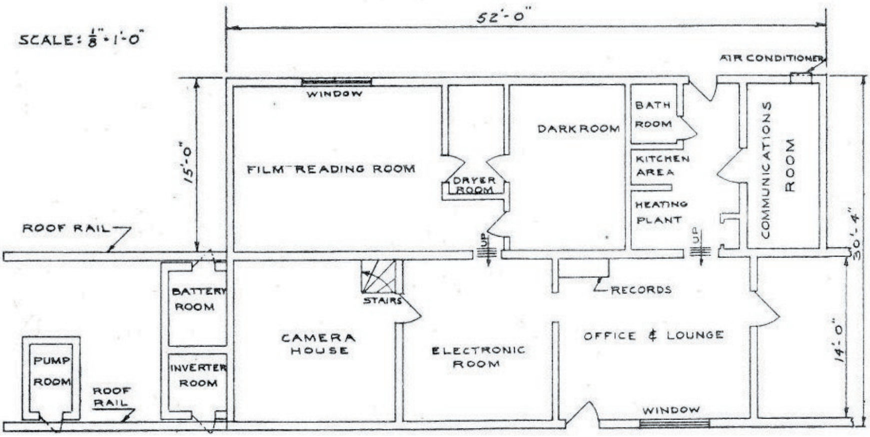
In August of 1956 Dr Donald Menzel of Harvard College Observatory met with C.G.Hide of the Council for Scientific and Industrial Research (CSIR) of South Africa to arrange for the establishment of a station in South Africa. It was decided to set up the camera at Olifantsfontein (meaning elephants fountain or drinking pool) some 40 km from Johannesburg and about halfway between Pretoria and Johannesburg. The reasons for this location were mainly because of easy access to a communication network as it was in the grounds belonging to the South African Post Office. In addition the reasonably good observing conditions of the Highveld and the proximity to a major airport favoured the location.

Later statistics covering a six year period proved this was the correct choice as during the winter months only about 20% of visible satellite passes were lost due to cloud cover with poor conditions in the summer months providing overall about 50% passes lost during 6 to 7 months of the year.

The geographical position of Station 9002 was: longitude east 28° 14′ 52.72″, latitude south 25° 57′ 39.30″, altitude 1 544 m.



Early view of the Olifantsfontein Baker-Nunn site shortly after installation. Photo: Peter Smits



Typical layout of a Class A Optical tracking Station – from Cospar Information Bulletin #25, Oct 1965: "Manual for the Establishment of an Optical Tracking Station".

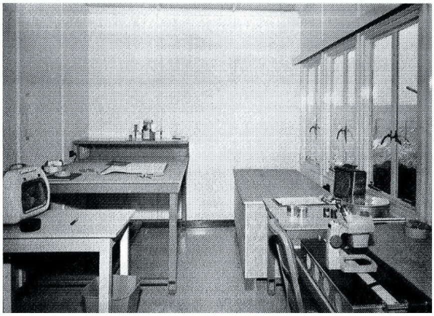
The South African National Committee for the International Geophysical Year (IGY) provided the initial buildings which were completed by November 1957. Except for the camera building the facilities consisted of 14-foot (~4 m) diameter prefabricated circular rondavels.

In September 1960 a country-to-country agreement was signed between the governments of the United States of America and South Africa naming NASA and the CSIR as cooperating agencies, specifying the Smithsonian Astrophysical Observatory installation of a BNC as one of the facilities in the cooperating program. This agreement remained in force until 13 September, 1975 and was not renewed.

Aerial view of the Olifantsfontein Baker-Nunn station after the new main building was constructed. Photo: Smithsonian Astrophysical Observatory.

George V.Barton, an amateur astronomer employed by SAO set-up the BNC – he had also installed the Las Cruces (New Mexico) and San Fernando (Spain) cameras. During the period January-June 1960 a new administration building was added to conform to the so called CLASS A tracking

Close up of the rondavels that were used before the new main building was erected. Photo: Greg Roberts



View of the film reduction room where the photographic film images were measured. Photo: Smithsonian Astrophysical Observatory.

station and the layout was similar to that shown in the diagram except that the camera was mounted in a shed separate from the building.

Robert Curry Cameron (1925-1972) was a professional astronomer who also discovered an asteroid (which he named after his wife Winifred). He was appointed the first station chief and the BNC was shipped to South Africa on 3 Feb 1958. Its first observation was of satellite 1958 Alpha Explorer 1 on 18 March 1958. When Cameron died at the age of 47 the crater CAMERON on the Moon was named after him.

A typical BNC station had an operating staff of five to seven people. They were expected to be able to perform any of the duties required, including making observations, processing and measuring images as well as some practical experience in maintaining the station mechanically and electrically. They had to undergo a rigorous interview to determine whether suitable for such a post. I had personal experience of this since I had applied for such a position at the station and had the interview during my visit to the Station during Easter 1966. I appear to have passed their requirements but ended up declining the offer as there was no long term security, no medical aid etc. It also meant relocation from Durban where I also had my girlfriend (who later became my wife).

Several station chiefs were appointed during the existence of the South African station. Some that have been identified are Robert Citron – I'm reasonably sure this was the person who interviewed me and he died as recently as February this year. Another one was C. Robert Bennett (known as Bob) who resigned as station manager on 30 September 1974. Other staff members identified were Werner Kirchof, L.H. Solomon and William Johnson.

The station remained in operation until the site was closed down and vacated at the end of 1975, thus ending 17 years of

Main building – Photo: Greg Roberts.
Note: Photos credited to SAO came from their Semi-Annual reports as found on the Internet. Photographs by Greg Roberts were taken Easter 1966. Photographs by Peter Smits – dates unknown.

successful satellite tracking. The camera was dismantled in September 1975 and the NASA laser unit was disassembled and moved to Orroral Valley in Australia. The BNC was loaned to the Canadian Forces on a long term loan and was moved to St.Margarets, New Brunswick, Canada in November 1975, together with the EECo clock. The local staff were paid off and by the end 1975 all SAO staff had left the site.

The physical plant was donated to the CSIR as well as several small pieces of equipment, whilst other equipment, including a station vehicle, air conditioner and generator were donated to Boyden Observatory. The obsolete Norrman clock was apparently donated to the Pretoria ASSA centre as I was subsequently approached by its chairman, Jan Stirling, asking if I was interested in having it. Due to logistics problems I had to decline the offer. It probably no longer exists.

The BNC became operational again on 31 August 1976 as part of the Canadian Space Detection Tracking System, working with the United States military Space Surveillance Network (SSN). The SSN was formerly known as NORAD (North American Radar Air Defence System) and tracked such satellites as MIDAS (Missile Defence Alarm System) and the DISCOVERY series of satellites. The latter returned photographic images of the Earth in recoverable capsules which were snatched in mid-air by aircraft trailing a net behind them. The station remained in operation until 1996 when it was closed down. The camera was subsequently used for scientific research.

It would appear that several variants of the initial 12 cameras were constructed. For example, three cameras were made for the United States Air Force and one for the United States Armed Forces BN Missile Re-entry Tracking project. Six cameras were employed in the early stages of the Ground Based Electro-Optical Deep Space Surveillance (GEODSS) program before being retired. These cameras were very similar to the twelve originally constructed and basically varied only in their mounting.

A brief internet search to try and determine what happened to the various cameras, was met with mixed success:

- The one at San Fernando in Spain is now the Fabra-ROA Baker-Nunn at Observatori Astronomic del Monsec in the Catalan Pre-Pyrenees. Here it is used for tracking space debri with a 4.4 degree square field of view and capable of reaching magnitude +20 with a 30 second exposure.
- The camera originally at Woomera was given to the Astronomy Research Group at the University of New South Wales where a new corrector plate was constructed and a CCD camera added. It is now operating as an Automated Patrol Telescope (APT) at Siding Spring Observatory in Australia.
- The camera that was in Arizona was donated to the National Air and Space Museum and apparently is still in storage.
- The camera in Ethiopia was abandoned – present whereabouts unknown.
- The cameras in India, Japan and Greece remained in their respective countries – current status unknown.
- The camera in Peru is now at Arequipa in an abandoned building.
- The one that was in Brazil was last seen rotting in the local docks.
- The University of Calgary, Alberta, Canada appears to have one – this might be the original Olifantsfontein camera?
- The one that was at Hawaii was dismantled for parts for the USAF cameras.
- A Baker-Nunn camera in California was recently given to amateurs.
- In 1966 Tim Puckett, a Georgian (USA) amateur astronomer, purchased three or four government surplus cameras which he planned to use for comet hunting. As recently as 2008 two were offered free by the Evergreen Aviation and Space Museum in McMinnville, Oregon (home of Howard Hughes' Spruce Goose) as they had three cameras that were donated to them by a donor in Corvallis, Oregon - (possibly the Tim Puckett cameras?). The proviso was that the new owner had to move the cameras from their present location and pay all expenses involved. I did not avail myself of this opportunity!

I would be very interested to receive any feedback / further information on any of these facilities to preserve an accurate record as possible for future generations.

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the radio MINITRACK satellite system. This error is still being perpetrated today, on the Internet-WIKI, for example. The Satellite Applications Centre (SAC) of the CSIR at Hartebeesthoek still had a MOTS camera as recent as last year.

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The Astrographic Telescope of the Royal Observatory, Cape

I.S. Glass, South African Astronomical Observatory

Introduction

The first photographically produced catalogue of stars, the *Cape Photographic Durchmusterung* (CPD), was the brainchild of David Gill, Her Majesty's Astronomer at the Cape in the years 1879-1907. It covered the whole sky south of 19 degrees south declination and included 454 875 stars. The CPD camera made use of a standard Dallmeyer portrait lens of 6 inches aperture and 54 inches focus, giving it a field of 6 degrees square.

Even while the CPD was progressing, the first international astronomical conference – the Astrographic Congress – was held in Paris in 1887 under the leadership of Admiral Mouchez, director of the Paris Observatory, and David Gill. Its aim was to promote a project called the *Carte du Ciel* ('Map of the Sky').

The *Carte du Ciel* and its telescopes

The *Carte du Ciel* was to be a much more ambitious sky survey than the CPD, involving as it did twelve observatories, each equipped with photographic refractors having the same aperture (13 in or 33 cm), field (2 degrees square) and focal length (3.43 m). Each participating observatory was assigned to cover a particular declination zone, the Cape's being -40° to -52°. Each photographic telescope was to have a guide telescope with an aperture of 10 inches (25.4 cm) diameter rigidly fixed to it.

Half of the Astrographic telescopes were made by the Grubb Company in Dublin. The others were mostly made in France where the brothers Henry had shown what was possible. Gill and Grubb corresponded extensively, covering all aspects of the design. The optics were something new for Grubb as, unlike the case for typical visual refractors where only the on-axis performance and achromatism had to be good, the new telescopes had the extra requirement of a large field. Grubb had difficulty in achieving good performance over the whole field. This is reflected in the fact that his lens designs for the early telescopes differed from those of the later ones (see Grubb, 1891).

Another requirement of photographic telescopes was that their drives should be extremely precise and steady so that guiding should not have to be done too often during the long exposures. To achieve this, Grubb used governor-controlled clockwork motors of a very heavy design. He also devised a scheme for synchronising the drive to the observatory time service by means of a phase-locked loop. Three contactor wheels on the final drive shaft were used to make comparisons with pulses generated by a pendulum swinging through a blob of mercury. Planetary gears could be engaged by electromagnets to speed up or slow down the drive as required (see Grubb 1888).

The RA drive was otherwise of typical Grubb design, making use of a precisely cut sector of a wormwheel instead of a complete wheel. This meant that the telescope had to be stopped every few hours; the sector was then unclamped from the polar axle and re-wound. The justification was that the declination axis could be much shorter than a large wormwheel would allow. The telescope was therefore less prone to oscillate or shake in the wind.

Construction

The construction of the telescope was sanctioned 30 Aug 1888 following the ap-

Fig. 1. (left) The pendulum that controlled the drive. Its tip passed through a blob of mercury to generate precise time pulses (see text).

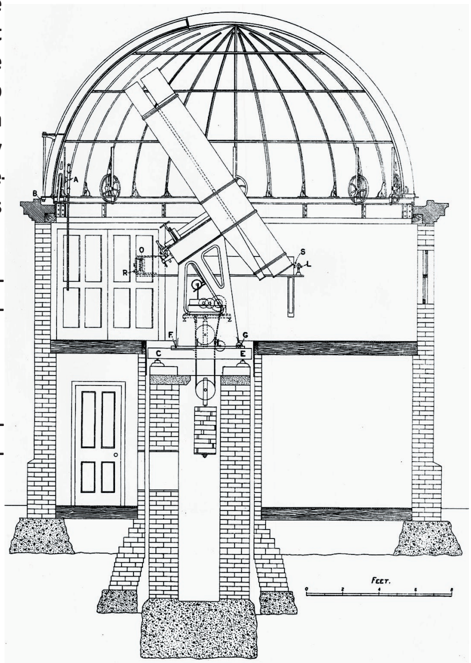

Fig.2. (right) Section of the Astrographic building and dome in Cape Town. The horizontal apparatus for imposing reseaus on the plates can be seen just behind the telescope at the level of the bottoms of the tubes.

plication of some political pressure and in the face of passive opposition from the then Astronomer Royal in England, William Christie (see Glass, 1997).

The building, shown in Fig. 2, contained downstairs a computing room, a developing room and a store room. Upstairs, there was a dark nook for handling plates and imposing a 'reseau' on them by projection. These reseaus were believed to improve the accuracy with which star positions could be measured but were later abandoned.

Fig. 3. The completed Astrographic telescope photographed around 1900. The large circular object inside the pier contained the governor for the clockwork motor.

The mechanical parts arrived in the Cape on 11 June 1890 and the objective of the guide telescope a few weeks later. Gill had to shorten the tube by about 3 cm to get it to focus! The photographic objective arrived later and was mounted by 12 August. Gill was unhappy with both lenses and returned them to Dublin for further figuring in January 1891. It was also necessary to alter the plateholder arrangements, to provide springs to keep the lenses centred in their cells and to make other small improvements. Grubb worked on the lenses until September 1891. He blamed their initial defects on sabotage!

The photographic lens as finally received still shows a slight elongation of images situated near the plate corners and the focal plane is slightly curved, requiring that focusing be done 4 or 5 cm from the plate centre for best overall results.

The Period of Astrometric Programmes

Only on 29 July 1892 did Gill begin the programme for which the telescope was designed. The Cape Zone required 1 632 plates, which were taken in duplicate. The publication of the Cape Astrographic Zone (CAZ) catalogue was achieved in 1923 under Gill's successor, S.S. Hough. It contained 20 843 stars of CPD mag 9.0 and brighter.

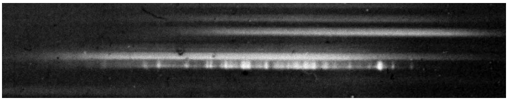

Fig. 4. One of several spectra taken in 1897 by McClean with his objective prism attached to the Astrographic Refractor in Cape Town. This is one of the earliest photographic spectra of the unusual massive interacting binary η Carinae (Photo courtesy of M. Kaye, Norman Lockyer Observatory, Exeter, UK).

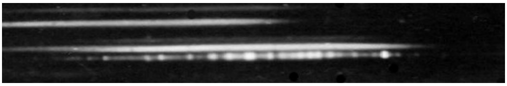

Fig. 5. Another spectrum of η Car taken in 1899 by Gill using the McClean 24-inch telescope and objective prism. The bright line on the right is Hβ. Shorter wavelengths are to the left (See Gill 1900).

Several other, smaller, programmes were conducted, sometimes simultaneously with the CAZ. One of the most interesting early applications of the telescope was during a visit in 1897 by Frank McClean, the famous English amateur who donated the McClean telescope. He mounted a 12-inch objective prism of 20 degrees angle in front of the photographic objective and made a spectrographic survey of all southern stars brighter than mag 3.5. In the course of this he discovered that oxygen is present in certain types of stars (McClean 1897). An example of a spectrum of η Carinae is shown in Fig. 4.

A series of photographs of Jupiter's satellites was taken in 1902-1905 for Willem De Sitter (later a famous cosmologist who suggested the possibility of an expanding universe based on his solution of Einstein's equations of General Relativity).

In 1910 the photoheliograph was mounted on the side of the Astrographic. The use of this telescope twice daily to take photographs of the Sun cannot have been good for nighttime work because of the heating that must have occurred.

From about 1917 Wood of the Union Observatory repeated the CAZ survey. The images were blinked against the first series by R.T.A. Innes.

Other early projects included selected areas for deeper study, polar areas, comets, variable stars and parallax plates. The latter were taken around 1917 by J.G.E.G. Voûte, a Dutch volunteer who was working at the Cape and played a large part in determining the distance of Proxima Centauri, the nearest star, then recently discovered by R.T.A. Innes at the Union Observatory in Johannesburg.

The Cape Astrographic Zone was re-photographed on a number of occasions to look for proper motions. The earliest of these programmes seems to have been started in 1917 by H.E. Wood of the Union Observatory in Johannesburg, with the participation of J.K.E. Halm, Chief Assistant of the Royal Observatory. These were blinked by Innes against the original plates to find stars of large proper motion.

S.S. Hough died in 1923 after a long battle with cancer and was succeeded by Harold Spencer Jones who brought new energy to the Observatory.

Fig. 6. The 12-inch diameter objective prism of 20° angle used by F. McClean with the Astrographic Telescope during his work on Oxygen in stars in 1897. This prism is owned today by the Norman Lockyer Observatory in Exeter, UK (Photo courtesy of M. Kaye).

In the 1920s the main programme was a systematic repetition of the CAZ programme. Spencer Jones initiated this even before he had arrived at the Cape. It was completed only in 1928. The smaller programmes in the 1920s included the usual transient phenomena such as comets and novas. Some Kapteyn `Selected Areas' were observed for magnitudes and proper motions. These were parts of the sky selected for in-depth studies too intense to be extended to the whole sky. Kapteyn himself was a noted Dutch astronomer based in Groningen who had worked with Gill and was co-author of the CPD catalogue. The products were uniform series of photographic magnitudes and proper motions for the original 20 843 stars of the CAZ, published in 1936, and for 20 554 fainter ones published in 1941.

A programme on the Solar parallax (distance) through triangulation of Mars was carried out during the opposition of that planet in 1924. This was when Mars was on the opposite side of the earth from the Sun and thus at its nearest. This telescope was also used for the Eros programme of 1931 when that minor planet was also in opposition.

In 1929 the photoheliograph was removed and placed on a mount in the NW dome, where it still is. Some other overhauling of the telescope was also carried out.

After 1929 a camera known as the Wide Angle Lens (WAL), of 6 inches diameter and 80 inches focal length, with a field of 25 square degrees, was mounted and used to take plates for the Cape Photographic Catalogue (CPC50). This programme complemented the CAZ by photographing the parts of the southern sky south of -30° not already covered and also complemented the AGK2 project being carried out in the northern hemisphere. Over 68 000 stars were listed, with proper motions, magnitudes, colours and spectral types by the time it was finished in 1968.

The Photometric Period

The Royal Observatory became interested in precision measurement of the brightness of stars by means of photography during the Second World War, partly in collaboration with R. Redman who was then at the

Radcliffe Observatory in Pretoria. The technique they used was `Fabry Photometry'. Conventional photographic photometry depended on measuring the diameters of star images but Fabry photometry involved spreading out the starlight evenly by means of a lens placed close to the image and focusing the objective of the telescope onto the photographic plate. The density of the image on the photographic plate was afterwards measured with a microdensitometer. This gave a considerable improvement in accuracy, to the 1% to 3% level. Though now completely obsolete, Fabry photometry was in use until about 1951.

The Fabry photometer was the most frequently used accessory from about 1944. One of the aims was to obtain accurate comparison stars around the sky in the so-called 'E-Regions' which were conveniently high in the sky at our latitude. The later Nobel prizewinner Allan Cormack participated in this work in early 1945 as a vacation student!

By 1952 a photoelectric photometer was mounted on the Astrographic, though plates continued to be taken and the twin photometric lenses were also in use. The photometer probably used a RCA 931A photomultiplier. In 1962 this photometer was reconstructed to make use of an E.M.I. end-window photomultiplier.

R.V. Willstrop used the Astrographic to mount a narrow-band photometer around 1957 and again in 1967 used a 10-channel photometer.

A Markowitz dual-rate Moon Camera was used during the International Geophysical year 1957-8 as part of an international effort to re-define time in terms of the earth's orbital properties.

In the 1960s the telescope continued to be used for a variety of programmes, principally photometric ones. The 18-inch reflector that came into service in 1957 and the 40-inch telescope in 1964 caused some diminution of interest in the Astrographic since they as aluminised reflectors were much more suitable for U-band (ultraviolet) measurements than a refractor. This decade saw the completion of a programme to measure the southern stars of the *Bright Star Catalog* (referred to as HR stars).

During the next 25 years the use of the telescope declined. Only occasional programmes were mentioned in the Annual Reports. A programme of proper motions of the Sco OB1 Association is mentioned as having been conducted for Leiden in 1981. Otherwise, occasional photographs of comets were taken. An interesting use was to repeat a plate of the 30 Dor region of the Large Magellanic Cloud, showing SN1987A, the brightest supernova since the start of the 17th century.

Later history of telescope

In 1933 a system was installed to rewind the drive weight automatically.

In 1942, during the Second World War, this dome, with the others, was painted

Fig. 7. The Astrographic building and dome (May 2012), just after repainting and exterior renovation.

Refractor Mount (MRM) around 1964.

In 1952 it had become clear that the frequent re-setting of the telescope for photometry (every few minutes) had caused a lot of wear. The two-colour PE measurements were made with 4 min between stars of which 2 min were taken up by recording. In 1954 the weight-driven drive clock was removed and replaced by a synchronous electric motor. However, the planetary gearing system used for guiding and set speeds was retained. The telescope was rewired and the 10-inch guider serviced. In 1957 it was overhauled at Simonstown Dockyard and roller bearings were fitted to the Dec and RA axes.

dark green, presumably to make the Royal Observatory less of a landmark for possible bombing raids. In 1945 it was re-painted with aluminium paint.

In 1950, the panels of the dome were replaced with Masonite

In 1952 the Wide Angle Lens was moved to the McClean telescope, where it still is, though now called the 'Old Astrometric Camera'. Twin photometric cameras (5-inch, F/7) were mounted in its place and stayed there until moved to the Multiple

In 1995 the Astrographic tubes were removed and a 16-inch Parkes F/5 Newtonian was placed on the mount. This was used by Shigeru Matsumoto, a student of the University of Tokyo, with the `PANIC' PtSi infrared camera for a survey of the Galactic Bulge in the J and H infrared bands.

Now, in 2012, this venerable telescope has had the algae cleaned off its dome and the outside of the building re-painted. The Dent clock that once stood inside has been removed for safekeeping but the pendulum apparatus of the original phase-locked loop is still in place.

It is hoped that the currently unused Parkes telescope can be removed and the Astrographic tubes replaced in the near future while there are still people around who can remember how they were taken off!

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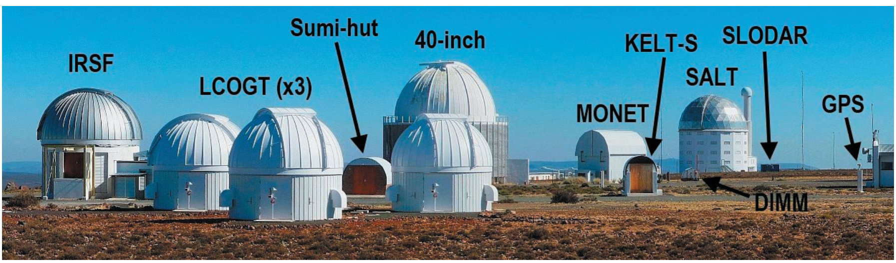
Geared to turn photons into paper

Willie Koorts

When visiting the Sutherland Observatory you are astounded by the sheer number of domes and hosted experiments populating the plateau today. The three domes present during the official opening of the Observatory on 15 March 1973 have since grown to 20. Although the number of hosted experiments have only increased from two to six, they got much more sophisticated. This article gives and overview of the facilities on the Sutherland hilltop today.

If we start with the three original domes which housed the 0.5-m (20-inch), 0.75-m

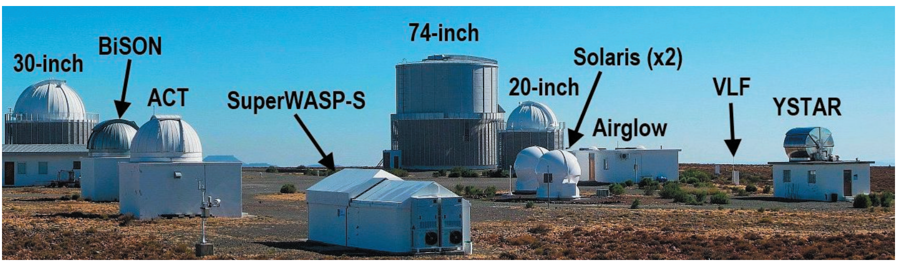


(30-inch) and 1-m (40-inch) telescopes respectively. The **20-inch** (as it is mostly still referred to), made by Boller & Chivens, was moved here from the Republic Observatory in Johannesburg where is was officially dedicated on 19 April 1968. The Republic Observatory closed down when the SAAO (South African Astronomical Observatory) formed. Only six of the 20 telescopes on the hilltop are manned of which the 20-inch is one. It is fitted with a dedicated photometer and is still well subscribed.

The date on the **30-inch** telescope's nameplate is 1974, indicating that it was the newest of the original three telescopes. The telescope was made by Grubb Parsons, England but its mounting is older, dating from 1964. The mounting was moved from the former Royal Observatory in Cape Town where it carried the MRM (Multiple Refractor Mount), three photographic refractors which could make simultaneous exposures in three colours. The 30-inch was mounted in the counterweight position. The MRM-tubes were removed in the early 1990s and replaced by a proper counterweight. After removal of the lenses, the tubes were donated to the Sutherland town where they are still on display in front of the Information Centre. The 30-inch is also manned and can be fitted with a suite of instruments.

The last of the original trio, the **40-inch** or 1-m was built by Grubb Parsons in 1962 and officially dedicated as the Elizabeth Telescope (after Queen Elizabeth) on 1 May 1964 at the Royal Observatory, Cape Town. It is also manned and is still in good demand with a suite of instruments available.

After the closure of the Radcliffe Observatory near Pretoria in 1974, the **1.9-m (74-inch)** Grubb Parsons reflector was moved to Sutherland. This is the oldest telescope



at SAAO, Sutherland, built in 1938, and has been kept competitive by constantly upgrading it with new technology. Together with its twin in Egypt (which has not been operational at times), they were the largest telescopes in Africa until SALT was opened in 2005. Quite a number of instruments are available for this telescope and it is fully subscribed by local and overseas observers alike.

The **IRSF** (Infrared Survey Facility), a joint project between The School of Science at the Nagoya University in Japan and SAAO was officially opened on 15 November 2000. The telescope, built by Nisimura, with its mirror diameter of 1.4m, is the third largest telescope on site, but its dome is only similar in size to the 30-inch (0.75m). The reason being its modern Alt-Az mounting and fast optics. Its dedicated instrument called SIRIUS (Simultaneous-3 colour InfraRed Imager for Unbiased Survey) observe objects simultaneously in three infrared wavelengths and can also be configured for polarimetery. It is mostly used by Japanese observers, but not exclusively. The main survey targets are the Magellanic Clouds and the Galactic Centre.

The last of the manned telescopes is **SALT** (Southern African Large Telescope). SALT was officially opened in November 2005. Its main mirror is 11m in diameter, making it the largest single optical telescope in the southern hemisphere. Two instruments are present at prime focus, a science camera and a sophisticated spectrograph. SALT

is a section 21 non-profit making company, belonging it shareholders which include 13 international partners spread over seven countries. Telescope time is shared pro-rata amongst its partners according to their contribution to the project. SAAO has been contracted to operate and maintain the facility.

The rest of the telescopes on site are all robotic. The oldest robotic facility in Sutherland is **BiSON** (**Bi**rmingham **S**olar-**O**scillations **N**etwork), built in 1989. It predates the Internet, so the data it gathered was originally sent back to the UK on floppy disks by post. It was the second of a worldwide network of six remote, ground-based telescopes providing round-the-clock monitoring of the globally coherent, core-penetrating modes of oscillation of the Sun – so-called helioseismology. BiSON is operated by the High Resolution Optical Spectroscopy group of the School of Physics and Astronomy at the University of Birmingham, UK.

Two identical domes were erected at the time when BiSON was built, the other destined for the **ACT** (Alan Cousins Tel-

escope). Its purpose is described in its original name, the APT (The Automatic Photometric Telescope) which was later renamed in honour of the life and work of Dr A.W.J. Cousins, in recognition of his long interest in accurate photometry. This was a joint project between SAAO, UCT and UNISA. The 0.75m compact split-ring equatorial telescope was built in the SAAO workshops and completed in January 1993. The mirror was figured by the CSIR's Optical group in Pretoria. Due a number of holdups, the telescope was finally only commissioned in mid-2000. It since experienced problems and is currently being refurbished with a number of systems being upgraded.

In April 2002 the first clamshell dome appeared, housing **YSTAR** (Yonsei Survey Telescopes for Astronomical Research). This project was run by the Yonsei University, Korea to monitor variable stars and other transient events. It sported an ultra-compact 0.5-m aperture Cassegrain telescope fitted with a CCD camera. This facility was de-commissioned at end of June 2011.

Another clamshell dome has been part of the Sutherland skyline since 2003 but the **MONET-South** telescope was only installed there in September 2008. Although the name sounds French, it is an acronym for MOnitoring NEtwork of Telescopes), operated by the Georg-August-Universität Göttingen, Germany. The project consists of a network of two 1.2m telescopes with its northern equivalent at the McDonald Observatory in Texas, USA. A science-grade CCD camera is the detector. Apart from doing robotic observations, the telescope can also be used for remote observing. A large fraction of the observing time is available to schools as part of the Alfried Krupp von Bohlen und Halbach Foundation's "Astronomie & Internet" project for schools. As reported in *MNASSA* Vol 69 Nos 11 & 12 December 2010, the Hermanus Centre is actively participating in this, involving local schools.

Another pair of identical clamshell domes mushroomed recently (2011) when a Polish group established two 0.5-metre robotic telescopes as part of a global network (Australia, Africa, South America) dubbed **Project Solaris**. Science-grade CCD cameras again are the instrument packages. The project has two main goals. Firstly to detect circumbinary planets around a sample of up to 350 eclipsing binary stars using eclipse timing and precision radial

velocities. Secondly to characterize the binary stars with an unprecedented precision to test the stellar structure and evolution models.

Another program searching for exoplanets since 2006 is **SuperWASP-South**, housed in a roll-off roof observatory. As the name suggest, it has a northern hemisphere twin, located on the island of La Palma. Both observatories consist of eight wide-angle CCD cameras that simultaneously monitor the sky for planetary transit events. SuperWASP is the UK's leading extra-solar planet detection program comprising of a consortium of eight academic institutions which include Cambridge University, the Instituto de Astrofisica de Canarias, the Isaac Newton Group of telescopes, Keele University, Leicester University, the Open University, Queen's University Belfast and St. Andrew's University.

There is a third exoplanet search program located in Sutherland, called **KELT-South**, housed in a roll-off roof observatory which started operating in September 2008**.** KELT is an acronym for Kilodegree Extremely Little Telescope because the "telescope" is simply an equatorially mounted CCD camera fitted with a lens of 4.5cm aperture. It too has a northern hemisphere twin, deployed in Arizona. The purpose of the project is to discover transiting extrasolar planets around stars in the brightness range of 8 < V < 10 mag. The telescope is owned and operated by Vanderbilt University, Nashville, Tennessee.

Another roll-off roof observatory, built in 2007 next to the IRSF, was dubbed the **Sumi-hut**, (named for the Sumitomo Foundation that supplied funding for the project). It houses the 220mm aperture WFCT II (Wide Field Cryogenic Telescope II), a special infra-red telescope whose interior, including detector and optics, is under vacuum and cooled to cryogenic temperatures. Like the IRSF, it too is a project of Nagoya University, Japan.

The last two observatories both house site testing gear. A roll-off roof shelter, commonly know as the *Ossewa* (since it resembles an Ox Wagon when open) was built in 1994 housing a **DIMM** (Differential Image Motion Monitor) system for doing seeing measurements. This system was used as a reference while a second portable DIMM was operated from three positions on site to decide on the final location of SALT. Dr Timothy Pickering recently upgraded the facility to a **MASS-DIMM** system, which is two instruments in one. MASS (Multi Aperture Scintillation Sensing) measures how different layers of the atmosphere contribute to the

seeing for altitudes ranging from 300 m to 32 km. At the heart of the modernisation is **TimDIMM,** the software he developed to run the camera and analyse the data from it. The dome has also been motorised, allowing full remote operation. Real-time seeing data is now published on the SALT weather page.

For one year during 2010, a **SLODAR** (SLOpe Detection And Ranging) optical turbulence monitor, developed at Durham University, UK, was erected near SALT and run in parallel with MASS-DIMM to cross-calibrate it. SLODAR provides real-time measurements of the atmospheric turbulence strength, altitude and velocity. The telescope has since been returned but the clamshell canvas shelter surrounded by a blue protective shadow-net windbreak is still there today.

At the site of the **LCOGT** (Las Cumbres Observatory Global Telescope) network all the foundations and three domes, each destined to house a 1-m telescope, have been completed. The next phase of installing equipment is planned for August. Apart for the scientific aims for the 1-m telescopes, a wider audience is destined to use the other two clamshell domes which will eventually contain four 0.4-m telescopes.

Hosted Experiments

A scientific facility like the Observatory, located on a remote site like this, but with an infrastructure of power, water, internet, etc and manned with technical backup is very attractive to house experiments. When the Observatory opened in 1973, two experiments were hosted on site. The Airglow building housed both the **Airglow experiment**, measuring the atmospheric glow as well as the photographic recording equipment of a **seismograph**, run by the South African Geological Survey. The seismometer instrument is located in an underground vault, with its pier built on the bedrock. The airglow experiment was terminated after a few years while the seismometer still exists today, but in a much more modern format and managed differently.

The **Seismograph** is now part of Project IDA (International Deployment of Accelerometers) is a global network of broadband and very long period seismometers operated by the Cecil H. and Ida M. Green Institute of Geophysics and Planetary Physics (IGPP), Scripps Institution of Oceanography (SIO), University of California, San Diego (UCSD). **Project IDA** is an element of the IRIS Global Seismographic Network (GSN) supported by the Cecil and Ida Green Foundation for the Earth Sciences and the National Science Foundation. There are currently 40 broadband stations deployed worldwide. A big satellite dish

next to the Sutherland vault supplies seismic data to the **CTBT** (Comprehensive Nuclear-Test-Ban Treaty) network which monitors nuclear explosions everywhere; on the Earth's surface, in the atmosphere, underwater and underground.

Geophysical Facilities comprise **SAGOS** (South African Geodynamic Observatory), a co-operative agreement between the National Research Foundation (NRF), South Africa and the GeoForschungsZentrum Potsdam (**GFZ**), Germany. The station was built in 1999 and is equipped with a Superconducting Gravimeter, a PRARE (Precise Range and Range-rate Equipment) Station and a **GPS** (Global Positioning System) Receiver as part of the International GPS Service for Geodynamics.

A second high quality **GPS receiver** is shared between the South African Department of Land Affairs and HartRAO's Space Geodesy programme as part of the International GPS Service (IGS). The latter system consists of about 125 satellite tracking stations, three Data Centres and seven Analysis Centres worldwide. The GPS data sets are used to generate GPS satellite ephemerides, Earth rotation parameters, IGS tracking station coordinates and velocities, GPS satellite and IGS tracking station clock information.

SANSA Space Science (formerly Hermanus Magnetic Observatory) has been operating a pulsation magnetometer from

Sutherland for the last ten years. This is located in a cluster of vaults just below the surface, to the south of site, far enough away from everything so as not to be affected by any electromagnetic interference.

Sprite is a global network (Scotland, California, Australia and South Africa) of data loggers and magnetic coils to measure, count and map the location of Sprite lightning (Transient Luminous Events). Each system consists of a data logger about the size of a briefcase and two magnetic field sensors. It runs off a 12V battery and connects to the internet. The experiment is run by the Department of Electronic and Electrical Engineering, University of Bath, UK. The Sutherland installation is located east of the 74-inch dome.

In one corner of the Airglow building (currently being used as the Electronics lab) is a computer connected to a **VLF** (Very Low Frequency) **antenna** outside. This is an experiment by Dr Andrew Collier, Physicist at the Waves and Space Plasmas Group, SANSA and the Space Physics Research Institute, University of KwaZulu-Natal, Durban. ☆

Astronomical Colloquia

These form an important part of a research facility, often as a sort of pre-publication discussion or a discussion of an individual's current research, and as such it is virtually impossible to "publish" this material. However by recording the topics discussed in the form below does indicate to those, who are unable to attend, what current trends are and who has visited to do research: it keeps everyone 'in the loop' so to speak

Also included are the SAAO Astro-coffees which are 15-20 min informal discussions on just about any topic including but not limited to: recent astro-ph papers, seminal/classic publications, education/ outreach ideas and initiatives, preliminary results, student progress reports, conference/workshop feedback and skills-transfer sessions.

Ed

SAAO Colloquia

Title: Las Cumbres Observatory Global Telescope (LCOGT) facilities: What are they capable of and how to access them?
Speaker: Abiy Tekola (Postdoc, SAAO)
Venue: SAAO AUditorium
Time: 11:00
Date: 3 May
Abstract: The Las Cumbres Observatory Global Telescope (LCOGT) is a private observatory building a network of small size robotic telescopes ranging between 0.4m to 2m all over the world. The observatory's main scientific focus lies on time-domain astronomy such as exoplanet and supernova related sciences. Three 1m and three 0.4m telescopes as part of the network are in the process of being constructed here in Sutherland and their operation is expected to start as early as the beginning of 2013. In this talk I will be giving an overview of the capabilities of these facilities and how they can be utilized by the South African Astronomy community.

Title: Project Solaris
Speaker: Milena Ratajczak (PhD student)
Venue: SAAO Auditorium
Time: 11:00
Date: 7 June
Abstract: Project Solaris is a Polish scientific initiative to open a new frontier in the hunt for extrasolar planets. With the Kepler Space Telescope discovering hundreds of systems with planets, also circumbinary ones, it is time for a ground-based survey dedicated to binary systems observations in order to look for Tatooine-like planets. Establishing a global network of four 0.5-m robotic telescopes (Africa, Australia, South America), we aim at detection of circumbinary planets around eclipsing binaries using eclipse timing and precise radial velocity measurements, as well as characterization of the binary system components with an unprecedented precision to test the stellar structure and evolution models. I will briefly present the main goals of the

project and our expectations, report the status of works at different sites, and introduce the reality of assembling four telescopes at three different continents by four people in 500 days.

SAAO Workshop Visit

Venue: SAAO Mechanical Workshops

Guide: Dr Lisa Crause

Time: 10:00

Date: 10 May

Abstract: Over the past nine months, the SAAO's mechanical workshop has taken delivery of four huge new state-of-the-art machines. It's hard to overstate the potential that they represent for the SAAO as their capabilities elevate us into a very special league, already making us the envy of several of our wealthy foreign collaborators. Amazing as these machines are, they're not simply plug-&-play devices so a great deal of work has gone into getting them set up and running properly. There's yet more to be done, but Craig (Mechanical Engineering, Head) and his team are now ready to offer an introductory tour of the workshop to anyone interested in finding out what really goes on down there. Although this is a technical subject, the demonstration and explanations will be accessible to everyone, so don't feel daunted by the prospect of visiting!

Title: Characterizing Optical and Radio Transients in Real-Time

Speaker: A/Prof Patrick Alan Woudt, UCT

Venue: SAAO Auditorium

Time: 11:00

Date: 17 May

Abstract: A wide range of current and future surveys aim to study the transient sky at a multitude of wavelengths. In the optical, the Catalina Real-Time Transient Survey (CRTS) and the Palomar Transient Factory (PTF) are paving the way in terms of characterizing the transient sky in real-time. This requires a rapid classification of the transient source to trigger the appropriate follow-up. In the case of CRTS, immediate alerts are made available to the community via VOEventnet structures, maximising the scientific returns from these surveys. In this talk I will present results from our high-speed photometric follow-up of cataclysmic variables discovered in the CRTS using the UCT CCD, and more recently, the new SHOC camera. I will also present details of the MeerKAT Large Survey Project on radio transients (ThunderKAT) with emphasis on the real-time character of the survey. Initial results from KAT-7 of the X-ray binary Circinus X-1 will be presented. This object is the target of a combined SALT, IRSF, KAT-7, and HartRAO observing campaign in June 2012.

Title: The Enigma of CK Vul - the Oldest "Nova"

Speaker: Dr Marcin Hajduk, Nicolaus Copernicus Astronomical Center, Poland

Venue: SAAO Auditorium

Time: 11:00

Date: 24 May

Abstract: CK Vul (Nova Vul 1670) was claimed to be the oldest recovered nova.

However, a few other scenarios had been proposed to account for unique properties of this object. I analysed the remnants of CK Vul using optical imaging and spectroscopy. The imaging, obtained between 1991 and 2010, spans 5.6% of the lifetime of the nebula. The flux of the nebula decreased during the last 2 decades. The central source still maintains the ionization of the innermost part of the nebula. Surprisingly, I discovered two stars located within 10 arcsec of the expansion centre of the radio emission that are characterised by pronounced long term variations and one star with high proper motion. I will discuss the relation of these stars to CK Vul and the nature of CK Vul in terms of recent observations.

Title: Strong Gravitational Lensing: A Double-edged Sword
Speaker: Dr Roger Deane, SKA Postdoctoral Fellow, UCT
Venue: SAAO Auditorium
Time: 11:00
Date: 31 May
Abstract: Strong gravitational lensing provides us with our deepest views of high-redshift galaxies, the effective sensitivity and angular resolution of which will only be possible with next-generation facilities for unlensed objects. However, any conclusions based on strong-lensing observations are crucially dependent on the 'calibration' of the cosmic telescope, i.e. the robust derivation of an accurate lens model. I will present a new Bayesian Markov Chain Monte Carlo algorithm to constrain the lens model of the high-redshift source IRAS F10214+47, which is routinely used as an archetype Ultra-Luminous InfraRed Galaxy (ULIRG). Using this new model, in combination with high resolution VLBI, MERLIN, EVLA CO (1-0) and HST optical/UV observations, the level of effective chromacity is constrained. This is the apparent distortion of the global spectral energy distribution (SED), owing to different emission components undergoing differing magnification boosts by virtue of their relative size and proximity to the lensing caustic. I argue that emission associated with the active nucleus in IRAS F10214+47 is preferentially magnified by an order of magnitude above that of emission associated with star formation, a model which explains a number of peculiarities in this famous galaxy. The demonstration of this spectral distortion by strong-lensing raises caution in the use of lensed objects as archetypical sources; as well as statistical conclusions based on samples without accurate lens models. This is particularly important for the large sample of far-infrared selected lenses recently discovered with the Herschel Space Observatory.

NASSP Colloquia

Topic: Primary Beams, Dynamic Range, The Westerbork Wobble & Other Marketing Ploys
Presenter: Oleg Smirnov
Date: 2 May
Time: 13:00

Venue: RW James Lecture Hall C, UCT.

Abstract: I'll present my experiences in obtaining deep noise-limited radio maps in the presence of direction-dependent effects. In particular, I'll talk about our record dynamic range 3C147 image, and what calibration

went into it. At 21cm, WSRT maps are usually thought to be limited by pointing error -- to investigate this, we started a project called "QMC", where we took observations with deliberately introduced pointing errors, and attempted to recover these in a "double blind" experiment. This was highly successful, and produced a number of interesting surprises. I will also show similar results obtained with the EVLA at 8.4 GHz, and with WSRT at 330 MHz, and discuss what lessons may be drawn concerning MeerKAT, the SKA, and deep science surveys in particular.

Title: Molecular Gas in High-Redshift Galaxies

Speaker: Andrew Baker from Rutgers State University

Venue: R W Jamnes, Lecture Hall C, UCT

Time: 13:00

Date: 9 May

Abstract: Fully understanding the evolutionary state of a galaxy requires that we characterize its gas reservoir, of which the molecular component represents the mass directly available for forming new stars. I will discuss radio observations of molecular gas in two populations of star-forming galaxies at high redshift (selected based on their rest-frame ultraviolet and far-infrared emission) and what we can learn from them. I will highlight recent work with the "Zpectrometer" (a new, ultrawide bandwidth spectrometer for the 100m Green Bank

Telescope) and prospects for future work with ALMA (the Atacama Large Millimeter/submillimeter Array).

Title: A Survival Guide to Research

Speaker: Dr Bruce Bassett

Venue : RW James Lecture Hall C

Date : 16 May 2012

Time : 13:00

Abstract: We discuss the ups and downs of research and how to survive grad school on your way to the research life you always wanted. We will also screen the recently released PhD Comics movie which deals with similar topics.

SKA Colloquia

Title: Exploring inner and outer space - two disciplines converge

Speaker: Dr Marc Roffey

Venue: Cape Town SKA Offices

Time: 15:00

Date: 2 May

Abstract: In February I gave a lecture at Valkenberg Hospital, to the Dept of Psychiatry and Mental Health (UCT), entitled "Exploring inner and outer space - two disciplines converge". The aim of the talk was to spread awareness of the activities of the Hospital's neighbour (The South African Astronomical Observatory), and to stimulate interest in astronomy/ cosmology generally, especially at this exciting time for South African astronomy.

It consisted of an overview of cosmology, followed by a focused look at the SKA project - to make the talk relevant to the professional interests of the audience, I concluded with a brief look at some parallels between neuroscience and cosmology.

Title: Radio transients in the north
Speaker: Prof Rob Fender (Southampton / UCT)
Venue: SKA Cape Town Offices
Time: 15:00
Date: 7 May
Abstract: In this talk I will present a brief review of the current state-of-the-art in the field of radio transients, namely our best estimates of rates and the dominant populations. I will then present the latest results on transient searches and follow up from the northern hemisphere, focussing on LOFAR but also on the GHz facilities which may be more relevant for work with MeerKAT. Notable amongst these are our recent roboticisation of the AMI array, giving us very rapid, high sensitivity follow up of GRBs and other fast transients with no human intervention.

ACGC Seminar

Title: The CORNISH Surveys of the Galactic Plane
Speaker: Melvin Hoare, University of Leeds (UK)
Venue: RW James Lecture Hall C, UCT.
Time: 13:00
Date: 4 May
Abstract : I will describe two radio surveys of the Galactic plane which pave the way for similar surveys with MeerKAT. The CORNISH survey has used the VLA to map 110 square degrees of the northern inner Galactic plane in the 5 GHz continuum with 1 arcsecond resolution. Data taking and reduction is complete on this survey and I will present an overview of the source catalogue. The second survey is CORNISH-South which uses ATCA to perform a similar survey at 6 and 9 GHz in the southern galactic plane and also includes radio recombination lines. This survey was one of the first to utilize the on-the-fly interferometric technique that significantly improved the efficiency and uv coverage. Data taking is complete and there is an opportunity to get involved with the data reduction of this novel survey. The main science driver for these surveys is the study of massive star formation and ultra-compact H II regions in particular. I will show how such unbiased radio surveys will enable us to understand the dynamical evolution and feedback role of the onset of ionizing radiation in massive star forming regions. These surveys also produce a large legacy of data for other studies such as planetary nebulae, active stars and binaries and extra-galactic background sources. ☆

Scutum the Protective Shield

by Magda Streicher
magdalena@mweb.co.za

Image source: Stellarium.org

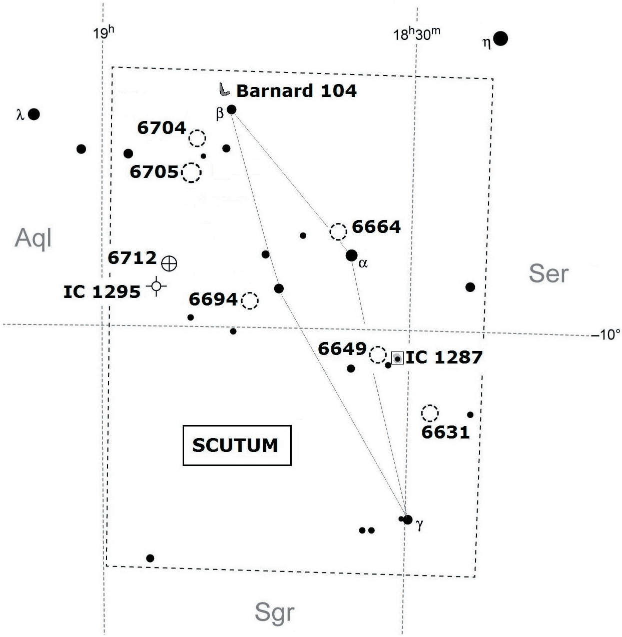
If we take the time to look up at the Milky Way during our southern winter it is such a privilege to be able to revel in the wealth of stellar beauty, and of course our eyes would also be exploring the hub of what forms the centre of our galaxy. Constellations like Sagittarius and Scorpius, which take pride of place, sometimes overwhelm the lesser known constellations suspended at the bright fringes of the Milky Way hub.

One such constellation is Scutum, which can truly boast objects of wonder to please the eye.

In composition, Scutum forms a long triangle stretching from beta and alpha in the north to gamma Scutii in the south. Scutum is the fifth smallest amongst the 88 constellations. Johannes Hevelius (1611-1687) named the constellation Scutum Sobieski, “the Shield”, in 1683 to celebrate King John Sobieski of Poland, who successfully defended his country against the Ottoman Empire.

The well-known object IC 4703 or Messier16, better known as the Eagle Nebula, in the constellation Serpens can be seen at a slight angle away at the south-western edge of Scutum. It is a beautiful area to explore through a telescope. The open cluster **NGC 6631** is located about 2.5° north-east of M16 inside the boundaries of Scutum. A loose, stringy V-formation contains around 20 faint stars in a north-west to south-east direction. Not necessarily bright and outstanding, but worth a visit nonetheless to open a path to the splendid objects housed by Scutum. A good number of PK planetary nebulae and smaller open clusters, like Ruprecht 141, 142, 144 & 170, can be found in the surrounding star field. Perek Lubos and Kohoutek Lubos published there catalogue of Galactic Planetary Nebulae which contains 1 036 nebulae in 1967 referred to simply as PK.

Snugly protected by the Scutum shield, and approximately 1.5° north-east of the open cluster NGC 6631, is the diffuse nebula **IC 1287**. An obvious glow enfolds the central double star Struve 2325, which can be seen with ease in ideal dark-sky conditions. The double star has a 5.8 super-white coloured star with a 9.1 magnitude companion with a



colour and is positioned only 35’ south of the open cluster **NGC 6664**. The cluster is relatively large and outstanding, although the star field is scattered with faint Milky Way stars that mingle well with this group of more or less a dozen stars. Immediately east of the group scattered faint stars can be seen perhaps slightly more outstanding than the cluster itself.

The northern part of the Scutum shield is marked by the magnitude 4.2 buttery yellow beta Scutii. Only a few arc-minutes north of beta Scutii the dark nebula **BARNARD 104** hides between the field stars, seen by many as a hooked V-shape. Shield your eyes from other stray lights in order to glimpse this dark void, and make sure the skies are favourably dark and transparent. Search out this shady hook and please share your thoughts on this dark side with the author.

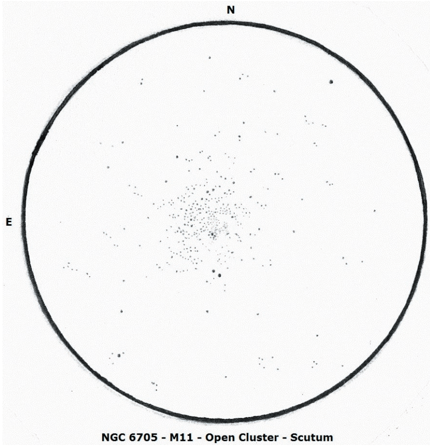
Scutum houses numerous open clusters but most of them are faint and not easy to spot against the backdrop of the dense Milky Way. **NGC 6704** is situated a degree east of beta Scutii, and comprises mostly magnitude 12+ stars in a very obvious north-south direction. What

12.3” separation and PA of 257°. Filters will bring out the washed-out, delicate nebulosity that extends slightly hazily towards the north-east from the stars. There is some speculation that it could be the traces of a supernova remnant.

The open cluster **NGC 6649** is situated only 40’ further towards the north-east and displays an outstanding bundle of colourful faint stars. The focus of this cluster is the lovely magnitude 9.7 deep red colour star situated on the southern outskirts of the group. The south-eastern side of the cluster contains the bulk of the stars.

Further north the magnitude 3.8 alpha Scutii displays a lovely, rich yellow makes this cluster special is the prominent dark lane in the eastern part of the group also running from north to south.

The showpiece object of the constellation, outshining the rest by a long way, is **NGC 6705**, better known as Messier 11, which is situated about 2° southeast of alpha Scutii. It is without doubt one of the most outstanding examples of an open cluster, with a lot of character, hanging on the Scutum Star Cloud. German astronomer Gottfried Kirsh (1639-1710) discovered this beautiful object in 1681. The cluster was first resolved in a myriad of stars during the middle of the 17th century, after which Charles Messier, the comet hunter, added it to his catalogue as the 11th entry on 30 May 1764. It is believed that the English observer William Henry Smyth (1788-1865) gave this object its now popular common name, the Wild Duck Cluster. It could well be that the name was inspired by the familiar flocks of ducks found in the south of England. The grouping appears as a splendid object through binoculars and can even be observed as a naked-eye fuzzy spot in truly dark skies. The cluster displays a swarm of bright pinpoint stars, well resolved, running in extended trails with dark spots among them with a more outstanding and larger dark patch west of centre. Careful observation brings to the fore a narrow, dark lane running through this V-shaped “flocks” of stars. A bright magnitude 8 star, probably not a true member, is embedded in the south-eastern part, with a pair of yellow-coloured magnitude 9 stars on the south-eastern rim. The Wild Duck Cluster beautifully reflects its name, with the flock of members following the



NGC 6705 or M11 is an outstanding example of an Open Cluster.

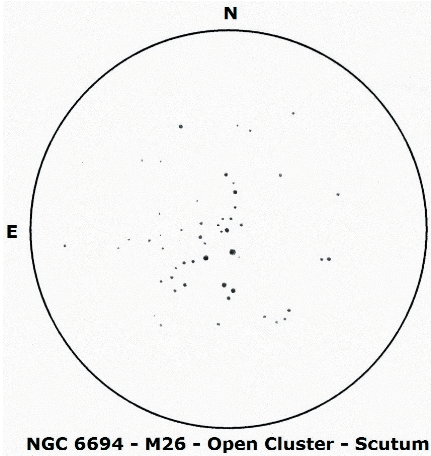
NGC 6712 or Bennett 117 is a Globular Cluster.

bright leaders in flight. This amazing cluster is believed to be about 500 million years old, with approximately 1 000 stars in its midst.

Against the Milky Way shield the eastern area of the constellation holds the globular cluster **NGC 6712**, also known as Bennett 117. This lovely, round, cotton-ball-looking cluster is outstanding, shining quite prominently against the star field. It displays a slightly brighter centre with faintly resolved stars on its surface giving it a frost-coated impression. A more prominent dainty string is obvious towards the southern edge, together with a few curly shorter strings on the edge. John Herschel recorded it as a "fine object, the stars very close and numerous".

Further towards the east is the planetary nebula **IC 1295**, also known as Van den Berg 124, which displays a ghostly small glow with a very low surface brightness. It seems to be slightly elongated in a north-east to south-west direction with a magnitude 11 star on its western edge. It is advisable to use a planetary filter to be able to glimpse this glow. The object is one of a hundred deep-sky object discovered in the 1860s by Truman Henry Safford at Dearborn Observatory in Chicago. Heber Curtis of Lick observatory first recognised it as a planetary nebula in 1919.

Two and a half degrees further south another well-known cluster, **NGC 6694**, has its home against the dense backdrop of the Milky Way. This elongated north-



NGC 6694 Open Cluster in Scutum displaying a rich field of coloured stars.

south cluster, better known as Messier 26, is impressive and outstanding, sharing the field with numerous faint stars. What impresses me most about this group is the S-shaped string starting towards the middle with a block of stars and then curving out towards the north. The north-eastern part of the cluster is much busier with star light and mingles well with field stars. The super-white magnitude 9.2 star draws the attention towards the south-western edge of the group. The cluster was first discovered by Le Gentil in France sometime before 1764 and is credited to him.

As people we are continually trying to shield ourselves against heart sore and danger, but a delight awaits those who care to search out the wonders against the backdrop of the Scutum shield.

Object	Type	RA (J2000.0)	Dec	Mag.	Size
NGC 6631	Open Cluster	18^h27^m2	-12°02′	11.7	5
IC 1287	Diffuse Nebula	18 31 6	-10 47	8.5	20′x10′
NGC 6649	Open Cluster	18 33 5	-10 24	8.9	6′
NGC 6664	Open Cluster	18 36 6	-07 49	7.8	16′
NGC 6694	Open Cluster	18 45 2	-09 24	8	15′
BARNARD 104	Dark Nebula	18 47 3	-04 34	-	-
NGC 6704	Open Cluster	18 50 9	-05 12	9.2	6′
NGC 6705	Open Cluster	18 51 1	-06 16	5.8	14′
NGC 6712	Globular Cluster	18 53 4	-08 42	8.1	4.3′
IC 1295	Open Cluster	18 54 6	-08 50	14.5	86″

Α	α	alpha	Ν	ν	nu
Β	β	beta	Ξ	ξ	xi
Γ	γ	gamma	Ο	ο	omicron
Δ	δ	delta	Π	π	pi
Ε	ε	epsilon	Ρ	ρ	rho
Ζ	ζ	zeta	Σ	σ	sigma
Η	η	eta	Τ	τ	tau
Θ	θ	theta	Υ	υ	upsilon
Ι	ι	iota	Φ	φ	phi
Κ	κ	kappa	Χ	χ	chi
Λ	λ	lambda	Ψ	ψ	psi
Μ	μ	mu	Ω	ω	omega

The **Astronomical Society of Southern Africa** (ASSA) was formed in 1922 by the amalgamation of the Cape Astronomical Association (founded 1912) and the Johannesburg Astronomical Association (founded 1918). It is a body consisting of both amateur and professional astronomers.

Publications: The Society publishes its own electronic journal, the *Monthly Notes of the Astronomical Society of Southern Africa (MNASSA)* bimonthly and an annual printed *Sky Guide Africa South*.

Membership: Membership of the Society is open to all. Potential members should consult the Society's web page assa.saao.org.za for details. Joining is possible via one of the Local Centres or as a Country Member.

Local Centres: Local Centres of the Society exist at Bloemfontein, Cape Town, Durban, Harare, Hermanus, Johannesburg, Pietermaritzburg (Natal Midlands Centre), Pretoria and Sedgefield district (Garden Route Centre). Membership of any of these Centres automatically confers membership of the Society.

Sky & Telescope: Members may subscribe to *Sky & Telescope* at a significant discount (proof of Centre membership required) . Please contact membership secretary for details.

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