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# mnassa

monthly notes of the astronomical society of southern africa
Vol 69 Nos 11 & 12 December 2010

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editorial address | MNASSA, PO Box 9, Observatory, 7935, South Africa
e-mail: *mnassa@saao.ac.za*
webpage: *http://mnassa.saao.ac.za*
*MNASSA* Download Page: *www.mnassa.org.za*

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**Cover picture: NGC1501 Planetary Nebula**

The Hermanus Astronomical Centre, and two school groups, recently used the 1.2m MONET North robotic telescope at McDonald Observatory to capture this image of the planetary nebula NGC 1501 in Camelopardis. For further details see the article on page 224.

# mnassa

Monthly Notes of the Astronomical Society of Southern Africa
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assa news

## A new chapter in the history of the Society's Handbook

Ian Glass

The Society has produced an annual *Handbook* since 1946, though its form has changed as its editors have changed. However, 2006 marked a significant new direction. Following Maciej Soltynski's advocacy of a new and modern format, the then editor, Auke Slotegraaf, produced the first edition of the *Sky Guide Africa South (SGAS)*. For the first time it was produced in colour, with a 'catchy' title, and was widely sold in bookshops. The income generated has been partly used to support the Society's Scholarship programme.

The then (unpaid) Business Manager and Treasurer of ASSA, Cliff Turk, marketed and distributed *SGAS* with great success but, with his resignation in 2008, continuity proved to be a problem. Marketing and distribution had become onerous because of the volume of sales generated. Tony Jones (the previous editor) and Karin Koch helped a great deal in plugging the gap and sending out many boxes of *SGAS*, especially at the beginning of the publishing year. Isobel Bassett has carried much of the load for the rest of the time in spite of difficult circumstances.

In 2010 Maciej Soltynski approached Struik to see if they would be interested in printing, marketing and distributing *SGAS*. When he received a positive response, he approached Council for a mandate to negotiate. With the support of Ian Glass, terms and conditions were agreed. The contract, drawn up by ASSA member Adv AJ Nel, was unusual from the publisher's point of view as Struik normally arranges for the editing and preparation. In this case, however, ASSA's *SGAS* new editor, Wayne Trow, had that responsibility.

**Maciej Soltynski (right) of ASSA and Pippa Parker of Struik Nature after the signing of the agreement between ASSA and Random House Struik**

**Summary of the publishing agreement with Random House Struik**

The contract with Struik was signed officially by Maciej Soltynski and Ms Pippa Parker (Publisher, Struik Nature) on 7 October. So that members of ASSA are informed of the agreement entered into, we give the following outline of the salient points:

Relevant details:

a. The contract is renegotiable annually.
b. ASSA will provide complete print-ready material in PDF, including advertisements.
c. ASSA is responsible for canvassing advertising that appears in *SGAS* and receives all revenue therefrom directly from the advertisers.
d. ASSA receives 250 copies at 'cost' from Struik for distribution to members. On opening an account with Struik, ASSA may purchase additional copies at 35% (less than 50 copies) or 40% (50 or more copies) discount. This is so that Centres may obtain copies of SGAS in bulk..
e. Struik is responsible for all other marketing, sales and distribution of *SGAS*. ASSA will receive a royalty based on a percentage of the recommended retails retail price.
f. ASSA will not supply any *SGASs* to non-members. Members of the public can purchase *SGAS* from bookshops or online sellers.

*SGAS 2011* should appear in bookshops during November. The print run is a conservative 4 000 (previously it was 4 500), but Struik will arrange a print re-run if justified. Members should note that the revenue is not all profit to ASSA as the editors subsequent to Auke Slotegraaf are paid honoraria for their (quite extensive) work and are covered by ASSA for computer-related expenses. ☆

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## New Members

*MNASSA* welcomes the following new members as approved by Council:

Mr Kevin Staats, Onverwacht
Mr Dale Blane, Henley on Klip
Mr Dale Liebenberg, Port Elizabeth
Mr Cornel du Plessis, Pretoria
Mr Charles Feldman, Highlands North
Mr Robert Johnstone, Windhoek
Mr Piet Delport, Krugersdorp
Mr Malcolm Smith, East London
Mr Johann Kruger, Newcastle

# Symposium 2010 report

Johan Smit, Chairman, Pretoria Centre, ASSA.

The Pretoria Centre hosted the Biennial ASSA Symposium from 7-9 October 2010, at the Silverton campus of the Council for Geosciences, and although the theme of the Symposium was "Light and Spectrum Pollution", a wide range of papers were presented with topics as diverse as "Mining in Space" and the problems facing "Science Journalism" in South Africa.

The first day opened with a tour of the Council for Geosciences, where delegates were introduced to the seismology department, and briefly discussed the seismic readings picked up from the meteor which streaked across Southern African skies late last year, and saw a real time read out from all the seismometers located around South Africa. Delegates were also shown the laboratories and a host of impressive equipment used by the geosciences.

After a warm welcome by the ASSA president, **Michael Poll**, opened proceedings. Andrie van der Linde, chair of the organising committee, informed delegates of the practical arrangements for the next three days.

**Professor Phil Charles**, Director of the South African Astronomical Observatory (SAAO) delivered the first paper. The last 18 months had seen SALT "stood down" while major repairs and upgrades were done, a process that was completed at the end of August 2010. Delegates were thus privileged to be one of the first audiences to hear this good news. Since the inauguration of SALT, the two major problems that had plagued SALT's performance were identified. These were a sharp cut-off in the ultraviolet region of the Robert Stobie Spectrograph, and a focus gradient across the field of view. Professor Charles described how the problems were investigated, analysed and tackled, almost entirely by SAAO astronomers and engineers. A future issue of *MNASSA* will carry the complete report by Dr Darragh O'Donaghie, whose team is to be congratulated on an outstanding effort. Professor Charles continued by outlining major new developments in the other international facilities at Sutherland, which are shifting heavily towards robotic operation, so expanding research facilities, especially the search for extra-solar planets. He concluded his address with a brief overview of the implications and progress of a proposed new wind-electricity plant near Sutherland.

**Dr Hubrecht Ribbens**, who spoke on "Techniques to Observe and Analyse Celestial Objects and Phenomena". This was a large and ambitious topic and time constraints meant that he could only gloss over the topic. All our discoveries create data which must be stored or catalogued. Currently there are several sextillion (trillion-trillion-trillion) objects that are waiting to be catalogued. This alone is a challenge and new discoveries continually create more data. Dr Ribbens then described how celestial objects are catalogued and which techniques are used to detect them. He touched on the subject of the need for one all-inclusive catalogue of all celestial objects and phenomena.

The final speaker for the morning was **Hendrik van Heerden**, of the University of the Free State. Hendrik is involved in a project to build a museum at the site of the historic Boyden Observatory which has continuously produced valuable astronomical observations for over a century. A summary of his talk appears elsewhere in this edition of *MNASSA*.

After an excellent lunch, the afternoon session was opened by Percy Jacobs, who introduced **Johan Smit**, the Chairman of the Pretoria Centre, who presented an entertaining talk on "The Dark Side of Light – Light and Spectrum Pollution". While active campaigners against light pollution would have been familiar with much of what Johan had to say, he managed to present the material in a compelling way, and made excellent use of photographs to demonstrate the negative effects of light pollution. He was also able to illustrate counter-intuitive aspects of light pollution: for example, security lights are more likely to aid criminals than home-owners and security staff! He finished off by giving some pointers on how to raise the subject with local government. Johan stated that the main argument to present to perpetrators of light pollution is that it is a symptom of wasted energy. Prof Charles supported this by showing some before and after photos of towns in Chile that went "dark sky friendly". The effects were dramatic, and one fact that came across was that these towns saved back the initial cost of upgrading to "sky friendly lights" within 3 years. This is why Chile is probably the richest country in the world in terms of world class observatories. South Africa has some way to go, as Prof Charles pointed out: the brightest spot on the horizon at Sutherland is Cape Town's light bubble.

Next on the agenda was **Michael Poll**, President of ASSA. Astronomical events and phenomena are frequently depicted in cartoons and cartoon strips

**Conversations over dinner at the Mohka Restaurant**

in newspapers and magazines and they often reflect public perceptions of the Sun, Moon and stars. Michael took us on an entertaining tour through examples of these cartoons and analysed the astronomy in them, and he pointed out how these could be used for educational purposes.

The final session for the afternoon was a **Workshop on laser safety and regulation** in South Africa. This was an important and useful workshop that will be presented in a future edition of *MNASSA*, when all the collected data from feedback has been collated and processed.

The day was concluded with a dinner at Mohka Restaurant at the Pretoria Botanical Gardens. Good food, wine and conversation did much to renew friendships and make new ones.

Danie Barnardo, Vice-Chairman of the Pretoria Centre of ASSA, chaired the first session of the second day, which started with a presentation by **Prof Barbara Cunow**. She started observing Saturn in 1980 with a small telescope and has continued this right through to the present. In other words, she has followed Saturn through a full Saturn year, and recorded all four seasons on Saturn. The detail captured in her drawings showed that this was definitely a labour of love and perseverance. We salute a true professional amateur! Her observations of the complete 30-year cycle will be completed as this issue goes to press, and a full, illustrated report will be published later.

**Allen Versfeld** was the next speaker, presenting a paper on Astronomy Outreach in the Digital Age. He said that traditional outreach methods are here to stay, but the Internet is beginning to its place as a default first-choice for more and more people. Unfortunately for those wishing to use the Internet to bring astronomy to the public, there are no hard and fast rules – the medium is too young and changes too fast. He introduced Urban Astronomer.com as an example of his own work in the field and discussed where he had gone wrong, and what lessons could be learned.

Allen was followed by **Case Rijsdijk**, who spoke briefly on the topic of stellar


**(left) Barbara Cunow and Allen Versfeld (above)**

evolution. Case walked us through the recently discovered very massive star's lifecycle, and looked at various possible endings, from neutron stars to black holes to quark stars and other even more exotic possibilities. Thanks to Case most of the delegates will now have to update most of their own presentations about stars to include these previously unknown large stars.

After the tea break, **Professor Matie Hoffman** (University of the Free State) took the podium. He spoke on "The Assessment of the Expected Impact on Observing Conditions at Boyden Observatory of Light Pollution Associated with the New Developments in the Area". As discussed the previous day by Hendrik van Heerden, Boyden is a working observatory with a long international history. Boyden is actively involved in work on accretion disks, and in making multi-wavelength observations. Proposed new housing developments and the Maselspoort resort near the observatory threatened to increase light pollution levels to the point where they would severely impact on the observatory's usefulness. Professor Hoffman spoke at length on the report compiled by his department as part of the Environment Assessment Report required for construction of new projects. Prof Hoffman was pleased to report that the developers were receptive to the report and were eager to follow through on his suggestions on how to mitigate the effects of light pollution and light trespass. He also took a few minutes to announce the plans to build a new planetarium / dome theatre on the site of the observatory.

**Prof Matie Hoffman**

The next speaker was **Heinrich Bauermeister** from MMS Technology, the company contracted to build the antennae for the MeerKAT radio telescope array. He gave a detailed technical presentation on how the antenna dishes were designed and fabricated. Moulds were prepared on site and the dishes were then constructed one layer at a time using modern aerospace technology. In reply to a question as to how quickly these dishes could be made, Heinrich replied that production could be increased to one dish per week, which raised the question as whether the three thousand dishes of the SKA could be constructed on time! See reports on MeerKAT in this issue.

After lunch Johan Smit introduced **Danie Barnardo**, of the Pretoria Centre of ASSA, who is also a geologist at the Council for Geosciences. Danie spoke on "Meteorites, Impacts and the Tswaing Impact Crater". Danie explained the geological makeup of the various types of meteorite found on Earth, and discussed the formation of impact craters. After a description of the different rock formations found at various well known impact sites around the world, Danie then focussed on the Tswaing impact crater, which is near Pretoria. After a detailed description of the history of the crater, he showed a number of photographs and maps of the area.

Danie also discussed the effect of impacts and – everyone's favourite topic— what are the chances of something like this happening again. Some interesting statistics were highlighted: Meteors of more than 1 metre in diameter enter the atmosphere about once a week. Most break up in the atmosphere (as a result of friction with the air molecules) and never reach the Earth's surface. Of the ones that do reach the Earth's surface, about three quarters fall into the oceans. So, only worry about the other quarter! About 7 reasonably large craters (about 100 meters in diameter) were created during the last 10 000 years. Expect something bad to happen once every 1 500 years.

The next speaker was **Michael Neale**, from the University of Pretoria's Department of Mining and Engineering. Michael recently returned from the Space Resources Roundtable XI / Planetary & Terrestrial Mining Sciences Symposium at the Colorado School of Mines. He spoke to the delegates about the need for South African involvement in "*In Situ* Resource Utilisation" (ISRU), which means the mining and collection of resources from space, for use in space. The most challenging aspect of space flight is lifting material out of Earth's gravity well. This is a hugely expensive enterprise, which severely limits the amount of tools, resources and materials which astronauts can take with them. The principle of ISRU is that the mineral wealth of the Moon, Mars and the Asteroids vastly exceeds that of Earth and should be much cheaper to harvest in space. He reported that there is a lot of interest from the mining industry internationally, and it seems likely that the next stage of human expansion into space will be led by miners and prospectors.

**Case Rijsdijk** then returned to deliver a second paper: "Reporting Science". Case discussed the rift in between journalists and scientists, and considered various causes. He then showed presented some examples of bad science reporting and suggested a few ways on how scientists could improve their relationship with the press. He also explained that the problem in SA was exacerbated by the lack of trained science journalists

The final paper of the symposium was presented by **Professor Derck Smits**, from Unisa, on the topic of Cosmic Masers. Although 2010 was widely celebrated as the 50th anniversary of the laser, the maser was discovered first, seven years earlier, in 1953. After briefly explaining how masers are formed, through the stimulated emission of photons from excited atoms, Prof Smits gave us a bit of history about the first discovery of a cosmic maser. In 1965 astronomers found a highly compact source of OH emission radiation, which was eventually identified as a maser occurring naturally in a vast cloud of ionised OH gas. Cosmic masers have also been identified as coming from the atmospheres of red giant stars and the cores of active galaxies. Derck then discussed some of his own recent work in trying to identify the sources of some interesting cosmic masers which so far remain a mystery.

After thanking all the speakers for their time and effort, Johan Smit then **formally closed** the symposium. Delegates met up later for a casual evening's stargazing at the Pretoria Centre's observatory. The 12.5 inch f/9.8 reflector in the Bennett observatory entertained us with splendid views of Jupiter. This long focus Newtonian telescope with its excellent optics is particularly suitable for planetary viewing. Some viewers reported seeing up to eight cloud bands on the surface of Jupiter.

**Excursions**

The following day, some of the delegates were given a tour of the Hartebeeshoek Radio Astronomy Observatory (HartRAO) in the morning and the Tswaing impact crater in the afternoon. We were joined by Doug and Andy from the Blackburn Leisure Astronomy Society [BLAS] in Brough, England, giving the symposium some international flavour.

**Delegates inside the Tswaing crater**

At **HartRAO** we were met by Dr Marion West who guided us through this very impressive facility. A slide show introduced the delegates to the facility and astronomy in the radio frequency range. A guided tour through the observatory, including the control room was conducted. Watching the 200 ton 26 meter telescope move was very impressive, especially for the technically inclined delegates. What impressed me most was the fact that they are doing observations in bright sunshine. We were fortunate to see the telescope move as one of its main equatorial bearings seized some time ago and was only recently repaired, see last edition of *MNASSA*. The fact that these repairs were done by South African expertise is more evidence that we as a country have much to be proud about.

The delegates then drove to the **Tswaing crater** where Danie Barnardo met and 15 delegates who drove to within 400m from the main lookout point on the Tswaing hiking trail which reduced the walking distance 7km to about 4 km. The main look-out point is also known as the Shoemaker Viewpoint, where there is a plaque in honour of Eugene Shoemaker, co-discoverer of Comet Shoemaker-Levy, which slammed into Jupiter in July 2004. Most of the participants had not seen Tswaing before and everybody was suitably impressed by the 1.13 km diameter, 60 metres deep impact crater that can be seen in all its glory from the Shoemaker viewpoint. Delegates then entered the hiking trail, which leads into the crater and along the way Danie explained that Tswaing has a brine lake, rich in soda-ash, in its centre, which makes this impact crater unique. According to impact scientists, the crater was formed 220 000 years ago by a 40 – 50 metre diameter stone meteorite, which slammed into the earth at a velocity of about 16 km/sec., resulting in an explosion with 500 times the magnitude of the Hiroshima nuclear device. Most living things within 40 km from the site would have been destroyed.

Finally, Allen Versfeld summed up the 2010 Symposium in these words: “Overall, the symposium was a great success, with a number of very interesting and informative papers presented. We all look forward to the next symposium in 2012!”

**Acknowledgements**

I wish to thank the Council for Geosciences for providing us with an excellent venue and facilities, my colleagues, Andrie van der Linde and Danie Barnardo, who did most of the hard work in organising the Symposium and the rest of the Pretoria Centre Committee for their support. Special thanks go to the delegates, especially those who attended from as far away as Durban, Bloemfontein, East London, Garden Route and Cape Town. ☆

# Follow-on to Charles Affair – NRF Establishes Astronomy Desk

(see *MNASSA* August 2010)

As reported in the August MNASSA (Vol 69, p5, 2010), Prof Belinda Bozzoli, Chairperson of the Board of the NRF, has, in the wake of this affair, made a number of recommendations to the Minister of Science and Technology. One of them was the establishment of an 'Astronomy Desk'. This is now in place according to the following press release from the Minister, dated 15 October 2010:

**Prof Hellberg heads DST's Astronomy Desk**

The Minister of Science and Technology, Naledi Pandor, has appointed Prof Manfred Hellberg, an Emeritus Professor of Physics and Senior Research Associate at the University of KwaZulu-Natal, to head the Astronomy Desk at the Department of Science and Technology (DST).Prof Hellberg's appointment, which is for six months, began on 1 October 2010. Minister Pandor recently established the Astronomy Desk in her department to advise on substantive policy and strategic matters regarding the development of astronomy and related sciences, as well as pertinent matters related to South Africa's bid to host the Square Kilometre Array (SKA) radio telescope. A reference team of senior scientists will support Prof Hellberg with technical and expert advice. The team consists of Professors Sunil Maharaj [UKZN], George Miley [Leiden], George Ellis [UCT], Harm Moraal [Northwest] and Renée Kraan-Korteweg [UCT].

The Astronomy Desk will advise and make recommendations on the following:

- How should South Africa obtain maximum scientific advantage and return on the significant investment being made in astronomy?
- The most appropriate relationship between South African national research facilities and internationally funded projects to ensure optimal benefit to South Africa?
- An appropriate structural, organisational and management relationship between optical and radio astronomy and the High-Energy Stereoscopic System, which measures gamma rays, in Namibia? This includes assessing the possibility of creating a single multi-wavelength astronomy facility or institute.
- In light of the above, what is the most appropriate governance model for astronomy facilities in South Africa?
- What would be a suitable site for the placement of the MeerKAT operations centre and any strategic or urgent matters that have a material impact on South Africa's bid to host the SKA?
- Any pertinent matters that require attention to ensure the continued health and functionality of the national astronomical facilities and the SKA project.

**Accusation by Ngcaba Ngcobo**

Ngcaba Ngcobo MP, the Chairman of the Parliamentary Science and Technology portfolio committee, issued a press release reported on 30 June 2010 in the *Cape Times*, stating that a report by the NRF had alleged that there was "potential" financial mis-management in the operation of the SALT telescope. The inference of the statement was that the NRF report was submitted by the NRF Vice-President for Facilities, Gatsha Mazithulela.

According to the *Cape Times* article, the NRF report was a mystery to the astronomical community, the Chairman of the SALT board and even to Prof Bozzoli (who stated that her report to the Minister was in any case confidential). While the PPC inquiry into the alleged financial mis-management that was called for by Ngcobo did not take place, there was a subsequent in-depth audit of the affairs of SAAO and SALT. This audit found only minor issues to complain about and recommended that certain procedures should be tightened up in order to provide for a better "audit trail". However, the key outcome of the audit was that no problems were found whatsoever in the financial management and arrangements between SAAO and SALT, thereby demonstrating that there was no truth in the allegations contained in the Ngcobo statement. ☆

## Dr Peter Martinez appointed chair of SACSA

The Minister of Trade and Industry, Dr Rob Davies, has appointed fifteen people from various government departments, academia and industry, to serve on the South African Council for Space Affairs (SACSA). Dr Peter Martinez MRSSAf, of the National Research Foundation's South African Astronomical Observatory and former ASSA President (2008/9) has been appointed Chairperson of the Council.

SACSA is a statutory body which has a responsibility to, on behalf of the State, take care of the space related interests of South Africa in compliance with international Agreements, Conventions and Treaties. SACS's immediate plans include consideration of the various building blocks that need to be part of a commercially-oriented national space regime. These include particularly: authorisation aspects of space activities; supervision of space activities; registration of space objects; indemnification regulations; and procedural implementation of all regulations, including any additional regulations required when conducting commercial activities (i.e. insurance and liability, environment, financing, patent law and other intellectual property rights, export controls and dispute settlements). ☆

# South African Space Association First Annual Congress

The South African Space Association (SASA) held their first annual congress in the SAAO Auditorium in Cape Town on 7 and 8 October 2010 to coincide with the World Space Week.

According to its web site, "SASA aims to be the leading platform for industry, academia and civil society to engage in the South African space arena, incorporating education, research, space awareness, policy, science and technology issues".

For the past fifty years South Africa has played an important role in space activities and is now coming into its own with its own Space Agency. In 2008, the Cabinet approved the establishment of a South African Space Agency to act as an institutional vehicle for the coordination and implementation of national space science and technology programmes.

The congress brought together a wide variety of space-related interests. Without mentioning every speaker, for example, Keith Gottschalk talked on the political side of things, Greg Roberts on amateur rocketry and satellite tracking, Kim de Boer and Justin Jonas on the current radio-telescope projects, Phil Charles on SALT and Herman Steyn and others on the South African satellite projects. Some of the talks were general overviews whereas others were more technical. Peripheral issues included space law, space tourism, space awareness, SA Government policy and reports on educational programmes. Willie du Preez spoke about the secret South African space programme of the last Apartheid decade and its driving of the titanium industry, which has had spin-offs in other areas, notably that of hip prostheses. ☆

# MeerKAT Dish Redesigned

Kim de Boer

**New Dish Design**

Following an extensive engineering design process, the baseline design concept for the South African MeerKAT precursor telescope has been decided. This design process consisted of an in-depth design study that investigated implementation options and tradeoffs for all key subsystems, and culminated in a Concept Design Review (CoDR) undertaken by an independent panel of international experts. The recommendations of the CoDR panel have informed the baseline concept, and the most visible design decision is that the MeerKAT will consist of 64 Gregorian offset dishes, each with an effective diameter of 13.5 metres.

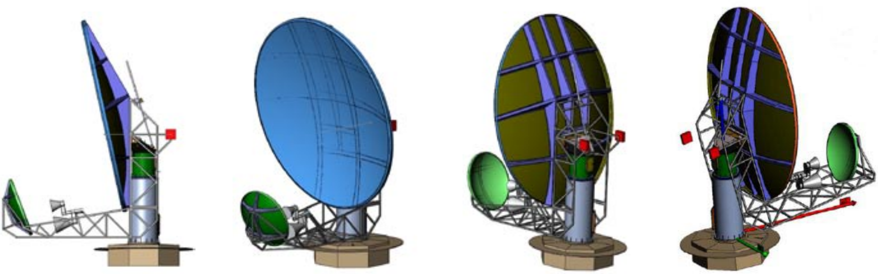
The International panel for the MeerKAT Concept Design Review (5–8 July 2010) reported that the overall impression of the state of the project was very positive. The review panel noted that in several instances, the

KAT-7 at Night (Picture credit, Peter Mcfarlane)

technical development for KAT-7 produced unique new technical knowledge.

An offset dish configuration has been chosen because its unblocked aperture provides uncompromised optical performance and sensitivity, excellent imaging quality, and good rejection of unwanted radio frequency interference (RFI) from satellites and terrestrial transmitters. The offset optical configuration also facilitates the installation of multiple receiver systems in the primary and secondary focal areas, and is the reference design for the mid-band SKA concept. This is the most innovative option of the design solutions that was considered, and it will allow the MeerKAT to operate at a sensitivity of over 220 $m^2/K$.

With all seven dishes of the MeerKAT precursor array (known as KAT-7) now in place, the construction of MeerKAT itself is the next big step for the SKA Africa team. This will start with the building of a qualification (prototype) dish of the new design, on site in the Karoo. This first dish will be located near the KAT-7 array, which will allow extensive testing of the performance of the new design against the existing array. This work will inform the international SKA Dish Verification Programme (DVP), an important component of the PrepSKA study and the international SKA pre-construction phase.



**The new design of the dishes of South Africa's MeerKAT telescope is in line with the kind of dish likely to make up the Square Kilometre Array (SKA) mid-band instrument**

**MeerKAT as SKA precursor**

The completed KAT-7 array is an important engineering test-bed for technologies and systems for MeerKAT, but it will also be used to do science. "We have already received several requests from radio astronomers around the globe who want to use it as a science instrument." explains Professor Justin Jonas, SKA Africa's Associate Director for Science and Engineering. The commissioning of KAT-7 is led by Dr Debra Shepherd, currently on secondment to SKA Africa from the National Radio Astronomy Observatory in the USA. It is expected that KAT-7 will be ready to do science early in 2011, while MeerKAT should be operational by 2015.

The MeerKAT sub-systems employ a number of novel technologies which are in the mainstream of SKA development. The MeerKAT design process will provide important deliverables for the SKA project, as expected from the precursor instruments. In addition to the pioneering use of composite materials for the dish reflector surfaces and structural components (KAT-7 is the world's first radio telescope with dishes made of fibre glass), design challenges include the development of very wide band waveguide feeds and receivers, low-cost cryogenic systems for cooling the receivers, direct digital sampling systems, high speed digital signal processing systems, algorithms for astronomy data processing, high performance computing platforms that match the algorithms, and very fast data transport networks. ☆

**Aerial view of KAT-7, the completed MeerKAT precursor array in South Africa's Northern Cape Province**

# Clearing the Cosmic Fog: the most distant Galaxy ever measured

A European team of astronomers using ESO's Very Large Telescope (VLT) has measured the distance to the most remote galaxy so far. By carefully analyzing the very faint glow of the galaxy they have found that they are seeing it when the Universe was only about 600 million years old (a redshift of 8.6). These are the first confirmed observations of a galaxy whose light is clearing the opaque hydrogen fog that filled the cosmos at this early time.

Studying these first galaxies is extremely difficult. By the time that their initially brilliant light gets to Earth they appear very faint and small. Furthermore, this dim light falls mostly in the infrared part of the spectrum because its wavelength has been stretched by the expansion of the Universe – an effect known as redshift. To make matters worse, at this early time, less than a billion years after the Big Bang, the Universe was not fully transparent and much of it was filled with a hydrogen fog that absorbed the fierce ultraviolet light from young galaxies.

The period when the fog was still being cleared by this ultraviolet light is known as the era of reionization and occurred when the Universe cooled down after the Big Bang, about 13.7 billion years ago. Electrons and protons combined to form hydrogen gas. This cool dark gas was the main constituent of the Universe during the so-called Dark Ages, when there were no luminous objects. This phase eventually ended when the first stars formed and their intense ultraviolet radiation slowly made the hydrogen fog transparent again by splitting the hydrogen atoms back into electrons and protons, a process known as reionization. This epoch in the Universe's early history lasted from about 150 million to 800 million years after the Big Bang. Understanding how reionization happened and how the first galaxies formed and evolved is one of the major challenges of modern cosmology.

Despite these challenges the new Wide Field Camera 3 on the NASA/ESA Hubble Space Telescope discovered several robust candidate objects in 2009 that were thought to be galaxies shining in the era of reionization. Confirming the distances to such faint and remote objects is an enormous challenge and can only reliably be done using spectroscopy from very large ground-based telescopes, by measuring the redshift of the galaxy's light.

On special request to ESO's Director General they obtained telescope time on the VLT and observed a candidate galaxy called UDFy-38135539 for 16 hours. After two months of very careful analysis and testing of their results, the team found that they had clearly detected the very faint glow from hydrogen at a redshift of 8.6, which makes this galaxy the most distant object ever confirmed by spectroscopy. A redshift of 8.6 corresponds to a galaxy seen just 600 million years after the Big Bang.

One of the surprising things about this discovery is that the glow from UDFy-38135539 seems not to be strong enough on its own to clear out the hydrogen fog. There must be other galaxies, probably fainter and less massive nearby companions of UDFy-38135539, which also helped make the space around the galaxy transparent. Without this additional help the light from the galaxy, no matter how brilliant, would have been trapped in the surrounding hydrogen fog and we would not have been able to detect it.

Studying the era of reionization and galaxy formation is pushing the capability of current telescopes and instruments to the limit, but this is just the type of science that will be routine when ESO's European Extremely Large Telescope – which will be the biggest optical and near infrared telescope in the world – becomes operational. ☆

## Astronomers discover most massive Neutron Star yet known

Astronomers using the National Science Foundation's Green Bank Telescope (GBT) have discovered the most massive neutron star yet found, a discovery with strong and wide-ranging impacts across several fields of physics and astrophysics.

This neutron star is twice as massive as our Sun. This is surprising, and that much mass means that several theoretical models for the internal composition of neutron stars now are ruled out. This mass measurement also has implications for our understanding of all matter at extremely high densities and many details of nuclear physics. Neutron stars are the superdense "corpses" of massive stars that have exploded as supernovae. With all their mass packed into a sphere the size of a small city, their protons and electrons are crushed together into neutrons. A neutron star can be several times more dense than an atomic nucleus, and a thimbleful of neutron-star material would weigh more than 500 million tons. This tremendous density makes neutron stars an ideal natural "laboratory" for studying the most dense and exotic states of matter known to physics.

The scientists used an effect of Albert Einstein's theory of General Relativity to measure the mass of the neutron star and its orbiting companion, a white dwarf star. The neutron star is a pulsar, emitting lighthouse-like beams of radio waves that sweep through space as it rotates. This pulsar, called PSR J1614-2230, spins 317 times per second, and the companion completes an orbit in just under nine days. The pair, some 3 000 light-years distant, are in an orbit seen almost exactly edge-on from Earth. That orientation was the key to making the mass measurement. As the orbit carries the white dwarf directly in front of the pulsar, the radio waves from the pulsar that reach Earth must travel very close to the white dwarf. This close passage causes them to be delayed in their arrival by the distortion of space-time produced by the white dwarf's gravitation. This effect, called the Shapiro Delay, allowed the scientists to precisely measure the masses of both stars.

It was lucky that the rapidly-rotating pulsar gives a signal to follow throughout the orbit, and the orbit is almost perfectly edge-on. In addition, the white dwarf is particularly massive for a star of that type. This unique combination made the Shapiro Delaz much stronger and thus easier to measure. The astronomers used a newly-built digital instrument called the Green Bank Ultimate Pulsar Processing Instrument (GUPPI), attached to the GBT, to follow the binary stars through one complete orbit earlier this year. Using GUPPI improved the astronomers' ability to time signals from the pulsar several fold.

The researchers expected the neutron star to have roughly one and a half times the mass of the Sun. Instead, their observations revealed it to be twice as massive as the Sun. That much mass, they say, changes their understanding of a neutron star's composition. Some theoretical models postulated that, in addition to neutrons, such stars also would contain certain other exotic subatomic particles called hyperons or condensates of kaons: these results rule out those ideas.

The result has further implications, outlined in a companion paper, scheduled for publication in the Astrophysical Journal Letters. This measurement tells scientists that if any quarks are present in a neutron star core, they cannot be 'free', but rather must be strongly interacting with each other as they do in normal atomic nuclei. There remain several viable hypotheses for the internal composition of neutron stars, but the new results put limits on those, as well as on the maximum possible density of cold matter.

The scientific impact of the new GBT observations also extends to other fields beyond characterizing matter at extreme densities. A leading explanation for the cause of one type of gamma-ray burst – the "short-duration" bursts – is that they are caused by colliding neutron stars. The fact that neutron stars can be as massive as PSR J1614-2230 makes this a viable mechanism for these gamma-ray bursts. Such neutron-star collisions also are expected to produce gravitational waves that are the targets of a number of observatories operating in the United States and Europe. These waves, the scientists say, will carry additional valuable information about the composition of neutron stars.

Pulsars in general give us a great opportunity to study exotic physics, and this system is a fantastic laboratory sitting out there, giving us valuable information with wide-ranging implications. What is amazing is that one simple number – the mass of this neutron star – can tell scientists so much about so many different aspects of physics and astronomy. ☆

# Zeroing in on Hubble's Constant

In the early part of the 20th Century, Carnegie astronomer Edwin Hubble discovered that the universe is expanding. The rate of expansion is known as the Hubble constant. Its precise value has been hotly debated for all of the 80 intervening years. The value of the Hubble constant is a key ingredient in determining the age and size of the universe. In 2001, as part of the Hubble Space Telescope Key Project, a team of astronomers led by Carnegie's Wendy Freedman determined precision distances to individual far-off galaxies and used them to determine that the universe is expanding at the rate of 72 kilometers per second per megaparsec. While the debate had previously raged over a factor-of-two uncertainty in the Hubble constant, Freedman and her team cut that uncertainty down to just 10%. And now that number is about to be decreased to 3% with the new Carnegie Hubble Program (CHP) using NASA's space-based Spitzer telescope. Freedman, who is director of the Observatories of the Carnegie Institution, will lead the effort, which includes Carnegie staff members Barry Madore and Eric Persson, and Carnegie Spitzer Fellow, Jane Rigby.

The Carnegie Hubble proposal was just selected by the Spitzer Science Centre on behalf of NASA as a Cycle-6 Exploration Science Program using Spitzer. This space telescope currently takes images and spectra – chemical fingerprints – of objects by detecting their heat, or infrared (IR) energy, between wavelengths of 3 and 180 microns (a micron equals one-millionth of a meter). Most infrared radiation is blocked by the Earth's atmosphere and thus it has to be detected from space. The Hubble Key Project observed distant objects primarily at optical wavelengths. In its post-cryogenic phase beginning in April 2009 Spitzer will have exhausted its liquid helium coolant but it will still be able to operate two of its imaging detectors that are sensitive to the near-infrared. This portion of the electromagnetic spectrum has numerous advantages, especially when observing Cepheid variable stars, the so-called "standard candles" that are used to determine distances to distant galaxies.

Spitzer's power will allow astronomers to virtually eliminate the dimming and obscuring effects of dust. It offers them the ability to make the most precise measurements of Cepheid distances that have ever been made, and to bring the uncertainty in the Hubble constant down to the few percent level.

Cepheids are extremely bright, pulsating stars. Their pulsation periods are directly related to their intrinsic luminosities. So, by measuring their periods and apparent brightnesses their individual distances and therefore the distance to their parent galaxies can be determined. By considering the rate at which more distant galaxies are measured to be moving faster away from us in the universe we can calculate the Hubble constant and from that determine the size and the age of the universe.

One of the largest uncertainties plaguing past measurements of the Hubble constant involved the distance to the Large Magellanic Cloud (LMC), a relatively nearby galaxy, orbiting the Milky Way. Freedman and colleagues will begin their 700 hours of observations refining the distance to the LMC using Cepheids newly calibrated based on new Spitzer observations of similar stars in our own Milky Way. They will then measure Cepheid distances to all of the nearest galaxies previously observed from the ground over the past century and by the Key Project, acquiring distances to galaxies in our Local Group and beyond. The Local Group, our galactic neighborhood, is comprised of some 40 galaxies. The team will be able to correct for lingering uncertainties again by observing in the near-IR. Systematic errors such as whether chemical composition differences among Cepheids might affect the period-luminosity relation, will be examined using the infrared data. Spitzer will begin to execute the Carnegie Hubble Program in June 2009 and continue for at least the next two years.

In the age of precision cosmology one of the key factors in securing the fundamental numbers that describe the time evolution and make-up of our universe is the Hubble constant. Ten percent is simply not good enough. Cosmologists need to know the expansion rate of the universe to as high a precision and as great an accuracy as they can deliver. ☆

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## Alternative yardstick to measure the universe

Eugenie Samuel Reich

**Type II supernovae may join their Type Ia cousins as gauges of cosmic expansion.**

Astronomers have long relied on stellar explosions called Type Ia supernovae to measure the scale of the cosmos. A second class of supernovae may now be put to the same use, providing an independent check on measurements that were first used more than a decade ago to discover the accelerating expansion of the Universe.

A growing number of researchers are working on the idea that some Type II supernovae – which are caused by the gravitational collapse of giant stars with iron cores – may have a role as gauges of cosmic distance. The method could be put to use with next-generation sky surveys – including the Dark Energy Survey due to start at Cerro Tololo in Chile in late 2011, and the Large Synoptic Survey Telescope, still in the development phase, at Cerro Pachón, also in Chile. Both are expected to find tens of thousands of supernovae a year. It would be stupid to ignore alternative methods to Type Ia supernovae, SN. A re-analyse of results shows the promise of the new cosmic measuring sticks.

**Standard candles**

The key feature of Type Ia SN – which result from the explosion of white dwarf stars that are sucking up material from companion stars – is that they only go off as the white dwarf approaches a critical mass, the Chandrasekhar limit (1.4 times the mass of our Sun). This means that such supernovae are remarkably consistent in their behaviour. Their intrinsic brightness can be predicted by observing how their apparent brightness from Earth rises and falls, and used to calculate the distance away that they must be. By providing a measure of the distance from Earth to remote galaxies, such Type Ia 'standard candles' underpinned the discovery of the mysterious repulsive dark energy that is driving the Universe's accelerating expansion.

Galaxy-distance estimates using Type Ia SN are precise to within an error of 7%. But such measurements are also thought to suffer from systematic errors, such as the possibility that the type of galaxy hosting the supernova makes a difference to its brightness, a factor that could vary with distance from Earth and so skew results. It is good to have more than one way to measure an important physical effect like the cosmic expansion.

**A Type II-P supernova, SN 2004dj, blazes at the top right of this Hubble Space Telescope image, taken in 2004.*****NASA, ESA , A.V. Filippenko (University of California, Berkeley), P. Challis (Harvard-Smithsonian Center for Astrophysics).***

Working out the intrinsic brightness of a second class of SN, Type II-P, so-called because their brightness stays on a roughly constant plateau (P) for around 90 days before falling off, is considerably more complex. But it is feasible, thanks to a technique pioneered in 2002 by astronomers Mario Hamuy, now at the University of Chile in Santiago, and Philip Pinto, at the University of Arizona, Tucson. The method was further developed by Poznanski and his colleagues. It is unlikely that this technique will be able to compete with Ia, but it can contribute complementary cosmic information.

For the Type II-P method, astronomers take a spectrum of the SN around 50 days after it explodes, and use the shift relative to a standard of a spectral line caused by the absorption of light by iron to determine the speed at which the star is ejecting some of its material. That speed and the 50 day timescale are used to calculate the size of the explosion. Taken together with temperature measurements, that reveals the explosion's intrinsic brightness. Finally, a comparison with the apparent brightness as seen from Earth shows how far away it must be.

In 2009, it was demonstrated that a sample of 17 Type II SN could be used to predict the distances from Earth of their host galaxies to within an error of 10% – not much more than the error of estimates using Type Ia explosions.

**Ironing out the errors**

But astronomers are still some way from being able to check the cosmic expansion using Type II measurements. All the supernovae in the sample were near to Earth, and when astrophysicists tried to apply the method to supernovae further away – about 1.7 billion light years or 530 megaparsecs from Earth – their results gave around 15% error. But using SN spectra collected by the Sloan Digital Sky Survey at Apache Point Observatory in New Mexico, which was primarily looking for Type Ia SN, and some of the spectra were taken only two weeks after the SN's explosion. This doesn't deliver as accurate an estimate of speed of the explosion and hence brightness and distance.

A re-analysis of results addressed the fact that the researchers had selected a biased sample of supernovae, favouring intrinsically brighter objects. By recalibrating spectral lines to calculate the speed of these supernovae explosions, he brought the error down to 11%: the Type II technique still works. Astrophysicists are very optimistic about the technique.

Work is continuing with around 60 Type II SN, spotted by the Palomar Transient Factory survey at Palomar Observatory in California, to get the method to work at greater distances and let them probe further back in the Universe's history. ☆

# South Africa's MeerKAT in high demand

Five years before South Africa's MeerKAT telescope becomes operational, more than 43 000 hours of observing time (adding up to about five years) have already been allocated to radio astronomers from Africa and around the world, who have applied for time to do research with this unique and world-leading instrument. Surveys of radio pulsars and hydrogen gas in the deep universe came out on top in the first round of allocating MeerKAT's observing time.

MeerKAT is South Africa's precursor telescope to the SKA (Square Kilometre Array) and will consist of 64 Gregorian offset dishes, each 13.5 m in diameter. A MeerKAT engineering test bed of seven dishes (KAT-7) is already complete on site in the Karoo region of South Africa's Northern Cape Province.

Following an October 2009 invitation to the world's radio astronomers to apply for MeerKAT telescope time to perform large survey projects, 21 proposals, involving more than 500 astronomers from around the world (59 from Africa), were received. A Time Allocation Committee made up of local and international experts rated the proposals on the basis of scientific merit, technical and operational feasibility, the extent to which MeerKAT has a unique role for the proposed observations or is an essential component in a larger campaign, and the resources each group was prepared to bring to the project.

The science objectives of the most highly rated projects also happen to be the prime science drivers for the first phase of the SKA telescope itself, confirming MeerKAT's designation as an SKA precursor instrument. Observing time has been allocated to:

Nearly 8 000 hours to a proposal to test Einstein's theory of gravity and investigate the physics of enigmatic neutron stars. This radio pulsar timing survey will be led by Professor Matthew Bailes at the Swinburne Centre for Astrophysics and Supercomputing in Australia.

Another 5 000 hours jointly to two proposals to survey the distant universe with MeerKAT. This ultra-deep survey of neutral hydrogen gas in the early universe will be led by Dr Sarah Blyth and Dr Benne Holwerda, both at the University of Cape Town in South Africa, in partnership with Dr Andrew Baker at Rutgers University in the US. The American team, involving several South African team members, called their proposal "LADUMA!" – an acronym for Looking at the Distant Universe with MeerKAT Array, but also a South African expression of delight when a goal is scored in football.

Eight other proposals were rated highly and have also been allocated time on the MeerKAT. They are:

- MESMER: MeerKAT Search for Molecules in the Epoch of Re-ionisation, led by Dr Ian Heywood, University of Oxford in the UK – 6 500 hours.
- MeerKAT Absorption Line Survey, led by Dr Yashwant Gupta and Dr Raghunathan

Srianand, both associated with the Giant Metrewave Radio Telescope in India – 4 000 hours.

- MHONGOOSE: MeerKAT HI Observations of Nearby Galactic Objects: Observing Southern Emitters, led by Professor Erwin de Blok at the University of Cape Town in South Africa – 6 000 hours.
- TRAPUM: Transients and Pulsars with MeerKAT, led jointly by Dr Benjamin Stappers at the Joddrell Bank Centre for Astrophysics, UK and Professor Michael Kramer at the Max Planck Institute for Radio Astronomy, Germany – 3 080 hours.
- A MeerKAT HI Survey of the Fornax Cluster, led by Dr Paolo Serra at ASTRON, an astronomy research institute in The Netherlands – 2 450 hours.
- MeerGAL: A MeerKAT High Frequency Galactic Plane Survey, led jointly by Dr Mark Thompson, University of Hertfordshire in the UK and Dr Sharmilla Goedhart of the South African MeerKAT team – 3 300 hours.
- MIGHTEE: MeerKAT International GigaHertz Tiered Extragalactic Exploration Survey, led by Dr Kurt van der Heyden, University of Cape Town with Dr Matt Jarvis who represents both the University of the Western Cape in South Africa and the University of Hertfordshire in the UK – 1 950 hours.
- ThunderKAT: The Hunt for Dynamic and Explosive Radio Transients with MeerKAT, led by Professor Patrick Woudt, University of Cape Town in South Africa and Professor Rob Fender at the University of Southampton in the UK – 3 000 hours.

“In addition to these ten high priority surveys, there is a strong case for MeerKAT to participate in the world-wide VLBI (very long baseline interferometry) observations, which use telescopes all around the world, working together. “We will ensure that MeerKAT becomes affiliated to international VLBI networks and will commit time to these observations,” explains Dr Bernie Fanaroff, Director of the SKA South Africa Project.

“The Hartebeesthoek Radio Astronomy Observatory (HartRAO) in South Africa will lead the VLBI collaboration with all major radio astronomy observatories around the world,” adds Professor Roy Booth, Associate Director: Science and Operations at the SKA South Africa Project. “MeerKAT will add considerably to the sensitivity of the global VLBI network.”

“We would also like to explore the potential for SETI (search for extraterrestrial intelligence) and for collaboration with NASA on downloading information from their space probes sent to other planets,” Dr Fanaroff adds as another key science objective for MeerKAT.

The teams who have submitted the successful proposals will be invited to work with the MeerKAT team throughout the design phase of the telescope, and to become involved in the project’s human capacity building programme. ☆

# Pushing the limits of the Foucault Test

Johann Swanepoel

**Summary**

The processes involved in the shaping and testing of two fast 20-inch diameter thin Pyrex mirrors are briefly described. Some improvements to extend the usefulness and accuracy of the age old Foucault knife-edge test, making use of affordable and easily available modern technology, are described in some detail.

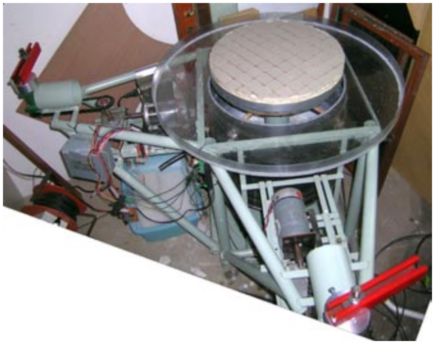


**Figure 1 - A modular multi-mode grinding and polishing machine for large thin mirrors**

## Introduction

Amateur Telescope Making (ATM) is a hobby that remains alive and well despite the general availability of commercial telescopes. This is evidenced by the popularity of events like the annual ScopeX in Johannesburg where telescope builders display their creations. ATM'ers worldwide have the knack of coming up with many innovative approaches to problems, making improvements to existing designs and methods and making do with materials that are generally or locally available. This also applies to the techniques for grinding, polishing and figuring of telescope mirrors of various sizes and focal ratios. Excellent mirrors are made both by hand and machine.

## Grinding and polishing machine

Two 20-inch (508 mm) diameter, 45 mm thick Pyrex blanks, each weighing about 20 kg, were imported from Newport Glassworks in California. The blanks had been factory fine-annealed and diamond pre-ground to F4.5. This latter step meant the removal of about 1.5 kg of glass to obtain a sagitta of 7mm and was worth the marginal increase in cost at the supplier's risk.

It was decided from the outset to build a machine that could perform the required fine grinding, polishing and figuring functions. The machine had to be modular (interchangeable components) and be multi-mode (able to emulate various other machines, like Hindle, Zeiss, Ritchie, Draper and Mirror-O-Matic). It had to make provision for modifications, adaptations and experimentation. So a machine was built from an old washing machine as basis with two removable steel frames added to hold motors, gearboxes, bicycle sprockets and chains. As most of the grinding and polishing would be done with mirror on top (MOT), using full-size tools, a crocodile frame was implemented to hold the mirror in the manner and for reasons given by Hindle [1]. Not all the mode capabilities were implemented at the outset – the latter three evolved later when the need arose to correct incalcitrant zones and deviations near the outer edge of the mirror. Special but simple wooden arms were implemented for these modes.

The machine has three DC motors, one for the central turn-table and one each for the arms. Motor speeds are controlled by varying the motor voltages. When required, an electronic timer module can be switched in to provide pulsed rotation of the central table to simulate 'walking around the barrel' as for manual polishing. An important aspect was ensuring regular and even rotation of the mirror during all grinding and polishing processes to avoid astigmatism.

As very little sensible information was available in the literature or on the web, especially that dealing with machine figuring – typical manual type polishing and figuring strokes do not always work as desired – the machine provided the opportunity to research some of these issues, especially the use of various sub-diameter pitch laps in parabolising and controlling the outer edge of the mirror.

**Shaping the mirror**

This started with rough grinding. The blanks had been factory diamond pre-ground (hogging) to F4.5 for reasons given above. A full-sized porcelain tile tool was then cast on the mirror and used on the machine, MOT, to remove pre-ground hypocycloidal marks and to grind the tool and mirror to make full spherical contact. 80 and then 220 silicon carbide grit were used for the grinding medium.

This was followed by fine grinding and smoothing, continuing with the tile tool and MOT but using aluminium dioxide (Alumina or Micro-grit), through a sequence of finer and finer grades – 30, 20, 9, 5 and ending with 3 micron.

Polishing was done MOT on a full-size pitch tool with cerium dioxide as the polishing agent. Obtaining the right pitch was a major challenge and a great deal of experimentation took place during polishing and figuring.

Figuring (parabolising/correcting) was a far more complex exercise. Initial parabolising was done with the full-sized pitch tool cut into a star shape, polishing MOT. This was followed by using various sub-diameter tools, tool on top (TOT). Refer to presentations hosted at [2] for more information.

Figuring is especially tricky on large fast mirrors where a great deal of correction is required. Table 1 shows the required correction in wavelengths at 550 nm. This is the amount of glass that would have to be polished away at the edge of a spheroid to convert it to a paraboloid having the same radius of curvature (ROC) at its centre as the spheroid.

| Focal ratio (F/D) | 3 | 4 | 4.5 | 5 | 6 | 8 | 10 | 12 | 15 |
|---|---|---|---|---|---|---|---|---|---|
| Diameter D (ins) | | | | | | | | | |
| 6 | 10.06 | 4.24 | 2.97 | 2.17 | 1.25 | 0.53 | 0.27 | 0.16 | 0.08 |
| 8 | 13.41 | 5.65 | 3.97 | 2.89 | 1.67 | 0.71 | 0.36 | 0.21 | 0.11 |
| 10 | 16.76 | 7.06 | 4.96 | 3.61 | 2.09 | 0.88 | 0.45 | 0.26 | 0.13 |
| 12 | 20.11 | 8.47 | 5.95 | 4.33 | 2.51 | 1.06 | 0.54 | 0.31 | 0.16 |
| 16 | 26.82 | 11.30 | 7.93 | 5.78 | 3.34 | 1.41 | 0.72 | 0.42 | 0.21 |
| 20 | 33.52 | 14.12 | 9.91 | 7.22 | 4.18 | 1.76 | 0.90 | 0.52 | 0.27 |
| 25 | 41.90 | 17.65 | 12.39 | 9.03 | 5.22 | 2.20 | 1.13 | 0.65 | 0.33 |

**Table 1 - The correction required for different mirror diameters and focal ratios.**

| Peak to Valley difference (correction error) (wavelengths) | RMS difference (wavelengths) | Strehl ratio | Energy in Airy disc (percent) | Energy in surrounding diffraction rings (percent) |
|---|---|---|---|---|
| 0 | 0 | 1 | 84 | 16 |
| 1/16 | 1/54 | 0.99 | 83 | 17 |
| 1/8 | 1/27 | 0.95 | 80 | 20 |
| 1/4 | 1/14 | 0.8 | 68 | 32 |
| 1/2 | 1/7 | 0.4 | 40 | 60 |
| 1 | 1/3 | 0.1 | 10 | 90 |

**Table 2 - Image quality for different correction errors.**

Mirrors have a theoretical resolving limit that depends on their aperture. At the focus the image of a star appears as a small bright disk surrounded by concentric rings of diminishing brightness, known as Airy disk or diffraction spot. In a perfect mirror 84% of the energy is in the central disc with the remaining 16% distributed in the surrounding diffraction rings. The figuring process attempts to approach this perfect mirror within an acceptable tolerance. Table 2 shows the effect of surface tolerance on image quality [5]. The aim was to achieve a Strehl ratio of better than 0.95.

**Testing the mirror**

Testing to establish the shape and surface tolerance of the mirror and amount of correction needed at any stage, is a crucial process in mirror making. Various tests are used for this, from the very simple Foucault knife-edge test to very elaborate tests based on laser interferometers.

The Foucault knife-edge test is an age old test, described by Leon Foucault in 1857, that is still used today. It is an extremely simple but very elegant test to which many variants have developed. The test is well documented [3] [4] [5].

In essence the test boils down to having a point light source and knife-edge at or near the centre of curvature of the mirror and measuring the longitudinal position of the knife-edge, against the radial position of nulls or crests in the shadows appearing in the mirror. If the light source is fixed with only the knife-edge moving, it is referred to as ‘fixed source’; if both knife-edge and source move together it is referred to as ‘moving source’. Two test cases are possible; in the first, the knife-edge is adjusted so that the nulls coincide with predetermined radial positions on the mirror (e.g. slots in masks) and the corresponding longitudinal knife-edge positions recorded; in the second, the knife-edge is placed in predetermined longitudinal positions and the corresponding radial position of the null or crest determined by some means (e.g. photographically).

In both cases a sufficient number of positions are required to properly characterize the mirror surface. Measured and calculated results are plotted to establish the longitudinal aberration (LA) and shape of the figure. Figuring corrections are then applied where necessary until the errors meet desired criteria. Modern technology and new approaches can extend the usefulness and accuracy of the test e.g. use of webcams to capture images and a variety of computer software to analyse images and compute results.

## The Foucault test – with masks

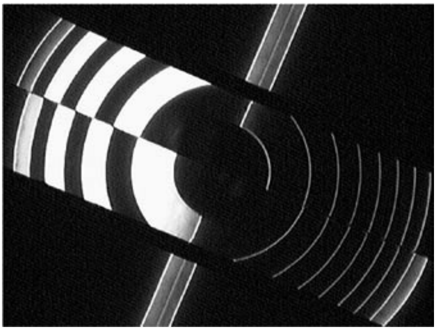
The traditional method is to place a mask, having a number of slot pairs, over the mirror. Each pair is associated with a radial zone position on the mirror. The larger or faster the mirror, the more zone slot pairs are required to adequately sample the mirror. The mask slot pair radial position is the independent variable whilst the corresponding longitudinal knife edge position is the dependent variable which needs to be measured. This can be done by eye directly behind the knife-edge or nowadays using a webcam/lens assembly behind the knife-edge and displaying the image on to a computer screen for better viewing. The objective is to judge equal graying of zone pairs.

As Slater and Carlin have shown [6] this is a judgment that is subjective and plagued by diffraction occurring at the slot edges. Because slots have a finite width, they average the image intensity across the slot width and place uncertainty on the exact centre of the zone. They showed that there are an optimum number of zone slot pairs as a function of mirror size and speed (see derived Table 3). In practice, the nearest integer value would be used; a value of one means leaving the mirror spherical is good enough. When longitudinal knife-edge readings are taken, several readings per position are averaged and the results analysed.

| Focal ratio (F/D) | 3 | 4 | 4.5 | 5 | 6 | 8 | 10 | 12 | 15 |
|---|---|---|---|---|---|---|---|---|---|
| Diameter D (ins) | | | | | | | | | |
| 6 | 8.2 | 5.3 | 4.5 | 3.8 | 2.9 | 1.9 | 1.3 | 1.0 | 0.7 |
| 8 | 9.5 | 8.1 | 5.2 | 4.4 | 3.3 | 2.2 | 1.6 | 1.2 | 0.8 |
| 10 | 10.6 | 6.9 | 5.8 | 4.9 | 3.7 | 2.4 | 1.7 | 1.3 | 0.9 |
| 12 | 11.6 | 7.5 | 6.3 | 5.4 | 4.1 | 2.7 | 1.9 | 1.4 | 1.0 |
| 16 | 13.4 | 8.7 | 7.3 | 6.2 | 4.7 | 3.1 | 2.2 | 1.7 | 1.2 |
| 20 | 15.0 | 9.7 | 8.1 | 7.0 | 5.3 | 3.4 | 2.5 | 1.9 | 1.3 |
| 25 | 16.7 | 10.9 | 9.1 | 7.8 | 5.9 | 3.8 | 2.8 | 2.1 | 1.5 |

**Table 3 - Optimum number of mask zone pairs.**

**Figure 2 - Example of 8-zone mask on 20-inch mirror showing outer zone nulled. Note diffraction at slot edges.**



## The Foucault Test – without masks

There is a better approach in doing the knife-edge test that overcomes the limitations of using masks. An almost unlimited number of test points or zones across the mirror are possible, also close to the edge of the mirror. It is quicker, more objective, convenient and reliable and allows repeatable measurements to be obtained. It is well-suited to testing large fast mirrors. The method provides other hidden information not easily visible to the human eye peering past a knife-edge.

This method is based on the knife-edge being placed at definite predetermined positions along the longitudinal axis (the independent variable) and a series of pictures or Foucaultgrams taken with a webcam from behind the knife-edge without any mask over the mirror. Each picture becomes the dependant variable that needs to be analysed to establish the radial position of the actual null or zone.

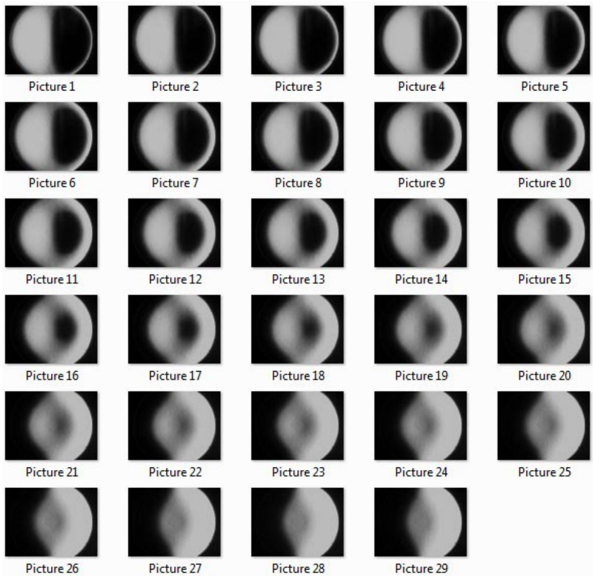
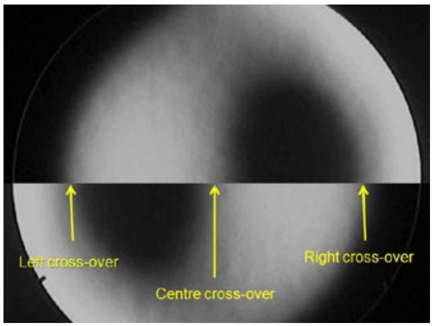



**Figure 3 (above) - Foucaultgram set for 20-inch f/4.3 Mirror. Images were taken at 0.25 mm intervals along longitudinal axis – set taken in less than 10 minutes.**

**Figure 4 (below) - Splitting and splicing of a typical Foucaultgram using GIMP.**




Suiter proposed a method [7] for the digital analysis and data reduction of a set of pictures. He used a digital video camera and frame grabber to capture a series of Foucaultgrams. Adobe Photoshop was used to process the pictures that were then split and spliced to determine null crossings. Data was analysed using a spreadsheet. The writer used Suiter's method but eventually simplified and speeded up the method of establishing the null cross-over points. This involved developing special software.

As many hundreds of pictures had to be analysed for the two mirrors, the writer found Suiter's method of splitting and splicing the pictures rather cumbersome and time consuming. Also, determining the null cross-over points still required some subjective judgement as a result of uncertainty caused by various forms of picture noise. Three cross-over points had

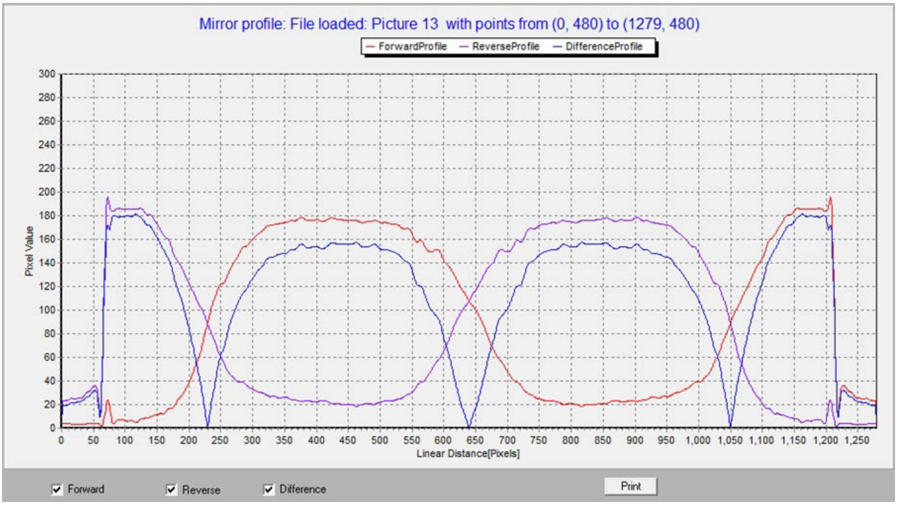



**Fig 5 - Pixel intensity profiles, forward, reverse and difference. Only left hand null need be read.**

to be read for each picture. A good characteristic of the split and splice method is the insensitivity of the cross-over readings to misalignments of the two split halves.

Figure 3 shows the thumbnail images of a typical Foucaultgram set taken with a webcam. Figure 4 is one of the actual pictures split and spliced, in this case done using GIMP, an open source graphics programme. A custom GUI programme (MirrorProfile) was developed in Delphi that simply does the splitting and splicing in a digital manner. It computes a pixel intensity profile for a line across the centre of the image loaded. The profile is then plotted together with its reversed image and the difference between the forward and reverse profiles superimposed to reveal the cross-over points. The three superimposed graphs are symmetrical and so only the left-hand point is needed for a reading. The positions of the left and right edge diffraction spikes are used to calibrate the positions of the nulls. Figure 5 is a typical display of the results. Readings to the nearest pixel are obtained for further analysis in a spreadsheet that computes and plots the residual longitudinal aberrations and other mirror quality parameters. The programme actually computes 20 vertically adjacent horizontal pixel profiles, i.e. a thin horizontal band rather than a single line. The data values are first ensemble averaged and the resulting single profile further filtered using a Savitsky-Golay polynomial smoothing filter before being displayed as per Figure 5. As can be seen from the slopes of the intensity profiles at the cross-over points, slight horizontal misalignments of the image will have little effect on the null positions. During setup the positions of the left and right edge diffraction spikes are used to align the camera in azimuth.

Figure 6 is a spreadsheet plot comparing the LA vs radius results of the two approaches using a picture set taken at some stage of the figuring process on one of the mirrors. The results agree very closely. MirrorProfile is just a lot faster.

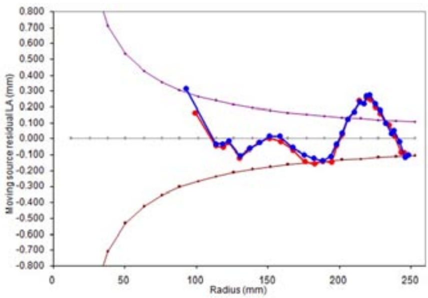



**Figure 6 - Comparison of the two approaches.**

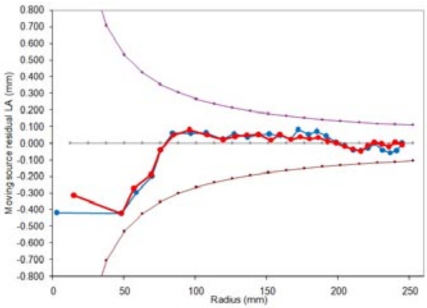



**Figure 7 - Repeatability of measurements.**

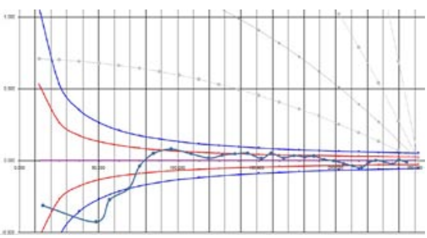
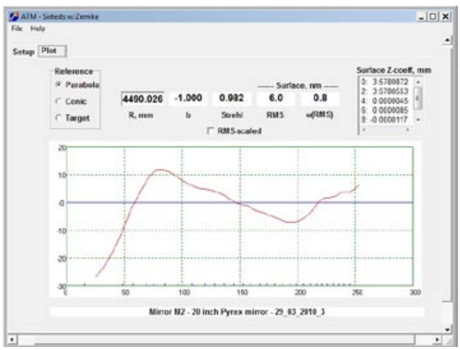


**Figure 8 (above) - Residual LA plot within tighter tolerance M-L masks.**
**Figure 9 (right) - Corresponding mirror surface profile in nm and quality parameters calculated using Sixtests [8].**

Figure 7 is a spreadsheet plot of the residual LA data derived from the picture set of Figure 3 and also demonstrates the repeatability of a second set of results taken several hours later. Each point represents the data derived from one image in a particular Foucaultgram set. Figure 8 is another spreadsheet plot of the last residual LA data derived for Figure 7 but showing tighter tolerance M-L masks. Data derived from the above-mentioned spreadsheet is used in Sixtests [8] to quantify the surface quality of the mirror. Figure 9 shows the results based on the data associated with Figure 8.

**The test setup**

The writer's instrument is a moving source slitless Foucault type tester that has undergone many modifications over time. As shown in Figures 10 and 11, a modified CCD webcam is mounted on an arm that allows the camera to slide in behind the



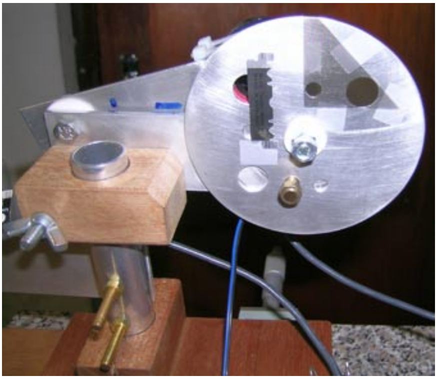
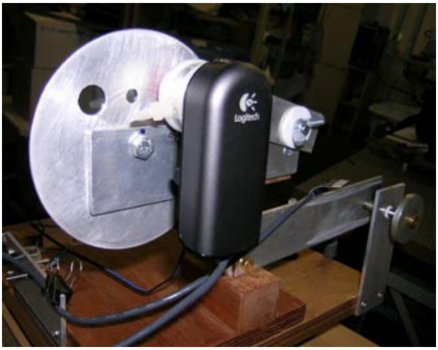


**Figure 10 (above) - Front of tester has a disc that can be rotated to select either a knife-edge or Ronchi grating.**

**Figure 11 (below) - Rear of tester showing CCD webcam and adjusting and panning arms.**




knife-edge and have its position optimally adjusted. The camera can be swung out to allow visual observation from behind the knife-edge. The camera's wide angle lens was removed and a tube mechanism fitted to allow a longer focal length lens system, made from eyepiece lenses, to slide inside the outer tube for optimum focusing. A longer focal length is required to magnify the image and so make full use of the CCD aperture. The test set is fitted with an adjustable side-arm to aid in the fine horizontal panning of the camera, necessary to properly centre the image during setup.

The instrument is fitted with a dial plate or disc with suitable holes over which a knife-edge and Ronchi grating are mounted. Its purpose is to allow quick and repeatable selection of these items in front of the LED light source and camera. Apart from its other uses, the Ronchi screen is used during the initial setup to aid precise longitudinal alignment of the moveable platform. It is a lot more sensitive than the knife-edge for this. Once setup, the series of images are taken without any further adjustments to the knife-edge while moving along the longitudinal axis towards the mirror.

**References**

[1] *Amateur Telescope Making* volume 3 – Chapter A.2, Hindle – Machine Polishing Mirrors.

[2] http://www.scopex.co.za/j_swanepoel_-_apr_10.html

[3] *Amateur Telescope Making* volume 1 – Chapters A.1.5, A.1.6.

[4] Jean Texereau, *How to Make a Telescope*, 2nd English Edition, (Willmann-Bell).

[5] Karine and Jean-Marc Lecleire – *A manual for amateur telescope makers*, (Willmann-Bell).

[6] Ken Slater and Nils Olof Carlin http://www.atmsite.org/contrib/Carlin/couder/

[7] Harold Suiter – "Digital knife-edge test reduction" (*ATM Journal* volume 2 chapter 13)

[8] Jim Burrows – http://home.earthlink.net/~burrjaw/atm/atm_math.lwp/atm_math.htm ☆

# Astronomy Education Milestone in Hermanus

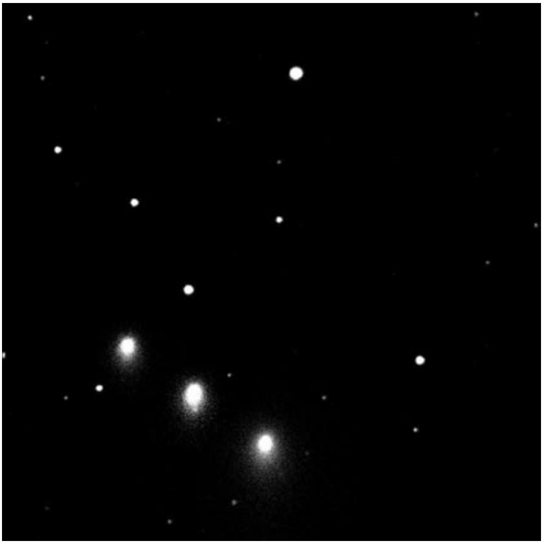
Pierre de Villiers, Hermanus Astronomy Centre

A milestone in Astronomy Awareness and Education in South Africa was achieved during October when Hermanus Centre members, together with science teachers and learners from Hermanus High School and Qhayiya Secondary School, saw "first light" on the 1,2m MONET North telescope at the McDonald Observatory, Texas via the internet from the Hermanus High School's computer room. This all happened under the capable, enthusiastic and patient guidance of MONET Project Leader Dr Rick Hessman of the Institut für Astrophysik, Göttingen, through a Skype link to his home in Göttingen, Germany.

The first session's main objective was to teach HAC members how to use this priceless educational resource "without breaking it" when using it without supervision, which was achieved in convincing fashion. Even though the "seeing" was not good – "pretty bad" in Rick Hessman's words – the experimental images recorded during the session are spectacular from an amateur's perspective. The photo of the tiny (56″ x 48″), dim (12th magnitude) planetary nebula NGC1501 in Camelopardis illustrates the point (see cover picture).

A second session three weeks later provided proof positive of Murphy's Law that everything that can go wrong – will! No internet connection forced transfer from the first-choice school location to a member's business office where the requisite software (Firefox, ImageJ and Skype) had to be installed before being able to log in more than two hours later than planned. The important but time-consuming process of focusing via the FHWHM ("Full Half-Width at Half Maximum") parameter proved very successful. Seeing was better than during the first session and a series of 53 x 3s exposures of comet 103P Hartley 2, together with the requisite dark frames, was recorded. The next object was the planetary nebula NGC2371. A clear filter

**The MONET North telescope at McDonald Observatory, Texas, used for the observation**



**A series of three exposures of comet 103P Hartley 2, showing its relative movement against the stellar background**

Several important lessons were learnt from the Centre's first experiences with what all participants regard as an awesome facility: Briefing the learners involved on what to expect from a session, preparing the control site in terms of requisite software (Firefox web browser, MONET Toolbox, ImageJ image processing software), two projectors for the control PC and the one doing the image downloads and initial processing, delegating the various parallel responsibilities of telescope control, weather and webcam monitoring, object coordinate acquisition and semi-realtime image downloads and ImageJ processing to different PCs and rotating groups of scholars under the supervision of a Centre member. The learning curve for all involved has hardly flattened from the near-vertical!

60s exposure looked quite good, but after 10 dark frames and before the colour filter exposures could be made the McDonald weather station link to the telescope was lost, which resulted in the telescope automatically closing down. End of session!

Sadly the only output from this truncated session are a movie clip of the comet moving through the background stars (on the website www.hermanusastronomy.co.za) and the attached composite photograph showing the 14.5 magnitude comet's movement relative to the background. Disappointing but still spectacular for all involved – notably the learner "controlling" the professional instrument almost 14 000 kilometers away!

It is the Hermanus Centre's intention to determine the most effective way of utilising such a priceless resource to foster an interest in astronomy in particular – and science in general – among typical South African learners. Once clarity on this has been obtained in the minds of the learners involved, this experience will be shared through the auspices of the SAAO and the ASSA to extend the benefits of this fantastic resource to as many secondary and tertiary education facilities in South Africa as is possible.

**Hermanus Centre members (unless otherwise indicated) Auke Slotegraaf, Lindelwe Nonqane (Quayiya SS), Bonke Xakatha (Quayiya SS), Wade Banks (Hermanus High School), John Saunders, Johan Retief, Martin Loynes, Piet Hoffman (Hermanus High School), Deon Krige and Pierre de Villiers**

It is interesting to note that this whole initiative originated almost by chance from a comment by Dr Amanda Gulbis – after addressing a Hermanus Centre meeting on "Occultations of Pluto" – that she had used the MONET telescope in her research. Subsequent enquiries confirmed that the facility could be used by anyone, subject to the proviso that the image streams are used exclusively for educational purposes.

The main credit for this amazing programme and facility is due to Dr Frederic ("Rick") Hessman and his team at the Georg-August Universität, Göttingen, as well as the Krupp Foundation for their foresight in recognizing the potential of such a facility, and the competent enthusiasm with which they are implementing their vision. Rick's team warrants salutation!

The effective use of such a powerful astronomy education resource makes input from all relevant parties in South Africa mandatory. The Hermanus Centre recognizes its pioneering experience in this regard and pledges its wholehearted support in ensuring that this wonderful resource is optimally utilized in the promotion of astronomy awareness and expertise in South Africa.

As recently reported in *MNASSA*, the establishment in Cape Town of the IAU Office for Astronomy Development among disadvantaged learners could hardly have been timed more fortuitously than now! May both developments contribute significantly to fostering an interest in astronomy (in particular) and science (in general) in South Africa. ☆

# The Boyden Observatories Museum – Project Overview

H.J. van Heerden, D.P. van Jaarsveldt, M.J.H. Hoffman

**Abstract**: *The planned museum at Boyden about the history of the observatories in Bloemfontein as well as the Roberts archives and all the most important contributors to astronomy in the region will be discussed. The layout, current progress, future plans, the people involved and all relevant information will be shown. A conclusion about the possible impact and the possible events around the opening will then be made.*

**Introduction**:

The first official announcement of the Boyden Observatories Museum Project. The Boyden observatory is a unique facility and has a strategic location, therefore the development is important. Boyden not only has strong research, public and educational outreach programs, but also has a strong heritage in terms of its impact on astronomy in the region and internationally. This is one of the main reasons behind the establishment of a museum at the Boyden Observatory, to preserve, display and remember this heritage. A strong team has therefore been taking shape the last year to tackle this prestigious project.

**The Team**:

- MJH Hoffman, DP van Jaarsveldt, HJ van Heerden, B van Zyl – Boyden Bloemfontein SA
- Keith Snedegar – Utah Valley University
- Allison Doane – Librarian, Harvard Plate stacks
- Owen Gingerich – Harvard
- John Butler – Armagh
- David Andrews – Armagh
- Kevin Schindler – Lowell
- Pat Seitzer – Michigan
- Rudi Lindner – Michigan

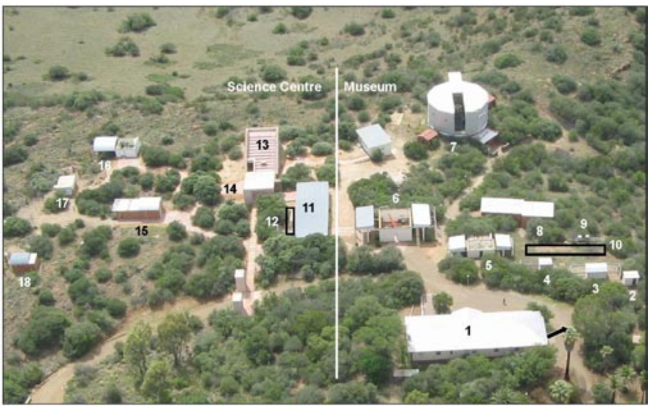



**Fig.1 Boyden Museum terrain layout**

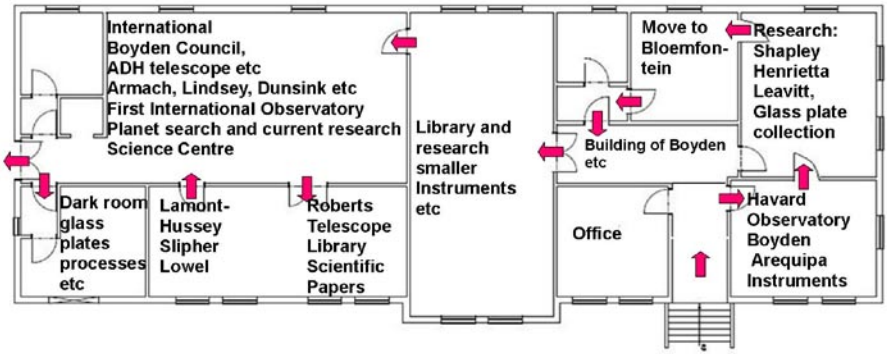



**Fig. 2 Boyden Museum main building layout**

**The Layout**:
The museum will have an extended layout in terms of the exhibits. The Boyden Observatory grounds can in evect be split into two specific sections: An Science Centre and The Museum section, with the current research components spaced throughout (Fig. 1). The main building (#1 in Fig. 1) lends itself to a further division for specific exhibits on locations, people, research and instruments (Fig. 2).

The main aim of the project is to not only preserve and recover the heritage and artifacts of the different components involved, but to expand the attractiveness of the Boyden Observatory in terms of its tourist attraction and teaching capabilities.

Milestones achieved thus far are the following:

- Partial cleanup and sorting of "stuff" in the individual store rooms.
- Partial archiving of old journals and magazines.
- Refurbishing of the hardwood floors in the Main and 13-inch Boyden Refractor buildings.
- Recovering of the main camera's used on the Lamont-Hussy 27-inch refractor telescope.
- Recovering on one of the Roberts telescopes.
- Recovering and partial restoration of a number of smaller instruments.

**In Conclusion:**

- The museum will attract a lot of local and international tourists and interest.
- Protection of historical astronomical artifacts and documents.
- Recognition of the important heritage created by the different individuals and institutions involved.
- Nice place to be!

Possible International conference/ symposium: "The discovery of the universe and its influence on the human race - religion, philosophy, science." ☆

# *Grus - an Elegant Starry Bird*

by Magda Streicher
*magda@pixie.co.za*

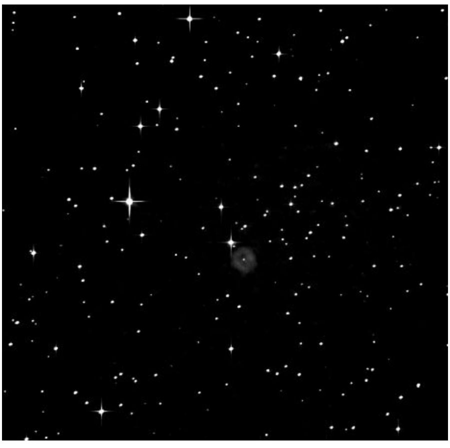
Image source: Stellarium.org

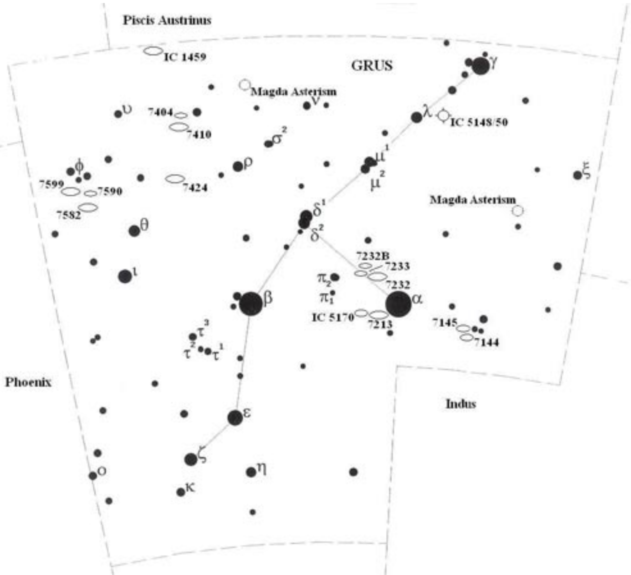
Slender and lithe forms are typically associated with wild birds. When we look up at the stars we also find interesting shapes and patterns that appear slender and lithe. Combining the world of the wild and the world of the night sky, it is not that difficult to find a constellation like Grus the Crane presenting itself to our imagination. In real life the Blue Crane is very special, and is our South African national bird.

Known by the Germans as *der Kranich,* was introduced by Johann Bayer in 1604. Bayer (1572–1625) was a German lawyer and amateur astronomer who assigned to bright stars of a constellation a letter of the Greek alphabet: alpha the brightest, beta the next brightest and so on. The French and Italians called the constellation *la Grue* and in England it had the popular names Flamingo and Stork.

The eye of this beautiful starry bird is represented by the magnitude 2.9 gamma Grus, a lovely white prominent star in the far north-west of the constellation. Follow the line of stars southwards to trace the outline of the bird. Delta$^1$ and Delta$^2$, at magnitudes 3.9 and 4.1 respectively, form a beautiful naked-eye double star more or less in the middle area of the starry line, but a dark night sky is recommended for splitting them with the naked eye.

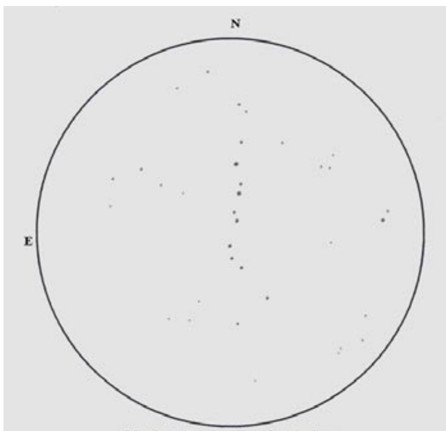
Perhaps the most famous object in Grus is the exceptional planetary nebula **IC 5148/50**, the only one in the constellation. This beautiful object is situated only one degree west from magnitude 4.4 lambda Grus along the long and slender neck of the bird. The ghostly round nebula appears smooth with a dark, hollow central region. The central star shows up well in photographs but, surprisingly, the author could not see it, and is not the first to have reported its elusiveness during observation. Higher power and an oxygen (O$^{III}$) filter highlights it's knotty and dusty, une-






ven surface. There is a definite brightening along the eastern and western edges, with the eastern edge perhaps a little brighter. The nebula's colour ranges from pale white to light grey, with a magnitude 11 star situated just outside its southern edge. The planetary is situated in a lovely field of view with a myriad of faint stars (see image by Lucas Ferreira). Brian Skiff, an astronomer at Lowell Observatory in the United States, on one of his visits to Chile in 1993, called it "a southern showpiece". He noted that oxygen ($O^{III}$) and UHC (ultra-high contrast) filters gave similar contrast enhancements, but that the UHC was better at showing the annularity, which was subtle. The object was mistakenly catalogued twice in the 19th century, as both IC 5148 and IC 5150, having been independently discovered by astronomers Walter Gale from Australia and Lewis Swift from the USA.

During an asterism search a long string of stars about 5 degrees north-west of alpha Grus was found, and although not yet confirmed as a Streicher object in the *Deep Sky Hunters Catalogue*, this **STREICHER** asterism is probably one of the longest star strings seen so far – almost 20 arc minutes long and stands out quite well against the star field (see sketch). The similar magnitude 10.5 stars running closely spaced from north to south all display a yellow to orange colour which is quite outstanding. The brightest star,

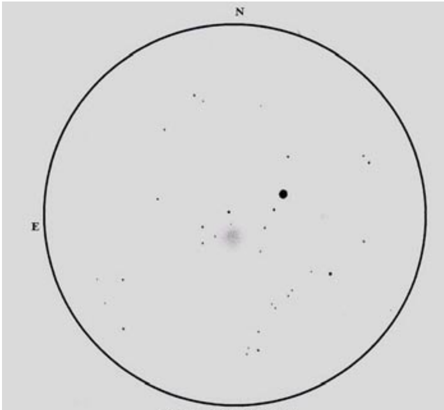



Magda Asterism - HD 2071 06 - Grus

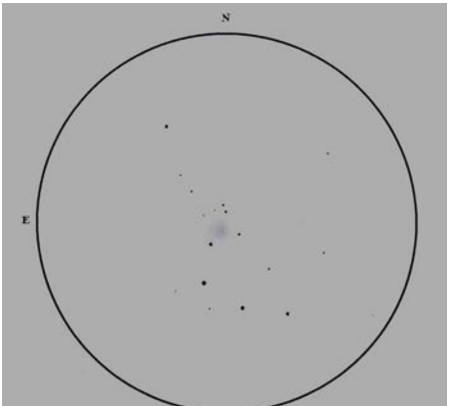
at magnitude 9.5 (HD207082), is situated just north of the string's centre. It is quite amazing! The Crane's right wing, as seen from the southern hemisphere, is reflected by the brilliant white magnitude 1.7 alpha Grus, also known as Al Nair. It is also a double star with a magnitude 11.8 companion and a separation of 28.4" in a position angle (PA) of 149.

Only 16 arc minutes to the south, and in the shadow of next-door neighbour alpha Grus, we find the elliptical galaxy **NGC 7213**. Rounder than round and relatively bright, it looks somewhat like a large star out of focus. The galaxy brightens up to an outstanding broad nucleus, the focal impression of the galaxy (see sketch). No fewer than seven galaxies can be seen in a one degree field of view. The Australian Professor Ernst Johannes Hartung (1893–1979) compares the object to a remote globular. Hartung first produced a comprehensive and highly respected guide for southern observers in 1968. The galaxy NGC 7213, which is also a member of the Grus cluster of galaxies, was discovered by Sir John Herschel during his stay at the Cape of Good Hope between the years 1834 and 1838. Just 33 arc minutes further east from NGC 7213 the exceptional, unmistakable pencil-like galaxy **IC 5170** can be seen as an oblong shape in an east to west direction. The galaxy brightens gradually towards the central area.

Two more galaxies can be found within 2.7 degrees south-west of alpha Gruis. The more northern of the two is **NGC 7145**, situated in a lovely star field. The galaxy displays a bright, round, diffuse glow without any detail, but the lovely star field compensates for the lack (see sketch). Only 23 arc minutes further south is **NGC 7144**, which reflects the same round glow, but with a considerably brighter nucleus. The two galaxies form a triangle with a pair of magnitude 12 stars to the north-west. A double star worth paying a visit,

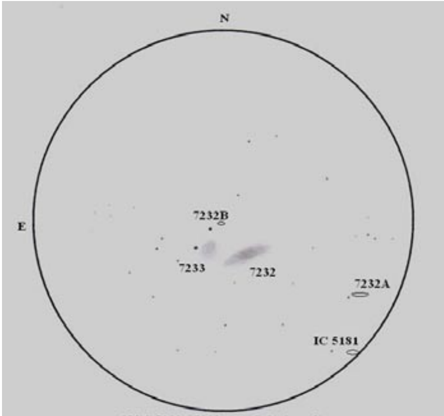


NGC 7213 - Galaxy - Grus



NGC 7145 - Galaxy - Grus

pi[1] and pi[2], situated 2.7 degrees north-east of alpha Gruis, displays a most outstanding crimson red and silvery white colour combination. The red carbon star pi[1] fluctuates from magnitude 5.4 to magnitude 6.7 over a period of 150 days. Carbon build-up in the star's upper atmosphere dims and reddens its light.



NGC 7232 - 7233 ext - Galaxies - Grus

A bunch of galaxies is situated between this outstanding double star and alpha Grus. The focus around the trio of galaxies is a pair of magnitude 8.5 yellow-coloured stars situated virtually between the star cities. **NGC 7232** appears as a soft, faint and elongated thin dust lane in an east to west direction, with a bright centre. The galaxy is also the largest of the three, and displays a soft, hazy outer envelope. The companion galaxy **NGC 7233** to the east and closest to the pair of bright stars is nothing more than a soft, wispy glow (see sketch). The very faint member NGC 7232B with a magnitude of 14.4 north of the pair of bright stars was not visible. Three more galaxies, NGC 7232A, IC 5181 and IC 5171, are situated a further 25 arc minutes to the west.

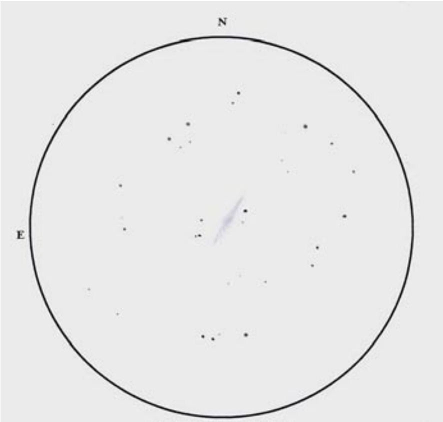
The far eastern part of the constellation houses a trio of galaxies one degree west of the Phoenix constellation and 1.4 degrees south of magnitude 5.5 phi Gruis. **NGC 7599** is the eastern partner and displays a cigar shape in a north-east to south-west direction. High power reveals the north-eastern tip to be somewhat frayed at the edges and hazier than the more define south-western tip. **NGC 7590**, about 5 arc minutes to the west, is the smallest of the three, and although faint, it is relatively easy to spot. The surface brightness of this galaxy works up to a quite outstanding oval nucleus. The south-western member, **NGC 7582**, the largest and brightest of the trio, displays a relatively bright oval in a north to south direction. High power reveals a very hazy edge, perhaps indicating a spiral structure with a small, point-like nucleus. The Grus Trio, as it is also known is quite outstanding against the star field, covering an area of only 18 arc minutes. Two other members in the area can be glimpsed: NGC 7632 to the east and NGC 7552 to the west. I cannot emphasise enough what an enormous privilege it is to be able to observe galaxies.

Situated between the Crane's eastern feathery wing about 4 degrees west of the Grus Trio, the galaxy **NGC 7424** portrays a beautiful open spiral with a very small, bright nucleus. Although it is difficult to detect the spiral arms it is by no means impossible. With the use of averted vision, structure can be glimpsed on the hazy surface. Averted vision is a way of gazing off to one side of the field of view to use your eye's sensitive rods to detect fainter specks of light. The supernova 200lig situated in NGC 7424 shed valuable light on the Wolf Rayet stars.

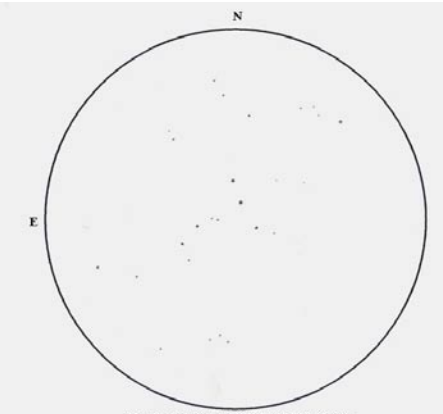
Barely 1.5 degrees further south and 2.5 degrees west of magnitude 5.7 upsilon Gruis, yet another galaxy **NGC 7410** (Bennett 129a) displays a bright, large and elongated spindle in a north-east to south-west direction. This edge-on galaxy is relatively easy to spot and gradually brightens towards a small nucleus. The edges of the galaxy are enveloped in haziness. The south-eastern side appears fainter and thinner, with a magnitude 12.5 star near the northern tip. Although it displays a smooth surface, higher power brings out mottled areas. A double star graces the star field just south of the galaxy (see sketch). In some ways the galaxy reminds one of a smaller version of the galaxy NGC 253 in the constellation Sculptor. Barely seen was the light speck of the companion galaxy NGC 7404 situated only 22 arc minutes north of NGC 7410.

There are few experiences that are as pleasurable as coming across an incidental star asterism in the course of observations. Not yet confirmed in the *Deep Sky Hunters Catalogue*, but a **STREICHER** asterism with a difference, the capital letter J is easy to distinguish against the backdrop of the relevant stars, with the top horizontal bar running from north-east to south-west (see sketch). This little surprise is located 3 degrees north-west of NGC 7410. The brightest star in this grouping is magnitude 9 (HD 2148 75). Seeing is believing!

**IC 1459** (Bennett 129b) is almost 80 million light years away and situated on the boundary between the constellations Grus and Piscis Austrinus. It is also one of the



NGC 7410 - Galaxy - Grus



Magda Asterism - GSC 8004 199 - Grus

brightest IC objects listed in catalogues – even brighter than most of the NGC objects in Grus. The galaxy displays a faint wisp of light surrounded by a halo of haziness. Slightly tilted in a south-western to north-eastern direction, the glow surprisingly displays a bright stellar nucleus with high power. The two stars positioned on either side of the galaxy reminds one of the constellation Aquila, with the galaxy occupying the spot of alpha Aquilae, or Altair by its common name. With even higher power and averted vision it is just possible to distinguish the galaxy IC 5264 pairing to the south-east. What makes IC 1459 so special is the fact that it is situated virtually in the centre of a string of a dozen galaxies spanning 2 degrees at approximately equal distances from one another. The string of galaxies runs in a curved line into the constellation Piscis Austrinus, with the most northern IC 5270 and IC 5273 to the south. In dark, ideal dark night sky conditions away from any intrusive city lights, it can be a challenge to pin down this string of galaxies.

The plains of the Karoo are the home of the southern crane, but what captures and holds the observer's attention is this bird's graceful flight. To study a constellation associated with such a splendid bird is an enormous privilege and pure pleasure. Grus is arguably one of the most beautiful constellations that the southern hemisphere has laid at our proverbial front door. ☆

| **Object** | **Type** | **RA (J2000.0)** | **Dec** | **Mag** | **Size** |
|---|---|---|---|---|---|
| Streicher | Asterism | $21^h47.8$ | -44º09′ | 10 | 20' |
| NGC 7144 | Galaxy | 21 52.7 | -48 15 | 10.9 | 3.2'x3.0' |
| NGC 7145 | Galaxy | 21 53.3 | -47 53 | 11.1 | 2.6'x2.6' |
| IC 5148/50 | Planetary Neb | 21 59.5 | -39 23 | 11 | 120" |
| NGC 7213 | Galaxy | 22 09.3 | -47 10 | 10 | 4.8'x4.2' |
| IC 5170 | Galaxy | 22 12.5 | -47 13 | 13 | 1.8'x0.8' |
| NGC 7232 | Galaxy | 22 15.7 | -45 51 | 11.6 | 3.0'x1.1' |
| NGC 7233 | Galaxy | 22 15.8 | -45 51 | 12 | 1.8'x1.4' |
| Streicher | Asterism | 22 41.6 | -38 09 | 8 | 12' |
| NGC 7410 | Galaxy | 22 55.0 | -39 41 | 10.5 | 5.8'x1.7' |
| IC 1459 | Galaxy | 22 57.2 | -36 28 | 10 | 4.9'x3.6' |
| NGC 7424 | Galaxy | 22 57.3 | -41 04 | 10.2 | 7.6'x6.2' |
| NGC 7582 | Galaxy | 23 18.4 | -42 22 | 10.1 | 6.9'x2.6' |
| NGC 7590 | Galaxy | 23 18.9 | -42 14 | 11.3 | 2.9'x1.2' |
| NGC 7599 | Galaxy | 23 19.3 | -42 15 | 11.1 | 4.7'x1.5' |

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**Book Review**



**Deep-sky Delights:** Magda Streicher



**Miscellany**

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

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