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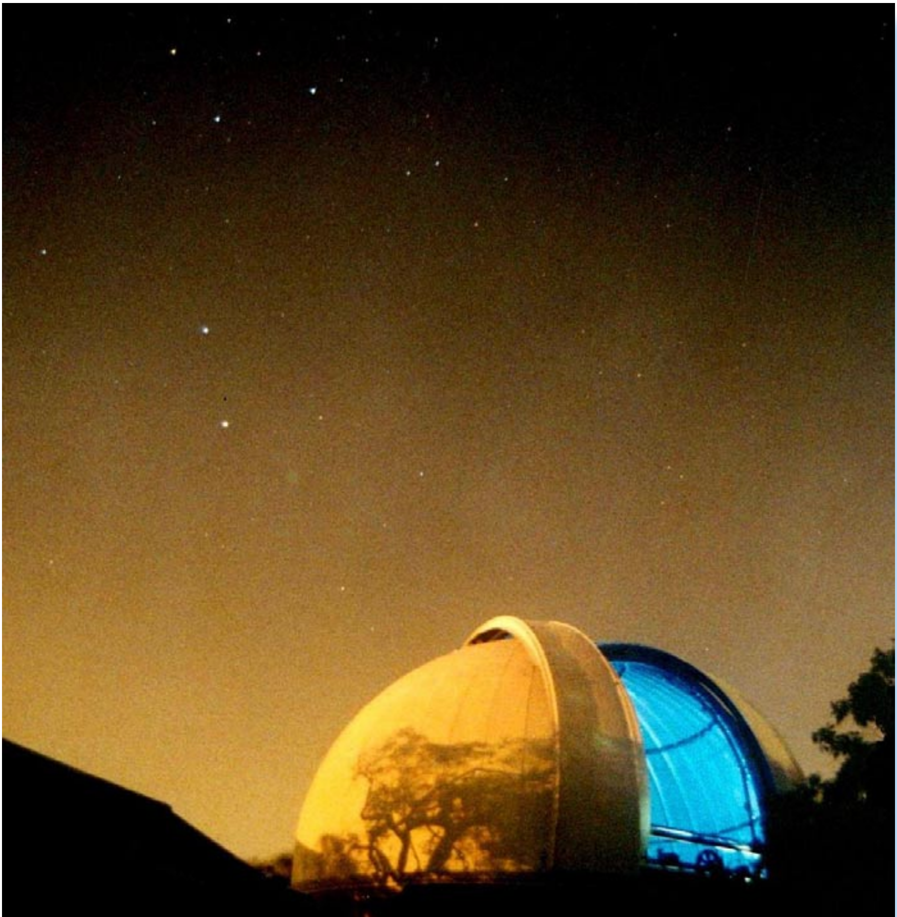

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From January 2011 *MNASSA* is available free of charge on the Internet. Paid subscriptions will no longer be available (see *MNASSA*, August 2010, p.113).

contributions

MNASSA mainly serves the Southern African astronomical community, professional and amateur. Articles and papers may be submitted by members of this community and by those with strong Southern African connections, or else the papers should deal with matters of direct interest to this community. Due dates for contributions are:

Vol 71 Nos 11 & 12 (Dec 2012 issue), 01 Nov 2012
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Articles in *MNASSA* appear in the NASA/ADS data system.

The McClean Telescope

The McClean telescope, after its refurbishment in November 2011, (see *MNASSA* Vol.71 nos 3 & 4, April 2012) set against the the Southern Cross and the Pointers. This grand old lady of astronomy is fondly remembered by many and it did excellent science for nearly 100 years. The Editor having taken the last photographic image (using a Kodak 103 Ja plate) in April 1996 of a lunar eclipse for a paper on Alexandrian Astronomy. Image: Wim Filmalter

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Monthly Notes of the Astronomical Society of Southern Africa

Vol 71 Nos 9 & 10 October 2012

assa news

ASSA Symposium 2012

The ASSA Symposium was held in the 1896 Building and the Auditorium at the South African Astronomical Observatory in Cape Town from Friday 12, to Sunday 14 October 2012.

The theme of the symposium, "Looking back, looking forward", reflected the significance of 2012. On the one hand, organised amateur astronomy in South Africa turns 100 this year, which was duly celebrated at the symposium. On the other hand, the decision to host the major part of the Square Kilometre Array in Africa promises a bright future for astronomy on the continent. So the symposium focussed on past and future of astronomy alike.

Friday 12 October

LRGB Astrophotography Processing Workshop

Dale Liebenberg presented this workshop in the 1896 Building at SAAO in two parts, separated by a lunch break. The morning session was on Data Processing, in which Dale discussed and demonstrated the typical workflow in processing a RGB raw image from sub frames. This covered; dark, bias and flat-field calibration, dithering and alignment (registration), normalisation, data rejection, group combine, deconvolution and RGB combination.

The afternoon session, titled Image Processing, was a hands-on workshop with attendees participating on their laptops using Adobe Photoshop CS 4 or later. Data was provided and the topics included; file formats and bit depth, importing raw data and data conversion, working with layers and layer masks, non-linear stretching, noise reduction, colour manipulation, sharpening, finishing and other tools used in astro-image processing.

After the workshop was completed, delegates paid a visit to the Iziko Museum in Queen Victoria Street in Cape Town and were also treated to a show in the Iziko Planetarium.

The remainder of the Symposium took place in the SAAO Auditorium. Video


Delegates admire the projector at the Iziko Planetarium.

transcripts of the above mentioned workshop and these talks were compiled by Auke Slotegraaf and uploaded to YouTube and can be accessed at http://symposium2012.assa.saao.ac.za/programme/

Saturday 13 October 2012

Morning Session. Chair: Lia Labuschagne (Cape Centre of ASSA)

(09:00): **Brief introductory remarks** by Chairperson.

(09:05): **General welcome** by Ian Glass, president of ASSA.

(09:15-09:55): **Justin Jonas.** SKA and Rhodes University.
The Square Kilometre Array: Africa has been selected to host the mid-frequency dish array of the SKA, which will be one of the largest scientific infrastructures in the world. This presentation gave and overview of the activities of the SKA South Africa project, including preparation of the site proposal, the design and implementation of the MeerKAT, the Human Capital Development Programme, the African VLBI Network, and the C-BASS and PAPER experiments.

(09:55-10:40): **Jasper Horrell**. **Interesting Technical Aspects of the SKA**: This talk was partly a tutorial in nature and also focused on some of the technical challenges that radio astronomy and the SKA brings. We looked at parts of the signal chain for a radio telescope array, how this links to optical telescopes, and focused on imaging challenges in particular. Also addressed were some of the computing/data rate issues that accompany the new instruments.

(10:40-11:10): **Maciej Soltynski.** ASSA Scholarship Convenor.
Galaxy Clusters: Galaxy clusters are the largest known gravitationally-bound objects in the universe and form the densest part of the large-scale structure of the universe. Their nature and formation were discussed, as well as how observations involving galaxy clusters have already, and will in the future, contribute to our understanding of dark energy.

(11:30-12:00): **Dale Liebenberg.** Port Elizabeth.
Astrophotography from a backyard observatory: Since the late 1990s, digital photography and advances in telescope

technology and associated software have allowed amateurs to not only take visually pleasing images of space, but also contribute to science. This talk gave a general overview of what is now possible for amateurs to achieve. Based on the Dale's own experience, topics included data capturing, image processing and typical hardware requirements.

(12:00-12:30): **Auke Slotegraaf**. Somerset West. Chairman, ASSA Deep-sky Section.

Some open clusters I didn't discover: Open clusters are an important species of galactic inhabitants. Their study sheds light on fundamental galactic properties and gives insights into stellar evolution. Before they can be studied, however, they need to be discovered. This talk briefly outlined this identification process, and described the contributions made by amateur astronomers in compiling a more complete census of galactic open clusters.

(12:30-13:00): **Willie Koorts**. SAAO Cape Town.

Geared to turn Photons into Paper: When visiting the Sutherland Observatory one is astounded by the sheer number of domes and hosted experiments populating the plateau today. The three domes present during the official opening of the Observatory on 15 March 1973 have since grown to 20. Although the number of hosted experiments have only increased from two to six, they got much more sophisticated. This talk, richly illustrated by photographs, was a follow-up of a recent *MNASSA* article (Vol. 71, nos 5&6, June 2012, p.120). It gave and overview of the facilities on the Sutherland hilltop today, including the Sutherland Visitors' Centre.

Afternoon session. Chair: Logan Govender (Chair, Durban Centre of ASSA)

(14:00-14:30): **Barbara Cunow**. Pretoria Centre.

Doing astrophotography with a DSLR on a tripod: Barbara presented images of the night sky taken with a modified DSLR on a tripod in urban regions in both the southern and the northern hemispheres. Her images obtained so far included all 88 constellations, all 110 Messier objects and a number of NGC and IC objects down to about 10th magnitude. Each picture is a

Attentive audience listening to a presentation, with Auke Slotegraaf in the back (with the hat) videoing proceedings! These videos are available on the ASSA website.

combination of a large number of short exposures, and she showed the procedures used for taking and processing the individual images and how the light pollution contribution is removed from the data. This project is an example of what can be achieved in astrophotography with minimum equipment from an urban site. The techniques presented are an effective tool to get people interested in the subject no matter where they are.

(14:30-15:00): **Johann Swanepoel**. Garden Route Centre.

The shaping and testing of two 20-inch optical telescope mirrors: The purpose of the presentation was to share Johann's experiences and knowledge gained in the making of two 20-inch F/4.3 telescope mirrors. It covered details of a versatile machine which he built for the grinding, polishing and figuring of the mirrors. It further included details of the various full and sub-diameter tools he made and used. An explanation was presented on the optical testing methods used throughout the figuring process, including an improved application of the Foucault test and the corresponding digital data reduction techniques.

(15:00-15:25): **Allen Versveld.** Pretoria Centre.

Astronomy Online: Astronomy outreach is understood to be vitally important, both to inspire future astronomers and as a popular and accessible means to offer a scientific perspective to the general public. The various incarnations of the Internet offer a range of new opportunities to conduct this outreach, letting us reach larger and more diverse audiences than ever before. The online astronomy space is currently dominated by American voices, but there is still plenty scope for local writers to speak to South Africans about our unique skies, our vibrant amateur astronomy community and big astronomy projects in Southern Africa.

(15:25-15:50): **Neville Young**. Pretoria Centre.

Lessons Learned in Outreach: In his 25 years of active involvement in the Pretoria Centre of ASSA, Neville have thoroughly enjoyed interfacing with scholars and the general public. This interaction has led to an understanding of what the public wants to know and how to explain astronomy concepts to them. Capturing the attention of students with breath-taking views through the telescope and quoting huge numbers no doubt impresses, but leaving the students with a genuine understanding that they can take away with them and use as a base towards a further appreciation of astronomy and science requires particular techniques. He used his experience to develop models which effectively replace 30 minutes of words and much confusing arm waving. This talk presented the lessons learned which form the basis of his approach to outreach.

(15:50-16:05): **HJ van Heerden**. University of the Free State.

ASSA's contribution to Bloemfontein's Two Observatories' Project: Bloemfontein's Two Observatories Project was launched in 2011 by the Physics Department at the UFS in close collaboration with ASSA Bloemfontein and the Free State Department of Economic Development, Tourism and Environmental Affairs (DETEA). The aim of the project is to preserve Bloemfontein's two observatories, namely, the Boyden Observatory and the Lamont Hussey Observatory, and to develop these facilities for academic, public and educational use. The last 20 years have seen a rapid revival of astronomy in Bloemfontein. Boyden Observatory was upgraded in several different phases, and included the refurbishment of the Boyden 60-inch telescope. An active astrophysics research group was established at the UFS. At this time, a long-held dream to establish a planetarium in Bloemfontein is about to be fulfilled at the old observatory on Naval Hill. This talk outlined the involvement of ASSA in public and educational events, including astronomy fairs and other outreach events, renovation and improvements of old telescopes, and finally, in historical research.

Chatting and meeting old friends over a cup of coffee.

(16:30-17:00): **Keith Gottschalk**. Cape Centre, UWC.

Astronaissance – Communicating Astronomy and Space to the African Imagination: Astronaissance neatly conceptualizes the crossover between the African Renaissance, the revival of Astronomy in Africa, and the rise of Astronautics and cognate space sciences . Story-telling, painting, engraving, writing, and above all, viewing the heavens above, have always been amongst the strategies for communicating this excitement and wonder. Today the Internet, learned societies, media, and public outreach projects are crucial when, for the first time ever, a majority of Africa's people now live under the light-polluted skies of our continent's towns and cities. Space-related products and services are woven into the fabric of our daily life as never before. Policy-makers and allocators of resources need to see as essential to their strategy communicating to Africa's citizens, voters, and taxpayers, the necessity of Astronomy, Astronautics, and the other space sciences.

(17:00-17:45): **John Menzies**. SAAO.

Extrasolar Planets: Over 800 extrasolar planets (planets associated with stars other than the Sun) have been discovered by a variety of methods. This talk gave an outline of the different detection methods, concentrating on those techniques employed by several different programmes at Sutherland.

(17:45-18:05): **Magda Streicher.** Polokwane.
Collection of Pencil Sketches of Astronomers: Twenty-three original pencil sketches of astronomers who have left their mark in astronomical history, were hand-drawn for Magda by Kathryn van Schalkwyk to be used in her recent book. A brief remark were made about every figure. These included people such as Barnard, Bennett, Herschel, Abell, Overbeek, Messier, Farell, etc. During the proceedings, Magda presented this collection to the President of ASSA, Ian Glass, as a contribution to the Observatory Library.

Past ASSA president, Magda Streicher (right), presented current ASSA president, Dr Ian Glass, with a copy of her book for the SAAO library.

Evening session.

(20:00-20:45): **Ian Glass. President of ASSA.**
Public talk: Nicolas-Louis de La Caille at the Cape: In 1751-53 Nicolas-Louis de La Caille of the Royal Academy of Sciences in Paris was the first important scientist to visit the Cape. At the age of 39 he came to the Cape and built an observatory close to Rogge Bay, near the present-day Strand- and Heerengracht streets. From this he surveyed the southern sky through a telescope: the first systematic survey made in either hemisphere. He named fourteen new constellations after the scientific instruments of the time, except for one, Mensa or Table Mountain. Other scientists in France had just found that the Earth is not round, but is flattened towards the North Pole. La Caille decided to measure its shape in the south by means of astronomical observations and a ground-based survey from Cape Town to the Piketberg. He was astonished to find that the planet seemed to be slightly pear-shaped. La Caille kept a most interesting journal of his stay at the Cape containing, besides scientific notes, many comments on the colonists, the natural surroundings and other matters. His precise writing avoided the sensationalism of earlier visitors.

This talk was followed by telescope viewing and a tour of Observatory, McClean telescope and Astronomical Museum until about 21:30.

Sunday 14 October 2012

Morning session. **Chair: Case Rijsdijk (Chairman, Garden Route Centre and Editor of MNASSA).**

(09:00-09:30): **Chris de Coning**. Historical Section, ASSA.

Cape Astronomical Association: Origins of ASSA: The Cape Astronomical Association was formed 100 years ago, in October 1912. As far as we know, this was the first astronomical association in South Africa. The initiative resulted from public interest in astronomy after the re-appearance of Halley's comet the previous year. From the beginning, the society was a close co-operation between amateur and professional astronomers. In fact, the founding meeting held by amateurs, was postponed in order to invite professional astronomers to join. SS Hough, Astronomer Royal at the Cape of Good Hope, became the first Honorary President. Ten years later this association gave rise to the Astronomical Society of South Africa (ASSA). The talk also discussed the ASSA archives housed in Cape Town.

(09:30-10:00): **Anthony Lelliott**. Wits University.

Astronomy and the School Curriculum in South Africa: The presentation provided an analysis of the current South African school curriculum in terms of astronomy content. When the curriculum was revised in the 1990s and early 2000s, astronomy was moved from the geography curriculum into the natural sciences. At the primary and junior secondary school level, basic astronomy content is relatively well covered in terms of the solar system and 'space science', with relatively little reference to current issues that occupy astronomers and cosmologists. Further there is a paucity of astronomy in the FET level of schooling (grades 10-12) so that there is no sequence of conceptual development of astronomical topics from upper primary school to matric level. The presentation considered the issues raised by Adams and Slater (2000), Sadler (2001) and Pasachoff (2001, 2002) in the USA, regarding the sort of astronomy that should be taught at school and early tertiary level. In view of the positioning of South Africa as an astronomy 'hub', the consequences of the current status of astronomy in the school curriculum were discussed, and recommendations for its development made.

(10:00-10:30): **Case Rijsdijk**. Chairman Garden Route Centre and Editor, *MNASSA.*

Analogies in Astronomy and Physics: Both astronomy and physics often have to deal complex concepts and one way to address this problem is by using analogies. However, many of these frequently require a high level of prior knowledge, reducing, or even nullifying, the analogy's effectiveness. In addition it needs to be understood that any analogy serves a limited purpose: it cannot be extended beyond its intended objective. This talk used some well-known, not so well-known and new analogies in astronomy and physics, using usually understood prior knowledge.

(10:30-11:00): **Lia Labuschagne.** Chair, Cape Centre.
Talking about astronomy in the Internet era: In a world where busy people complain about information overload, it is a challenge to communicate effectively about any topic – and that includes science in general and astronomy in particular. People's communication needs, habits and preferences are changing rapidly – and at the same time there is a constant flow of useful data and interesting information about astronomy from a myriad of sources. Lia looked at the context of communicating about science and touch on some of the ways in which we can ensure that our communication is interactive, integrative and imaginative. She also touched on the potential of e.g. social media and mobile technologies to integrate with more traditional channels of communication and outreach.

(11:30-12:15): **Reneé Kraan-Korteweg.** Professor of Astronomy, UCT.
Large MeerKAT Survey Proposals: MeerKAT is South Africa's SKA precursor telescope and will consist of 64 SKA-ready radio dishes. This array of telescopes is currently under construction near Carnarvon in the Northern Cape and is expected to start full scientific operations in 2016. After a few words on the main science goals of the SKA, Reneé presented an overview of the large legacy survey projects that have been defined for MeerKAT, and gave more details on the ones that are UCT-led. This included some of the observations that have been performed to-date with KAT-7, the MeerKAT technology demonstrator.

(12:15-13:00): **David Buckley**. Southern African Large Telescope.
What's Up with SALT? This talk gave a review of SALT, the issues that were dealt with in getting it going, the first science results and the future possibilities.

Afternoon session. Chair: Maciej Soltynski, ASSA Scholarship Convenor.

(14:00-14:45): **Bruce Bassett.** African Institute of Mathematical Sciences, Muizenberg.
Observational Cosmology: a 30 year window. Bruce reviewed the amazing progress that has been made in observational cosmology over the past 15 years, discussed the big open questions and looked forward to the incredible changes that we can expect in the next 15 years.

(14:45-15:15): **Berto Monard**. Klein Karoo Observatory.
Observing programmes at the Bronberg and Kein Karoo Observatories: Two observatories and their environment were

presented and the observing instrumentation discussed. A brief introduction to variable stars and differential photometry were given. Five major observing programmes were described, observing results shown and merits discussed. Berto's presentation was richly illustrated with photographs and diagrams.

(15:15-15:45): **Greg Roberts**. Country member, Pinelands.
Tracking Space Debris-including Spy Satellites: Space debris is becoming an ever-increasing threat to artificial earth satellites. This talk described the amateur contribution to detecting such debris and outlined the various techniques used and results achieved.

(15:45-16:15): Nicola Loaring. SAAO.
The SAAO Outreach Programme: Nicola presented an overview of the outreach programme at SAAO. She outlined the aims of the programme and briefly summarised the initiatives used by the SAAO to reach learners, educators and the general public. She examined the scale of the programme and mentioned a few recent highlights, along with exciting future opportunities.

After these, the Symposium was closed by the President of ASSA, Ian Glass. ☆

Square Kilometre Array Celebration

Press release Issued by: SKA South Africa Project, on behalf of the Department of Science and Technology.

South Africa's President joined dignitaries, scientists, a large media contingent and members of the local community in the small town of Carnarvon today to celebrate South Africa's successful bid to build the world's largest scientific instrument – the Square Kilometre Array – in Africa.

President Jacob Zuma touched down by helicopter at the telescope site about 100 km from Carnarvon where the first seven telescope dishes are already operational. The newly appointed Minister of Science and Technology, Mr Derek Hanekom, as well as his predecessor who played a key role in securing the SKA bid for Africa, Ms Naledi Pandor, were part of the celebrations.

The President's visit to the SKA site has been described as a turning point for science in Africa, proving that African science enjoys support at the highest level. The support of the South African government has been recognised as a key factor in the country's successful SKA bid.

Following a tour of the dishes and a demonstration of the cutting-edge technologies involved in operating a modern radio telescope, President Zuma joined nearly 4 000 local residents in Carnarvon for a community event. There was huge excitement about the President's visit and he was welcomed enthusiastically by the large crowd.

"I am absolutely excited to be here and see this area making such a significant contribution to global science," the President told the crowd. "I'm also very happy to see young people speaking so confidently and passionately about the project, and already building their careers in science and technology."

"Welcoming the SKA to Africa is a major step towards using science and technology to transform African economies and allowing African countries to participate fully in the global knowledge economy," President Zuma said. "The SKA will propel our continent to the frontline of radio astronomy and it will open many doors

President Jacob Zuma listens to Dr Bernie Fanaroff (cr. Siyabulela Duda).

for Africa in decades to come." President Zuma congratulated the SKA South Africa team on winning the SKA bid and thanked them for the hard work that was necessary to achieve this.

"This is a fabulous celebration of the SKA project that we are proud to share with the people of Carnarvon and neighbouring towns, all South Africans and the rest of the continent, Minister Hanekom said. He thanked Minister Pandor for her hard work in leading the SKA project to the point where South Africa successfully secured the major share of this iconic radio telescope that will be designed and built over the next 12 years.
"The SKA is a game-changer for Africa, bringing about a science Renaissance across the continent," Pandor said. "The SKA has put Carnarvon on the world map! Let's continue using it to make South Africans proud and to inspire young people about a future in science and technology."

While KAT-7 – the seven prototype telescope dishes already in place on the Karoo site – is impressive, they will be dwarfed by the sheer number of telescope dishes that will blossom across the Karoo from 2013 onwards. Following the construction of 64 dishes that will make up the MeerKAT telescope, another 190 dishes will be added during phase 1 of the SKA from 2016 to 2019. By 2024 about 3 000 dishes will be spread across South Africa and its eight African partner countries, with about 2 000 of these at the core SKA site in the Karoo. The core site will also host a large number of flat mid-frequency antennas, each about 60 m in diameter – the so-called "fish eye lenses" that will be used for full-sky surveys.

The 64 MeerKAT dishes will form an integral part of SKA phase 1 – further recognition of South Africa's excellence in designing and planning the MeerKAT project and the success of its KAT-7 precursor telescope. During a recent visit to the Karoo site and the SKA SA's office in Cape Town, a review panel consisting of top scientists from around the globe said that they were "blown away" by the excellent work of the South African MeerKAT team. The first MeerKAT dish – about 13,5 m diameter and with a novel "offset" design – will be installed by the end of 2013. The new dish design will allow the telescope to be even more sensitive.

"This project is giving effect to our dream that Africa must become a global science and technology destination and that cutting-edge science will be done in Africa by African scientists," Pandor said. "Our SKA success is also reversing brain drain into brain gain by bringing top researchers to the continent to do cutting edge work on African soil."

"It was an enormous achievement for Africa to win the right to build the SKA here, but now the really challenging work starts," SKA project director Dr Bernie Fanaroff explained. "The implementation phase ahead of us, including the extensive infrastructure, engineering and computing solutions that the SKA will require, will present us with a series of formidable challenges."

He explained why the enormous data volumes that the SKA will generate are expected to extend the frontiers of technology and deliver numerous beneficial spin-off technologies. The SKA will require processing speeds up to 1 000 times faster than the best supercomputers available today, as well as novel approaches to computer programming and the processing of complex data.

"We are getting to grips with what is required and we remain confident that we will be able to deliver a successful SKA," Fanaroff said. "We are working closely with the international SKA Office."
Building the SKA will be a global project paid for jointly by all member countries, but the fact that the dishes and fish eye lenses will be built here in Africa, and most of it within South Africa, places local industry in a strong position to compete for these huge contracts.

"The success of KAT-7 has caught the attention of astronomers around the world," Prof Justin Jonas, SKA associate director explained. "KAT-7 was designed to be an engineering prototype to test systems and technologies for MeerKAT, but it is working so well that is it now in demand by scientists around the globe who want to use it for groundbreaking research."

Northern Cape Acting Premier Grizelda Cjiekella said that the Northern Cape Province is extremely proud to host the SKA, but that she was especially determined to use this project as a catalyst for encouraging young people in the region to work hard at science and mathematics at school so that they will be able to benefit from SKA bursaries to pursue SKA-related tertiary studies and become part of the SKA project team.

Jason Slaverse, grade 12 learner at Carnarvon High School, was also at the SKA site and the community event and spoke passionately about his dream to become an SKA scientist.

Minister Pandor thanked the media for their key role in sharing the SKA project with all South Africans and the rest of the world, emphasising how important public support for the SKA was in the success of the SKA bid. She encouraged journalists to continue reporting on progress with the SKA project to make all South Africans proud of the country's achievements with this project. ☆

Northern Cape Acting Premier Grizelda Cjiekella and enthusiastic grade 12 learner Jason Slaverse.

PAT Wild (1937–2012)

Case Rijsdijk

Peter Anthony Thornton Wild, affectionately known as PAT Wild, died on 23 September 2012 at the age of 75. The most notable feature of career was service – service to UCT for 37 years, to astronomy and later, to the Lavender Hill community. He served all with dedication, compassion and meticulousness. In addition he was an outstanding and patient teacher. I was privileged to have been a student of his.

He was born in Grahamstown on 18 April, 1937 went to Graham College after which he studied physics at Rhodes University. From there went to Manchester University and Jodrell Bank radio-astronomy laboratory where he got his PhD. He came to UCT in July 1963 where he taught and researched physics and astronomy until 1982, during which time he became Associate Professor of Astronomy. He was a committed and successful teacher and will also be a well-remembered student advisor in the Science Faculty.

When, in 1982, UCT started on its research-led initiative, he was persuaded to leave physics and astronomy. He spent the next 18 years giving leadership to the needs of researchers as the first Head of Research Administration, and from 1992 until his retirement in 1999 as Deputy Registrar, Academic and Research.

Outside his academic work he was also an active member of the ASSA. As its President from 1975 – 1976 and served on the MNASSA editorial board from 1980 – 1985.

He was also an active member of Rotary in Wynberg which got him involved in voluntary work at Lavender Hill High School for more than ten years. Here he set up the Friends Association of Lavender Hill High School, an Alumni organisation, to help with the school's fund-raising. He was also a role model for staff and an inspirational motivator, guide and mentor.

PAT was a warm and generous family man and is survived by wife Carole. They got married in 1965, and had four children; Jackie, Lauren, Robyn and Matthew. They had four grandchildren, the last a granddaughter, who was born shortly after he died.

When PAT retired from UCT in 1999, he remarked to the registrar, Hugh Amoore: "the great privilege [it was] to be associated with the best university in Africa for the whole of my life". To those who knew PAT Wild will say; what a privilege it has been to have known him. ☆

Presidential address: Forty years of infrared astronomy

IS Glass: ASSA President

Summary: This address is mostly a personal reminiscence concerning my career in infrared astronomy. It starts with a brief introduction to the infrared and its peculiarities. Next, the equipment that I developed or brought to South Africa is described. This is followed by a few of my astronomical high points. The last part deals with the era of infrared satellites and my later interest in data mining.

Introduction

When I was a PhD student at MIT in the 1960s, the space age had just dawned and it became possible for the first time to observe x-rays, gamma rays and the far infrared radiation that could not penetrate the earth's atmosphere. It was an exciting decade in other ways too, with the discovery of pulsars, quasars and many phenomena unknown to previous generations of astronomers. Thus my career began at a fortunate time, when it was easy to discover something new.

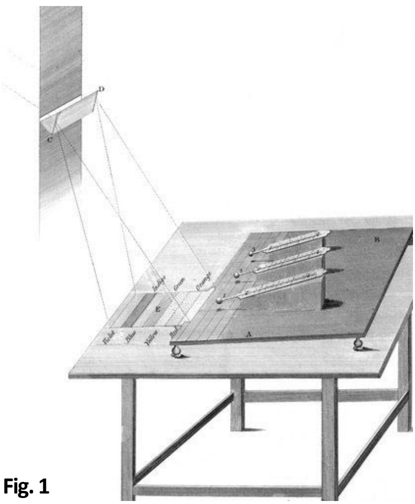


Fig. 1

About the infrared

Infrared radiation was discovered in 1800 by William Herschel, the father of Sir John Herschel who visited Cape Town in the 1830s. Herschel wanted to know how much of the heat from the Sun was associated with each colour of the spectrum. He used the apparatus shown in the diagram to measure it using a thermometer. The effects were very small, so he placed additional thermometers on each side to make sure that drafts in the room etc. were not affecting his readings. As he slid his 'detector' along, he found that the heating effect increased towards the red end. Whether accidentally or otherwise, he found the heating effect was most pronounced beyond the red end of the visible spectrum – the infrared. He followed up his discovery by showing that heat rays could be reflected and refracted just like ordinary light. Fig. 1 shows William Herschel's apparatus for examining the heating effects of different colours of sunlight.

Our eyes evolved to be most useful in Sunlight, which is produced by a star with a temperature of 5 800°C. However, room temperature objects such as ourselves radiate at a wavelength of 10 microns, which is about 20 times that of visible light. The atmosphere of the earth also radiates. At this wavelength, infrared observing can be compared to visual observing with a telescope made of fluorescent tubes in the daytime! Space itself is filled with the electromagnetic background radiation from the Big Bang, with a temperature of 3° above absolute zero, or -270°C. This peaks at a wavelength of about 1mm.

You know that stars can be seen in the daytime through a telescope, but against a bright background. To measure their brightness, that of the adjacent sky has to be subtracted away. The same problem arises in the infrared, even at night.

The earth's atmosphere is pretty clear in the visible region but this is rather a special case. Most celestial electromagnetic radiation does not get through the atmosphere. Gamma and x-rays have shorter wavelengths than visible light and, luckily do not reach us. The same is true for many, but not all, infrared wavelengths somewhat longer than visible light and the atmosphere is completely opaque from the longest infrared wavelengths until mm-wave radio is reached. Then comes the range available to radio astronomy and, finally, at very long wavelengths, there is again no transmission.

This all implies that:

- Infrared detectors must be housed in very cold surroundings to keep the background low.
- The measuring aperture at the telescope focus must be as small as possible to avoid unnecessary bits of sky.
- The detector must "see" only the mirrors of the telescope. A "field lens" matches the telescope to the detector.
- Only wavelengths that pass through the Earth's atmosphere can be observed from ground-based observatories.
- The filters that define the wavelengths to be observed must be cold, so that their own emission out of band is suppressed.
- Ideally the telescope should be very cold and situated in space – which is why satellite-mounted telescopes are usually the best. It is no good to cool earth-based telescopes because this will only cause condensation of water vapour.

Though infrared was technically difficult in the early days, there were rewards waiting for us. We could now observe cool objects that were otherwise invisible, such as forming stars and dust shells around dying stars. Further, infrared light is hardly absorbed at all by dust clouds, enabling us to look into places such as the centre of the Milky Way galaxy that are otherwise hidden. To give an example, only about one photon in 1 000 billion (10^{12}) gets to us from the Galactic Centre whereas at wavelengths only four times longer than visible light we receive one photon in 10.

Though quite a lot was found out about solar radiation in the century and a half that followed Herschel, the sensitivity of detectors remained rather low. The stimulus that was needed came from German developments of Lead Sulphide (PbS) detectors during the Second World War. These and the manufacture of multi-layer interference filters enabled Harold Johnson, an astronomer-physicist in Arizona, to start multi-colour photometry of stars

The technology of Infrared

My good fortune was to be a post-doc at Caltech in 1970 in G Neugebauer's group. He, with RB Leighton, had just made the first survey of the infrared sky, revealing the existence of unusual objects that radiate much more strongly in the infrared than could have been expected. During this time also, the first modern infrared photometers using liquid nitrogen cooled PbS detectors had been developed by Neugebauer and his student EE Becklin. In Texas and Minnesota, FJ Low and EP Ney developed the superconducting germanium bolometer, useful at long infrared wavelengths.

Early IR astronomers were usually experimental physicists like myself. Techniques were improving and developing rapidly. To be a practitioner one had to know Mechanical design, high vacuum, cryogenics (the science of cold substances), low noise amplifiers and digital electronics, optical design, computer programming, project management and how to circumvent bureaucrats. One even had to know a little astronomy!

Infrared optics differ from visible ones mainly because glass is opaque beyond certain wavelengths. Instead one uses crystalline materials such as CaF_2, KBr, and Sapphire (Al_2O_3), some of which dissolve in the water vapour in the air! The behaviour of their expansion properties and their optical constants at low temperatures must be known – even Zerodur and similar glasses are not zero-expansion under these conditions.

You may wonder at the inclusion of 'project management'! But special parts often had long delivery times and one had to plan well ahead for everything to come together at the right time. Similarly, bureaucrats did not understand that it was often impossible to obtain competitive bids for some items.

It is also one thing to have equipment working in a laboratory and quite another when it is on a mountaintop, in a freezing dome, essentially under field conditions. Building the apparatus is only half the work – de-bugging and setting up observational procedures and data reduction systems require significant further effort.

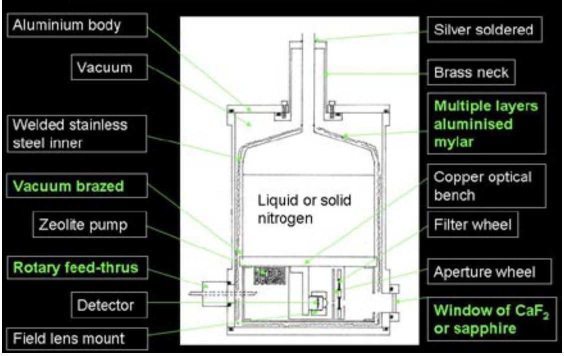
Early Equipment that I designed

After Caltech I was employed at the Royal Greenwich Observatory for five years, the middle three of which were spent at the SAAO as a visitor. One of my first tasks was to design a cryostat, also called a Dewar, to hold the cold parts of a photometer. Fundamentally, this is a vacuum flask, like an ordinary picnic flask, but it has to be such that it can be opened and worked on. A picnic flask can be baked and sealed off and keeps its vacuum for many years, but an experimental Dewar relies on a material called Zeolite which absorbs gas when cold and releases it at room temperature. A Dewar on a telescope has also to be tiltable to a considerable angle without losing its liquid nitrogen.

One of the problems with early Dewars was that the joint between the stainless steel liquid container and the copper optical bench, usually brazed, would corrode and start leaking. This I discovered could be avoided by using a specialized technique called vacuum brazing that avoided the use of ordinary fluxes.

Looking at the Fig. 2, light from the telescope comes in from the right through the 'window' and passes through a filter wheel to choose the wavelength and then an aperture wheel (at the focus of the telescope) to select which part of the sky is to be measured. Then it passes through a CaF_2 field lens to the detector, which is about 0.5mm in diameter. The field lens focuses the primary of the telescope onto the detector to prevent extra radiation from getting to it and also has the effect that the centring of the star in the aperture is less critical.

Fig. 2 My early metal vacuum flask design (1971)



The Dewar I designed could hold liquid nitrogen for about 36 hours and so needed filling only once each day. The first one was in service for about 35 years and is now in the Astronomical Museum at SAAO. Another one is still in active use at Sutherland! Fig. 3 shows how the Dewar was mounted on a telescope as part of a photometer.

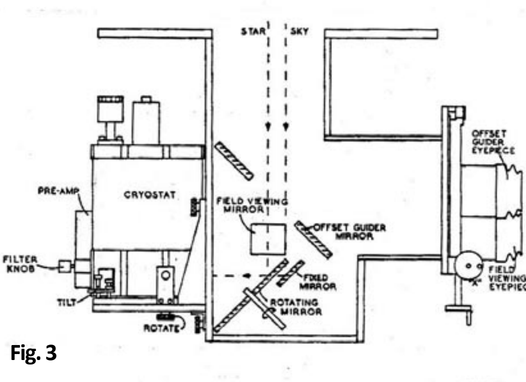


Fig. 3

The part of sky to be looked at is first centred on a graticule using the "Field Viewing Eyepiece" by putting the "Field Viewing Mirror" in place. Then the viewing Mirror is moved out of the way so that the light reaches the detector. Because few telescopes guide well, the "Offset Guider Eyepiece" is centred on a bright star nearby and used to keep the telescope on target while the infrared measurement is made.

The brightness of the star is measured alternately with that of the sky at 12.5 times a second using the rotating "chopper" mirror, which has three blades, and a fixed mirror behind it. Fig. 4 shows the rotary star-sky chopper which formed part of this photometer.

The signal from the Detector was processed by passing it first to a device called a "lock-in amplifier" that added when the star was being looked at and subtracted when the sky was in view. The signal was averaged over 10 or 20 seconds and then the telescope was moved in declination so that the star was reflected off the fixed mirror and the sky off the moving mirrors. This higher-level chopping, called "nodding", helped to eliminate some imperfections in the sky subtraction process caused by the slightly different views the detector had of the telescope off the two mirrors. Every 10 seconds the averaged output of the lock-in amplifier was digitized and recorded.

At first the recording was done on a printed tape, annotated by an assistant. The numbers had to be typed afterwards onto punched cards for computer processing. This incredibly tedious task was soon avoided by recording the data on punched paper tape as an intermediate step, but considerable editing of cards was still needed. Eventually, when mini-computers came along, recording was done online and one could check the quality of the measurement in "real time". Later, of course, PCs were used.

Fig. 5 shows how the photometer was mounted on the 18-inch telescope in Cape Town in 1971. Measurements could be made at first at four infrared wavelengths, namely 1.2, 1.65, 2.2, 3.4 microns, or about 2.5 to 7 times the wavelength of visible light. After a few years the PbS detectors were succeeded by photodiodes made of Indium Antimonide (InSb) which had much better performance but were trickier to operate. They needed to be cooled to the temperature of solid nitrogen (by pumping on the liquid nitrogen) and "flashed" using a bright light through the 1.2 micron filter

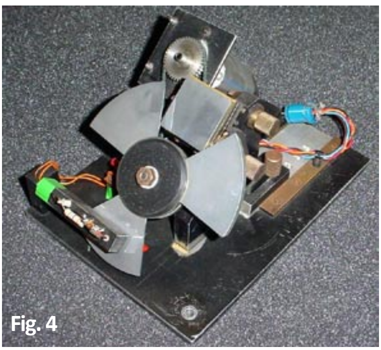


Fig. 4

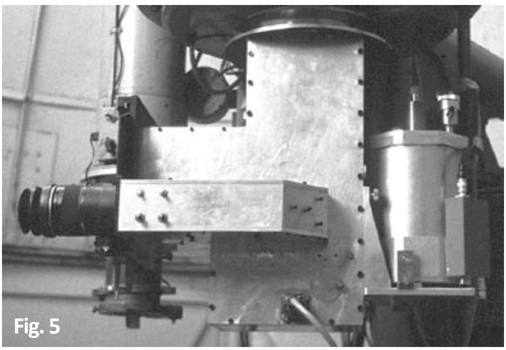


Fig. 5

after cooling. Usually the Dewar was filled in the middle of the day and was at operating temperature by evening.

A second Dewar, made commercially, could be substituted to give coverage at 5, 10 and 20 microns. It required superfluid helium a bit more than one degree above absolute zero, as the coolant. This was made by pumping on normal liquid helium and demanded a knowledge of special techniques. This photometer was also used on the 1.9m telescope, then in Pretoria but later at Sutherland. At different times it was taken to the 1.0m telescope in Sutherland, the 60-inch infrared flux collector in Tenerife and the Anglo-Australian 3.9m telescope in Australia. A copy was made at SAAO and is still used on the 0.75m telescope in Sutherland.

In those early days, I had to get liquid nitrogen from the physical chemistry department at UCT and I carted it in 25 litre containers to the Cape Town and Sutherland telescopes. Liquid helium was much more awkward to get hold of because it was only made by the Wits University Physics department. It was very difficult to transport (not allowed on aeroplanes) and was evaporating continuously. It used to be said that liquid nitrogen cost the same as beer and liquid helium the same as whisky!

Infrared Laboratory

Maintaining, updating and aligning infrared equipment meant a good deal of laboratory work. Fig. 6 was taken around 1980 shows the lab that I established in the McClean telescope dome, where the Astronomical Museum is now situated. Various cryogenic storage vessels can be seen as well as a mass spectrometer leak detector.

Automated observing

Observing on the 1.9m (Fig. 7) usually involved climbing several hundred metres per night up ladders to reach the Cassegrain focus, set the telescope etc. Eventually a long-exposure TV camera and later

Fig. 6

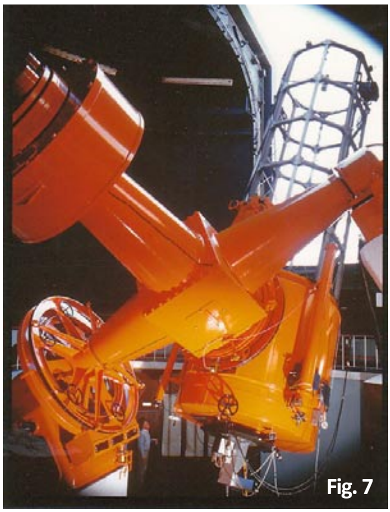
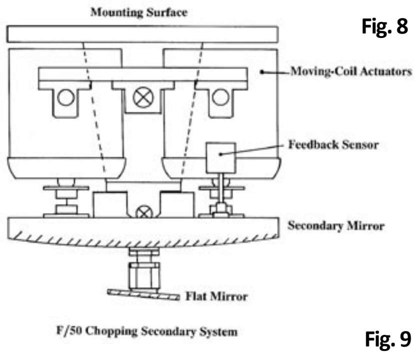


Fig. 7

a CCD camera were installed with an automatic system for nodding the telescope very accurately. The F18 Cassegrain secondary was replaced by a gold-coated F50 system (Fig. 8). This mirror oscillated in a stepwise manner to act as a star-sky chopper and gave greater sensitivity and lower background radiation from the telescope. After automating the filter, aperture and viewing mirrors the photometer could be operated from the control room for higher efficiency.

Fig. 8



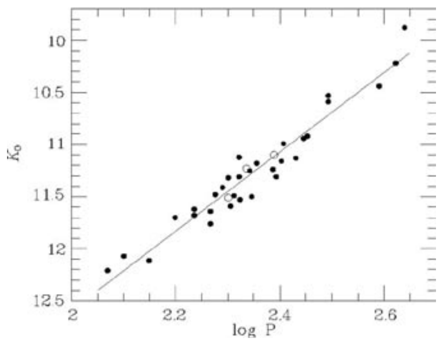
Some astronomical highlights

To do astronomical photometry one has to have a network of infrared standard (comparison) stars well spread over the sky. Setting up these occupied a lot of my first couple of years in Cape Town. The exciting part could then follow. I will give just a few examples of the science that I did in what follows. Altogether I wrote or was a co-author of over 220 papers, some of which, of course, were more significant than others.

The period-luminosity relation for Miras

Miras are long-period variables that vary very dramatically in the visible region. Cepheid variables had long been known to show a well-defined period luminosity relation, which made them very useful as distance indicators and an essential step in working out the distance scale of the Universe. However, though much effort had been expended on trying to find a similar relation for Miras, most of their energy output is in the infrared and they were too erratic in the visible to yield anything usable.

Fig. 9



In the 1970s Tom Lloyd Evans identified a number of Miras in the Large Magellanic Cloud (LMC), i.e., at roughly the same distance from us, and I observed a number of them in the infrared a few times each. It turned out that in the infrared there was a clear trend – the longer the period, the higher the average apparent brightness at 2.2 microns. Tom and I published this result in *Nature* (**291**, 303, 1981)

This discovery naturally excited some interest and a bigger programme was started to find more Miras and measure them in the LMC and elsewhere. Figure 9 was published by Glass, Catchpole, Feast, Whitelock and Reid in 1987 (in Kwok &

Pottasch (eds)m Late Stages of Stellar Evolution, pp51-54, Reidel, Dordrecht). It shows that the infrared K magnitude for S and M-type Miras with periods between 200 and 400 days have 2.2 micron magnitudes linearly related to the logarithm of the period with a scatter of only 0.13 magnitudes.

The infrared emission of Seyfert Galaxies

One of my long-term infrared interests was to study how active galaxies of various kinds behaved in the infrared. There had already been some indication that they varied with time, something unexpected from very distant objects and implying that the scale of the emitting regions must be from light-days to light-years. I therefore undertook a monitoring programme of bright Seyfert galaxies stretching over many years, observing each one as often as my telescope time allocations would permit – typically once every three months.

Some galaxies turned out to be surprisingly variable. However, one of them, from a catalogue of objects found by the late Tony Fairall, had been observed coincidentally over a long time by two scientists of the International Ultraviolet Explorer satellite team in Madrid. We cross-correlated the UV and IR light curves and found that variations in the UV were followed after a distinct delay of about 400 days by infrared variations (Fig. 10).

This was strong confirmation of a model where a very compact UV source, perhaps the accretion disc around a massive black

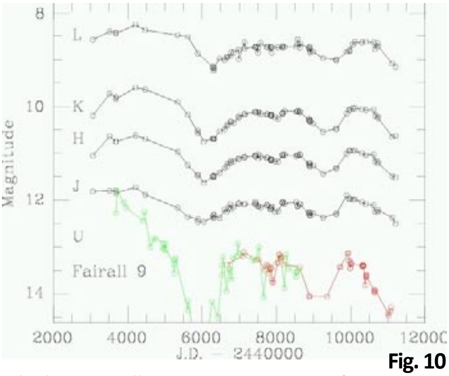


Fig. 10

hole, was illuminating a ring of dust situated about 400 light-days away. (Clavel, Wamsteker & Glass, *ApJ*, **337**, 236-250, 1989). This paper is still one of the strongest pieces of evidence for the infrared emission mechanism in the standard model of active galaxy nuclei.

Imaging the Galactic Centre

As mentioned, the centre of the Milky Way galaxy is hidden from us in visible light by think dust clouds but infrared radiation is able to penetrate. Before the advent of imaging detectors in the infrared only very crude images had been made by scanning across the area with a single detector and recording the output on a strip chart.

I realized that we were in a good position to obtain much better images than most other infrared observers because of our relatively generous allocations of telescope time. I therefore persuaded Robin Catchpole and Patricia Whitelock to join me in a large project to map the Centre.

To accomplish this I designed a special Dewar to allow simultaneous scanning in three colours. Whitelock wrote the data acquisition software and Catchpole did the analysis. The observing, shared by us all, took many weeks spread over three years and required 477 scans lasting about 10 minutes each. The result was by far the best image of the Galactic Centre produced up to that time. Fig. 11 shows about half the area scanned in "false colour", using red to represent 2.2 microns, green to represent 1.65 microns and blue to represent 1.2 microns.

Analysis showed that the dark clouds present coincided with ^{13}CO radio line emission from dark clouds that moved perpendicular to the line of sight and so were probably in orbit around the Centre and not very close to it. We were also able to study the density of stars as a function of density from the Centre.


Fig. 11

The coming of Infrared Arrays

In the early 1980s infrared array detectors began to appear. Unlike visible-region detectors, sensitive infrared photodiodes cannot be made on silicon chips so that it was necessary to develop two-layer hybrid devices. The "Chip" layer shown in Fig. 12 is made of an infrared detector material such as InSb or HgCdTe with photodiodes formed on it. The "Substrate/Chip" layer is a conventional silicon-based CCD or other type of readout. Every single infrared pixel is connected to its own readout circuit by a "bump bond" made of Indium. Indium is a malleable material and bumps of it are grown on the chip surfaces. Then the two layers are pressed together to make the hybrid detector.

It was our misfortune that we could not buy the best IR arrays, which were made in the USA, because of Apartheid sanctions. However, we did obtain a chip made by Phillips in the UK around which I built the first of four infrared cameras. This array did not use bump bonding but rather a kind of through-hole plating with holes in the centres of circular pixels. Though I was able to make pictures, there were many problems and the camera was not capable of precision work.

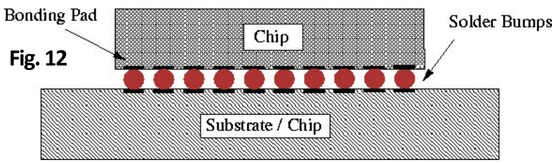
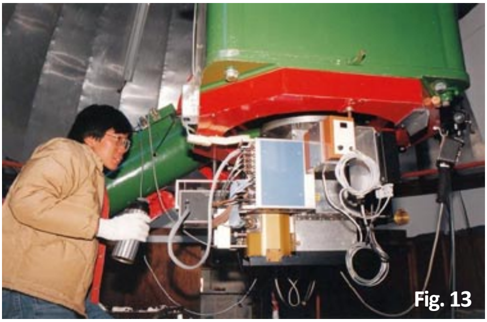


Fig. 12

The next camera that I constructed was much more successful. Through Japanese colleagues I got hold of a



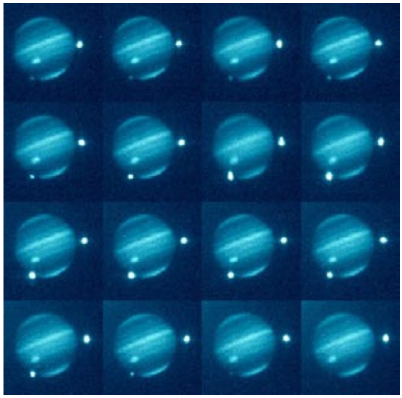


Fig. 14

Mitsubishi array with dimensions 1040 x 1040 pixels, by far the largest format then available. It was, however, silicon-based, with photodiodes formed of Platinum Silicide. These had quantum efficiencies of 1 to 3 percent, enough for industrial thermal imaging but not too wonderful for faint sources. Nevertheless, I persevered and the camera was used for a number of successful programmes for surveying variable star fields. Fig. 13 shows the PtSi camera in use on the 0.75m telescope at Sutherland with K. Sekiguchi filling the Dewar.

The images in Fig. 14 were taken with the Platinum Silicide camera (incidentally called 'PANIC', for PtSi Astronomical Near-Infrared Camera). It shows the crash of one of the fragments of Comet Shoemaker-Levy into Jupiter in July 1994. Our infrared pictures were among the first obtained and were downloaded via the Internet over 20 000 times, a large number for those days. In the infrared one can see the cloud belts very clearly as well as the red spot and the satellite Io (which moved noticeably). The collision site is seen developing and then fading away.

The Infrared Survey Facility

In the late 1990s, a group from Tokyo and Nagoya Universities in Japan expressed interest in constructing a 1.4-m infrared telescope at Sutherland. Petrified at the idea that the government might not finance the SALT telescope if it was known that we were getting a telescope from Japan, the SAAO director of the time insisted that the word 'telescope' should not be mentioned. Hence we called it the IRSF or Infrared Survey Facility.

Fig. 15 shows the telescope under construction. It is of altazimuth design and was manufactured by the Nishimiura Company with a lot of input from Nagoya University students and engineers. It can be pointed much more precisely than all the other telescopes at Sutherland and carries out its survey work largely automatically while the observer sits and reduces the previous night's data. South African users get 1/9th of the time outright on this telescope and share another 1/9th with Japanese astronomers. Attached to the telescope is a very powerful camera

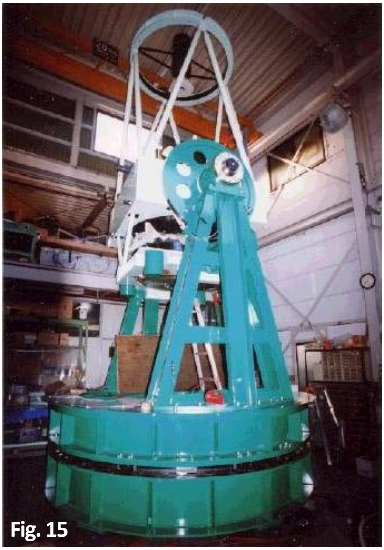


Fig. 15

called ‘SIRIUS’ which images in three colours simultaneously using modern high-performance arrays with dimensions 1024 x 1024 pixels each.

My part was to organise the agreement and the construction of the building as well as acting as local manager for the construction phase of project, which was completed in 2000. The IRSF has proved extremely successful in use. It has surveyed the Magellanic Clouds and a large part of the inner Milky Way galaxy, for example.

Infrared Satellites

Several infrared satellites have orbited the earth during the last 30 years. They have taken advantage of the low background of space and the possibility of cooled optics to achieve much greater sensitivity and wavelength coverage than is possible from inside the earth’s atmosphere.

The first of these was IRAS, an American and Dutch project. It surveyed almost the whole sky and vast catalogues of infrared sources at wavelengths of 12 to 120 microns were published. Identifying the sources in the visible and the near-IR was naturally of great interest. In particular, MW Feast showed that many sources in certain less obscured fields (called the Baade’s Windows) a few degrees from the Galactic Centre were Mira variables that had been identified some years previously by Lloyd Evans. There were some other bright infrared sources in these fields, however, and I was able to show that these were very long-period Miras that had thick dust shells and so were too faint for Lloyd Evans to have discovered.

I also interested myself in what appeared to be very cool stars in the more heavily obscured fields closer to the Galactic Centre and started to look for them at a wavelength of 3.5 microns by scanning a single detector over them. One source that turned out to be multiple excited my interest. However, it was found almost simultaneously by a Japanese group, who thought it was a ‘Quintuplet’ and this name has stuck. I had some contacts in ESO, Chile, which by then had a primitive Phillips infrared camera and organized an observing trip to take pictures and spectra there. Fig. 16 shows a composite of a number of exposures at 2.2 microns. It turned out that this source is a small open cluster with some very unusual ‘coccoon’ stars. Many papers have been published about it since

(Glass, Moneti and Moorwood, *MNRAS*, 242, 55p, 1990).

Third Infrared Camera

My third infrared camera was the first one to use a modern infrared array, a hybrid 256 x 256 chip whose infrared layer was made of HgCdTe. This detector is similar to what was used in the infrared camera of the Hubble Space Telescope. It was mounted on my original infrared photometer (Fig. 17), upgraded and with a SBIG autoguider. The electronics were taken over from the PANIC camera already described. A miniature “Offner Relay”, a clever optical design involving only spherical surfaces (M2 and M3), was used to form a field image which could be masked with a cold stop to remove undesirable background radiation from outside the F15 beam of the 0.75m telescope (Fig. 18). This camera was mainly used by Lloyd Evans to locate sources found by the IRAS satellite (the positions of these were only known to within about 1 arcmin).

Data Mining

Vast survey databases (2MASS, IRSF, MACHO, IRAS, ISO, Spitzer, Hipparcos, etc.) have been created and placed on-line over the last decade. It is usually impossible for one person to extract all the science from any one of these and so a new research technique called “data mining” has come into existence.

MACHO was a variability survey of some 20 million stars in the Magellanic Clouds and the Galactic Centre, originally designed to look for gravitational lensing events. However, it had a most important by-product which was the discovery of huge numbers of variable stars and the measurement of their periods. At about the same time both hemispheres were surveyed from 1.2 to 2.2 microns

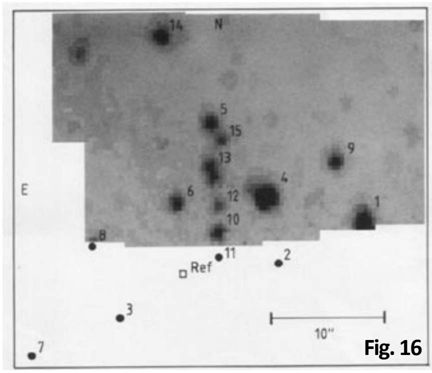


Fig. 16

Fig. 17

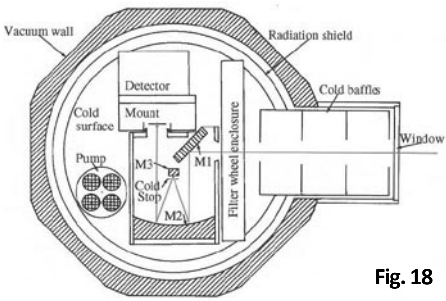


Fig. 18

in a ground-based project called 2MASS. PR Wood in Australia made a cross-correlation of near infrared data with MACHO variables in the Magellanic Clouds and discovered an entirely new set of period-luminosity relations among the semi-regular variables.

I had in the meantime been involved with a group of people who were conducting a mid-infrared survey (called ISOGAL) of the inner galaxy using a European satellite called ISO (Fig. 19). I suggested that the Baade's Windows fields should be included as fiducial fields because we already had a lot of information about the stars they contain and might be able to use this to interpret other fields that were more obscured. To my (and our) surprise, we found a number of stars that were almost as bright in the infrared as the Mira variables but had not been found to be variable by Lloyd Evans.

So what could these be? I applied to the MACHO group, whose data were then still proprietary, and formed a project with David Alves of the Space Telescope Science Institute to look at these objects.

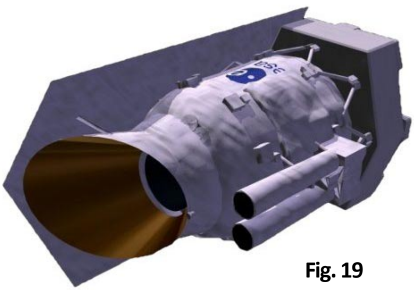


Fig. 19

They turned out to be variables whose amplitudes were too small for Lloyd Evans to have detected by photographic means.

We showed that they were semi-regular variables (SRVs). SRVs with periods greater than 70 days were found in many cases to be losing substantial amounts of mass (ApJ, 552, 289-308, 2001).

Later with M Schultheis (Institute of Astrophysics, Paris) I showed that the Galactic Centre Baade's Window around NGC6522 was full of semi-regular variables that obeyed period-luminosity relations similar to, but not exactly the same as, those followed in the Large Magellanic Cloud as found by Wood).

This paper also showed that our general knowledge of the distribution of variable stars with period was seriously inadequate because traditional photographic surveys, such as those used by the Harvard pioneers, had been insensitive to small amplitude variations (*MNRAS* 345, 39-48, 2003).

It became possible to make an absolute calibration of the period-luminosity relations followed by the M-type variables thanks to the Hipparcos satellite which determined the distances to large numbers of nearby stars. To do this I made a compilation of local semi-regular variables with period data (often from amateur sources) and Hipparcos distances. The data are unfortunately somewhat marginal in some cases but it is to be hoped that the GAIA satellite and the many ground-based variability surveys will rectify the situation in the course of time (Glass and van Leeuwen, *MNRAS* 378, 1543-1549, 2007).

Fig. 20

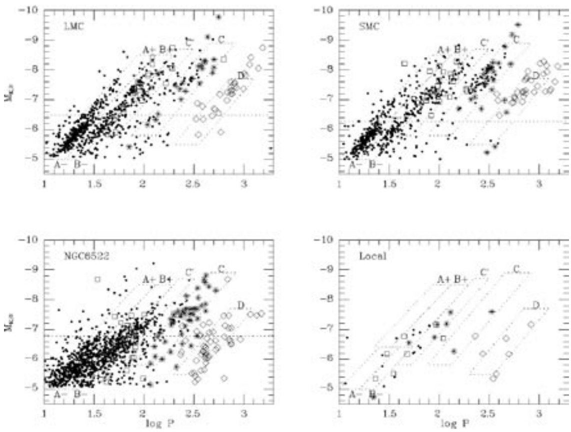
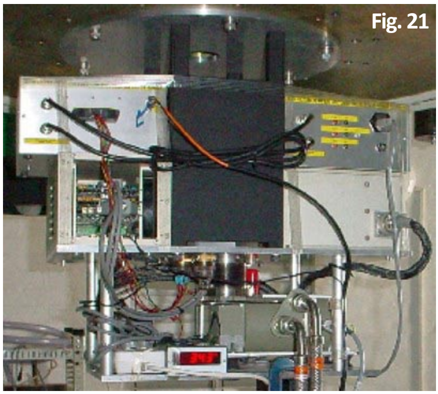


Figure 20 is a kind of summary of period-luminosity relations that compares the Miras and semi-regular variables found in the Large and Small Magellanic Clouds (top left and right) with those in the NGC6522 Baade's Window near the Galactic Centre (bottom left) and the local stars with distances from Hipparcos (bottom right).

The NGC6522 sequences are not as clear as the Magellanic Cloud ones because these stars are in the Bulge of the Milky Way and their distances are not quite as well-defined as those in the Magellanic Clouds. The classification boxes marked A, B, C, etc. come from a Japanese study of the Magellanic Clouds made with the IRSF in Sutherland by Y Ita et al.

Fig. 21



Last instrument

My fourth and last infrared camera was intended for use with the IRSF telescope at Sutherland (Fig. 21). The SIRIUS camera, which was usually attached to it, does not survey beyond 2.2 microns and my idea was to extend coverage to 3.6 microns, where interesting and unusual sources began to stand out from ordinary stars.

It was by far the most complicated camera that I had made. It was intended for use with a 512 x 512 pixel InSb array. Only a rather poor array, of "Engineering Grade" was available to me and even then, it turned out that the wiring diagram furnished with it was incorrect. Unfortunately the diagnosis of the problem only emerged after I retired. It caused the star images to be elongated in the declination direction.

Instead of using a liquid cryogen, this camera was cooled to 34 degrees above absolute zero by means of a closed-cycle refrigerator using high-pressure helium as the working gas. Nevertheless, I did get quite an interesting narrow-band image of the Galactic Centre region, which is in Fig. 22. Most of the 3.6 micron sources present are Miras or other stars with dust shells below the temperatures of normal stars.

Fig. 22 shows the centre of the Milky Way galaxy at 3.6 microns, taken with my last camera. It covers 3.45 arcmins square. Most of the sources are Mira variables, some of which are OH sources in the radio region. The non-circled sources are known from previous Galactic Centre studies (*MNASSA* **63**, 28-33, 2004).

The end of the road

Fig. 23 is a picture of the "Dewar Graveyard". There was nobody to succeed me in this type or work and so the infrared programme that I initiated in 1971 has now completely stopped. In their heyday, the instruments that I developed were very widely used by others besides myself and were the source of a good fraction of the output of the South African Astronomical Observatory.

This has been a largely personal reminiscence of some of the things I was involved with and it is only right to acknowledge that many other people inside and outside SAAO contributed in one way or another to what I have described. I would also like to mention the invaluable help provided by the electronic engineers and technicians, the instrument workshop technicians, the night assistants at Sutherland and the many other Observatory staff in the background whose praises are rarely sung but who helped keep the show on the road all these years. ☆

Fig.22

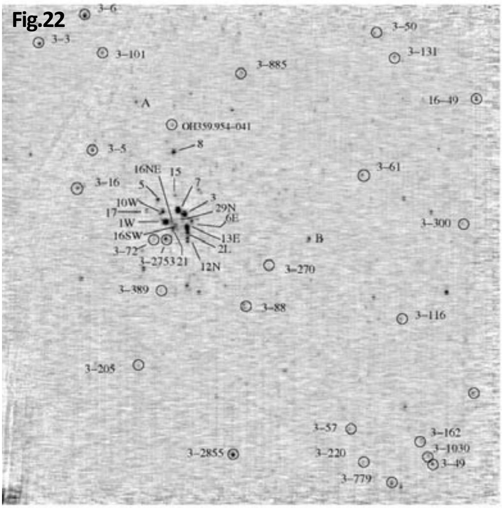


Fig. 23

Station 13 revisited

Greg Roberts *grr@telkomsa.net*

The article I wrote on the somewhat mysterious tracking station at Babsfontein in Gauteng (*MNASSA* Vol. 11 No's 3&4, April 2012), resulted in some correspondence, enabling me to get into contact with people who had worked at the station. This made it necessary to update the original article.

The need for a Tracking Network

As a result of launches of captured German V-2 rockets from the White Sands Proving Ground in New Mexico, it became obvious that a much longer range was needed, away from populated areas, to test fire long range missiles. On 10 June 1949 the Banana River Naval Air Station, which had a launch site at Cape Canaveral, was redesignated the Joint Long Range Proving Ground base. The base was renamed Patrick Air Force Base on 1 August 1950. On 30 June 1951 the Long Range Proving Ground became the Air Force Missile Test Centre and the Joint Long Range Proving Ground became the Florida Missile Test Range. In 1958 it was renamed the Atlantic Missile Range (AMR), and was again renamed in 1964 to the Eastern Test Range (ETR). On 12 Nov 1991 it became known as the Eastern Range with the activation of the 45th Space Wing which assumed operational control for the range. On 19 Nov 1991 the Western Space and Missile Centre, located at Vandenberg Air

Map plotting the tracking stations of the AMR (Atlantic Missile Range). Source: www.aardvarkmap.net

Force Base, California, became the 30th Space Wing and the Western Test Range became the Western Range.

The original AMR consisted of 12 tracking facilities, as follows (see map):

Station 1: Cape Canaveral located on the mainland

Station 2: Jupiter Air Force Base, also on the mainland, south of Cape Canaveral

Station 3: Grand Bahama Island, commonly known as GBI, 240 km from the Cape

Station 4: Eleuthera Island, Bahamas

Station 5: San Salvador, Bahamas (where Columbus first landed)

Station 6: Mayaguana Island, Bahamas, 880 km from the Cape. It was simply a relay station

Station 7: Grand Turk Island (Turks and Caicos Islands)

Station 8: Dominican Republic

Station 9: Mayagüez, located on the island of Puerto Rico, some 1 500 km from the Cape

Station 9.1: Antigua

Station 9.2: Trinidad

Station 10: Saint Lucia some 2 250 km downrange from the Cape

Station 11: Fernando de Noronha off the coast of Brazil, at one time a prison colony

Station 12: Ascension Island, in the middle of the Atlantic Ocean and just over 8 000 km downrange from the Cape

The stations were initially equipped with single-point radars of WWII vintage. By the end of 1957 the range's optical systems included long-range tracking telescopes and infra-red tracking equipment. Cine-theodolites tracked the space vehicles out to a distance of about 30 kilometres whilst long range telescopes tracked vehicles as far as 320 kilometres downrange with infra-red cameras missiles at night. In addition the range also operated a fleet of telemetry tracking ships and aircraft.

Tracking Techniques

Electronic tracking was done using two techniques: one known as "pulse radar" and the other "continuous wave" (CW). With the former, high power pulses are beamed at the space vehicle and reflected back to the transmitter antenna, either reflected by the rocket's metal skin (called "skin tracking") or by a pulse that left the transmitting antenna. This pulse however triggers a beacon or transponder in the target, which in turn sent back a pulse of energy that was received by several antennae. The advantage of using the transponder method is that the transponder could boost the weak signal received and retransmit at a much higher level, so increasing the range of the system. This was known as "beacon tracking".

In "continuous wave" tracking the ground based system transmitted radio signals to a small beacon located in the space vehicle which then sent back a CW signal back to earth where it was received by several antennae. By using a phase comparison baseline it was possible to determine the flight path. Several systems had been devised, named AZUSA, MISTRAM (MISsile TRAjectory Measurement), UDOP

(UHF Doppler at 440 Mhz) and GLOTRAC (GLObal TRACking). Only GLOTRAC was used at Station 13. It was developed by General Dynamics/Astronautics using pulse radar and employed doppler with a transponder installed in the space vehicle.

Station 13

In February 1961 a site was acquired near Pretoria and became Station 13. This was located on an old South African Air Force bombing range and the missile test range was extended to 90 degrees east longitude in the Indian Ocean where it met the Western Range.

In publications the name Station 13 appears to have not been used very frequently, instead calling it simply PRETORIA. This could have caused some confusion as there were five tracking facilities within 50 kilometres of Pretoria. Perhaps it was to make it less obvious to politicians, etc. that the US had several tracking facilities in apartheid South Africa.

Colin McElroy, in an e-mail communication with the writer wrote:
I worked at the Babsfontein station from 1964 to 1967 for the RCA (Radio Corporation of America) Service Company Missile Test Project. RCA Service (RCAS) did a lot of technical support. Pan American Airways Guided Missile Range Division (Pan Am) was the range manager and subcontracted to RCA to maintain and operate the radars, telemetry, communications, etc. At more remote places Pan Am had a much bigger role because they had to provide everything from toilet paper to spare parts. They had cooks, barbers, supply clerks, housing, diesel mechanics, firemen, medics and so on, but in Pretoria staff just lived on the local economy, which was great.

It was a wonderful time for us because we were a novelty, young and made pretty good money. Several of the "Range Rats", as we were called, married South Africans and some settled there. I left SA at the end of 1967 because the SA Tax people decided that we should have been paying taxes. RCA solved the problem by replacing us all. I don't know if there was a real tax problem or another tit-for-tat over some apartheid thing.

I transferred to Station 13 to work on the new GLOTRAC system after working

The TLM-18 60 foot automatic tracking antenna showing the feed support and arms. This was situated at Fort Monmouth, New Jersey.
Source: http://radiwiki.wikispaces.com/TLM-18+at+Camp+Evans,+NJ

on the MISTRAM system on Eleuthera in the Bahamas. Both of these were interferometer baseline radars. In Pretoria we had one 12 foot (3.6 m) transmit dish antenna and three 6 foot (1.8 m) diameter dish receivers connected by a few hundred metres of 50 mm diameter coax. I wonder if anyone dug that up?

As far as personnel go, there were five people on the GLOTRAC setup, six on the radar I think, and at a guess about 20 in telemetry, maybe a couple of communications guys and a site manager. All were US RCA employees. In addition there were also South Africans to maintain/operate the power generation, supply, a secretary and maybe a couple of others. There was also a liaison Colonel (?) with the US Embassy whom we would see once in a while as well as a representative of Pan Am in Pretoria. His duties were to ensure that transient personnel between Ascension and Mahe, Seychelles, used the correct flights at Jan Smuts Airport (Oliver Thambo, today), provided transportation, passport renewals, visas, lodgings, etc.

As I recall we tracked a couple of the early Apollos, maybe Atlas/Agenas and some odds and ends. However, I suppose the data was not needed as things were proven. The weight of our transponder (in the space vehicle) could be used for better payloads. Long story short, it was deactivated in 1966 and I read that the SA Post Office got the vans for communications.

After GLOTRAC I went to work on the telemetry site. Although I do not recall the size of the antenna, I do recall standing in front of the feed trying to get the new S-band to work. I don't think it was anywhere near the size or complexity of the dish you reference, perhaps 40 to 50 foot (12–15 m) diameter.

One problem with Pretoria seemed to be that many of the trajectories were so far north that they only appeared above the horizon for a short time so the data was not so valuable. Just a guess though. Much of the time we had no idea what we were tracking because all we had were times, frequencies, look angles and doppler. So we would just track it, get it on tape and send it off on the USAF C-130 transport that arrived once a week. So the target could be US, USSR stuff, or maybe even UFO for all we knew.

APL (Applied Physics Laboratory, John Hopkins University) had some kind of operation at the front gate with two guys. I'm guessing early GPS or other satellite downloads. Greg Roberts confirms this and adds that APL developed the Transit navigation satellite system – precursor to GPS. The SECOR (Sequential Correlation of Range) satellites as mentioned in the April 2012 *MNASSA* article were part of the Army Map service range only system used at four ground stations and were part of the Transit system development.

Pretoria was also a transit point for people heading to/from the station at

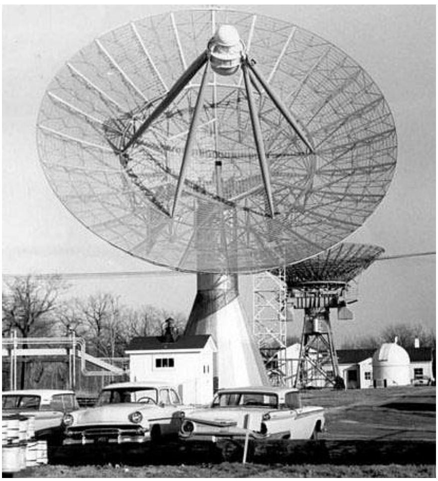
Mahe, Seychelles and the tracking ships operating in the Indian ocean.

I think it was all pretty dead by 1969 from what I read. Perhaps the scarcity of Station 13 info on the web is that it was a bit controversial politically to be dealing with apartheid. Also it was a relatively small operation and did not deal with the testing of ICBM's which was the main purpose of the range.

The radar and telemetry systems at Station 13 were mothballed in December 1969 and the property was returned to South Africa on 8 January 1996.

Dishes and frequency coverage

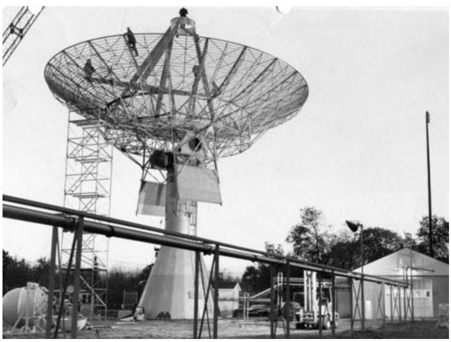
From the above, and various other sources, Station 13 was equipped with several dishes, the largest of which appears to be the TLM-18 dish which was standard equipment at most of the stations. This was 18 m in diameter with a feed assembly which was a section of wave guide, 1.5 m in diameter with a cut-off frequency below the minimum telemetry frequency of 215 MHz. The received signal was amplified and used both for guiding the antenna and for supplying telemetry data. It could initially operate in the range 216 to 260 MHz and provided 28 dB gain with switchable linear or circular polarization. As Colin mentioned, it was later improved by adding an S-band reception facility.



In tests it was found the dish could accelerate at better than 5 degrees/second/second up to velocities of 10 degrees/sec. The half-power beamwidth was about 5.2 degrees (in the 216-260 Mhz range). This is no doubt `the "possible 84 foot (25 m) dish" I mentioned in my earlier article.

The largest radar antenna was the MPS-25 which is a transportable version of the more powerful FPS-16 radar. The MPS

TLM-18 dish at Fort Monmouth, New Jersey.
Source: http://radiwiki.wikispaces.com/TLM-18+at+Camp+Evans,+NJ



designation means “fixed, radar, detecting and/or range and bearing”. This had a peak transmit power of 0.25 Megawatts and had a diameter of 3.66 m. At the operating frequency of 5.4 to 5.9 GHz (called C-band), the gain was 47 dB with a noise figure of 11 dB and receiver bandwidth of 2 MHz. The dish could move at up to 42 degrees/second and used pulse doppler (mono-pulse).

The frequencies used at Station 13 for the various tracking systems were:

- GLOTRAC was used at the station and was developed by General Dynamics/ Astronautics using continuous wave (CW) radar and doppler using a transponder installed in the space vehicle. The radar operated on a frequency of 5052 MHz.
- S-band 2100–2300 Mhz was used, for example, to track APOLLO Moon missions (Unified S-band).
- TV 860–880 MHz Ranger Moon missions and on various space craft – e.g. Saturn 5 launch vehicle test flights. The Saturn 5 was the first stage rocket used for the Apollo missions.
- VHF Telemetry (1) 240–260 Mhz
- VHF Telemetry (2) 136–138 MHz also 150, 400 and 421 MHz which was used in Transit/SECOR missions.

No account of optical tracking facilities appears in any mention of Station 13.

Life of a Range Rat

As Colin mentioned, the personnel manning these remote outstations were known as “Range Rats”. John L. Gladden wrote a lengthy article which he called “Home on the Range – Recollections of a Range Rat” (see link below), which makes interesting reading and some of it will be of interest to South African readers. The Range Rats liked travelling through South Africa. Some of the folks who were stationed on Ascension would take their vacations in South Africa. It was like going to the US except for the funny accents and everybody driving on the left side of the road. There was plenty to do in Pretoria, Durban, Cape Town or Johannesburg. Almost everyone understood English so it was easy for the Range Rats to get around and make acquaintances with the inhabitants. Some

The MPS-25 3.66 m radar antenna on Johnson Atoll.

Source: www.honeysucklecreek.net/

of the employees that were stationed there met girls whom they later married and travelled the Range with.

Range Rats who were going back to Ascension from South Africa would buy fresh steaks from a popular butcher shop in a village near Pretoria. They would pack the steaks in a cooler with dry ice and carry it aboard the US Air Force plane as luggage. There would be a big cookout on Ascension when they got there. The South African beef was some of the best and was very cheap in comparison to American beef prices.

Conclusion

So this concludes my story about Station 13. My curiosity has been satisfied. There are at least still three former employees currently living in South Africa. I was able to contact two of them. Most of the stations that were in the network have since disappeared or become inactive and are now history. Unfortunately I have been unable to find any photographs of Station 13 or of its actual instrumentation.

Acknowledgements

I particularly would like to thank Colin McElroy <sammacel@yahoo.com> for his invaluable input, most of which I have reproduced above, as received.

[**Editor's Note.** I have merged some of Greg's comments with Mr McElroy's for the sake of continuity, but this has not affected the content in any way.]

References:

Dr Wernher von Braun. *How we track our Spacecraft,* Popular Science magazine, November 1965.

Eastern Range http://en.wikipedia.org/wiki/Eastern_Test_Range

Development of the 45sw Eastern Range – fact sheet http://www.patrick.af.mil/library/factsheets/

Frank S. Cox, 1959. *Operational Characteristics of the Tlm-18 Automatic Tracking Telemetry Antenna*. IRE Transactions on Space Electronics and Telemetry, Pp. 87-91

Pan American Airways Guided Missile Range Division http://en.wikipedia.org/wiki/Pan_American_Airways_Guided_Missile_Range_Division

Websites with much info on and for ETR Range Rats:

www.spacecovers.com/jpers/zjp_emp_rca_etr_rangerat01.htm

Home on the Range www.scribd.com/doc/3489733/Home-on-the-Range

Unified S-Band used for tracking Apollo missions http://en.wikipedia.org/wiki/Unified_S-Band

Astronomical Colloquia

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

Also included in this section are the colloquia/seminars at the SAAO, NASSP and the Astrophysics, Cosmology and Gravity Centre at UCT, ACGC. Also included are the SAAO Astro-coffees which are 15-20min informal discussions on just about any topic including but not limited to: recent astro-ph papers, seminal/classic publications, education/outreach ideas and initiatives, preliminary results, student progress reports, conference/ workshop feedback and skills-transfer.

Editor.

SAAO

Title: Cosmology with the Two Micron All Sky Survey
Speaker: Maciej Bilicki
Venue: SAAO Auditorium
Date/Time: 30 August/11:00
Abstract: The Two Micron All Sky Survey (2MASS) is the most complete survey of the whole sky. Its Extended Source Catalog (XSC) contains almost 1 million galaxies up to a distance of ~450 Mpc. I will discuss some recent applications of the data from the 2MASS XSC for cosmological studies. These include the motion of the Local Group of galaxies through the Universe, bulk flows of our cosmic neighbourhood, detailed 3D maps of the cosmos and so on. Finally, I will mention what more can be done from the survey in the (near) future.

Title: KELT-South - The Little Telescope that Could
Speaker: Rudi Kuhn (UCT/SAAO)
Venue: 1896 Building
Date/Time: 05 September 2012/11:00
Abstract: The Kilodegree Extremely Little Telescope (KELT) project is a survey for new transiting planets around bright stars. KELT-South is a small-aperture, wide-field automated telescope located at Sutherland. The telescope surveys a set of 26 degree by 26 degree fields around the southern sky, and targets stars in the range of $8 < V < 10$ mag, searching for transits by Hot Jupiters. This talk will describe the KELT-South system hardware and software and a brief overview of the quality of the observations. I will show that KELT-South is able to achieve the necessary photometric precision to detect transits of Hot Jupiters around solar-type main-sequence stars. I will also discuss the recent discoveries of KELT-North and the implications of those discoveries for KELT-South.

Title: Long-term Properties of X-ray Binaries Transient in the Magellanic Clouds [Be/X-ray pulsar (BeX) and Supersoft X-ray Sources (SSS)]
Speaker: Andry Rajoelimanana (SAAO)
Venue: 1896 Building
Date/Time: 12 September 2012/11:00
Abstract: My talk will be divided into two parts:
First part: "Long-term properties of SMC BeX system." The Magellanic Clouds, particularly the SMC, host a large number of high-mass X-ray binaries (HMXBs) when compared to our Galaxy. The majority of these HMXBs are Be/X-ray binaries (BeX) in which a neutron star orbits a rapidly rotating Be star in a very wide (P ~ 20-200 d) and eccentric orbit. I will present my work on the long-term temporal properties of these systems, using optical light curves from the MACHO and OGLE monitoring of the Small Magellanic Cloud. I will also present some recent SALT/RSS optical spectroscopic observations of these systems during their optical high and low states.
Second part: "Optical and X-ray Properties of CAL83: - Quasi-periodic Optical and Supersoft Variability." Supersoft X-ray sources (SSS) are characterised by very soft spectra with most of the counts detected mainly below < 0.5 keV. Due to the low extinction toward the direction of Magellanic Clouds, SSS are easily detected in these galaxies. I will present the long-term variations of the SSS CAL83 using the combined lightcurves from the MACHO and OGLE project databases, then compare the variations in CAL83 to those seen in RX J0513.9-6951, with particular emphasis on the optical/X-ray correlation. We further investigate such a correlation using archival X-ray data of CAL83 obtained by XMM-Newton.

Title: The XMM-Newton Survey of the SMC: a new X-ray source census
Speaker: David Buckley
Date/Time: 20 September 2012/11:00
Venue: SAAO Auditorium
Abstract: The XMM-Newton X-ray observatory has performed a survey of the Small Magellanic Cloud comprising of 30 fields covering 5.5 square degrees, totalling 1.1E6 sec of observations. The survey has been supplemented by 61 archival observations, totalling 1.6E6 sec. The actual exposure time is distributed inhomogeneously over the SMC, with two thirds of the fields having 10-30 ks exposures, while some fields have up to 400-600 ks deep exposures. Initial investigations of our point-source catalogue, comprising 5236 sources, shows that it is complete down to a limiting flux of about 1E-14 erg/s/cm, which corresponds to a luminosity limit of 4E33 erg/s. This survey provides a unique data set to investigate the X-ray source populations of the SMC, in particular its remarkably large population of Be/X-ray binaries, super-soft X-ray sources and supernova remnants. The census of the X-ray source optical counterparts, for which

about half the X-ray sources have a confirmed or tentative counterpart, which is actually dominated (~90%) by background AGN, will be discussed. Some initial results and plans for future ground-based follow up observations of new SNR candidates with SALT and other facilities will also be discussed.

Title: Multi-wavelength Studies of Star Forming Cluster Populations at z~0.5
Speaker: Solohery Randriamampandry
Venue: 1896 Building
Date/Time: 26 Sept/11:00

Abstract: Multi-wavelength analysis of star forming galaxies in clusters is one of the most promising approaches to investigate the link between cluster environment, star formation and galaxy properties. In this work, we particularly look at the still unrevealed nature of the far-infrared-radio relationship in massive galaxy clusters at intermediate redshifts where the relationship is relatively unexplored. In this talk, I will discuss the ongoing multi-wavelength data analysis of star forming galaxies in the massive X-ray luminous cluster MS0451.6-0305 at z=0.538. Our major aim is to shed light on the evolution of the far-infrared-radio relationship in rich clusters. Preliminary results show that the far-infrared and radio luminosities for our sources are strongly correlated for star forming galaxies. In addition, the far-infrared and radio luminosity ratio (qIR) measured for these sources is comparable to that measured in low redshift clusters and is indicative of an excess of radio emission. I will also present work done on the optical properties for a sample of 25 star-forming galaxies (LCBGs) that include results on stellar mass measurements, comparison of stellar with dynamical mass as well as their comparison to the field at the same redshift.

Title: Using SALT/RSS data to understand (U)LIRGs
Speaker: Rajin Ramphul
Venue: 1896 Building
Date/Time: 3 October 2012/11:00

Abstract: (Ultra) Luminous InfraRed Galaxies ((U)LIRGs, L IR > 10 11 L sol) are known to be highly interacting galaxies with strong star-formation and have been proposed as an evolutionary step in the sequence between spiral galaxies and ellipticals via mergers. This talk will focus on the current work we have undertaken on a sample of (U)LIRGs observed with SALT/RSS in long-slit mode during the commissioning phase of 2010 and in ongoing proposals. A mini python/pyraf/iraf reduction pipeline was devised for quick and efficient data reduction. Automatic line intensity measurements are used to derive chemical abundances, star formation rates and the galaxy rotation curve to understand the galaxy kinematics. Another aspect for exploration discussed is to derive the stellar populations of these galaxies using UlySS (University of Lyon Spectroscopic analysis Software) by Koleva et al 2008.

Title: Insights into Galaxy Evolution from Quantitative Morphology
Speaker: Dr Yogesh Wadadekar
Venue: 1896 Building
Date/Time: 11 October/11:00
Abstract: The study of the morphology of galaxies is useful to understand the formation and evolution of galaxies and their sub-components as a function of luminosity, environment, and star-formation and galaxy assembly over cosmic time. Disentangling the many physical effects that affect galaxy evolution and morphology, requires larger galaxy samples and automated ways to measure morphology. The advent of large digital sky surveys, with unprecedented depth and resolution, coupled with sophisticated quantitative methods for morphology measurement have led to new insights into galaxy evolution. I will review recent progress in the field using illustrative examples from my own research

ACGC

Title: Non-parametric Reconstruction of Dark Energy using Gaussian Processes
Speaker: Marina Seikel, UCT
Venue: M111, Maths UCT
Date/Time: 11 September 2012/13:00
Abstract: An important issue in cosmology is reconstructing the effective dark energy equation of state directly from observations. With few physically motivated models, future dark energy studies cannot only be based on constraining a dark energy parameter space, as the errors found depend strongly on the parametrisation considered. We present a non-parametric approach to reconstructing the history of the expansion rate and dark energy using Gaussian Processes, which is a fully Bayesian approach for smoothing data. This method is also used to perform consistency tests of the concordance model. For the reconstructions we use distance measurements of supernovae Ia as well as Hubble rate measurements from baryon accoustic oscillations (BAO) and cosmic chronometers.

Title: The Deep Polarized Sky
Speaker: Russ Taylor, University of Calgary
Venue: M304 (Maths, UCT)
Date/Time: 20 September 2012/13:00,
Abstract: Deep spectro-polarimetric imaging of the sky at 1.4 GHz with the Dominion Radio Astrophysical Observatory Synthesis Telescope has revealed an increase in the average fractional polarization of AGN integrated radio emission that continues to the sub-mJy regime. The deep polarization sky thus presents a puzzle that cannot be understood by simple extrapolation of the polarization properties of the strong AGN source population. At the same time observations and modeling of integrated polarized radio emission from disk galaxies is revealing significant polarized signals, and suggests that the

evolution of the global properties of the magnetic fields in galaxy disks can be traced through statistical analyses of integrated polarization. Deep wide-field, spectro-polarimetric imaging surveys with our current largest telescopes, and planned with MeerKAT, promise to a) probe the polarization of the faint AGN population, b) allow measurements of the magnetic field properties in disk galaxies out to high redshift, and c) detect evidence of the cosmic magnetic web via propagation effects. All are key investigations in the effort to probe the evolution of cosmic magnetic fields.

Title: Effective Field Theory of Multi-Field Inflation a la Weinberg
Speaker: Nima Khosravi, AIMS.
Venue: M111 (Maths building, UCT).
Date/Time: 9 October 2012/13:00
Abstract: We employ the effective field theory approach for multi-field inflation which is a generalization of Weinberg's work. In this method the first correction terms in addition to standard terms in the Lagrangian have been considered. These terms contain up to the fourth derivative of the fields including the scalar field and the metric. The results show the possible shapes of the interaction terms resulting eventually in non-Gaussianity in a general formalism. In addition generally the speed of sound is different but almost unity. Since in this method the adiabatic mode is not discriminated initially so we define the adiabatic as well as entropy modes for a specific two-field model. It has been shown that the non-Gaussianity of the adiabatic mode and the entropy mode are correlated in shape and amplitude. It is shown that even for speed close to unity large non-Gaussianities are possible in multi-field case. The amount of the non-Gaussianity depends on the curvature of the classical path in the phase-space in the Hubble unit such that it is large for the large curvature. In addition it is emphasized that the time derivative of adiabatic and entropy perturbations do not transform due to the shift symmetry as well as the original perturbations. Though two specific combinations of them are invariant under such a symmetry and these combinations should be employed to construct an effective field theory of multi-field inflation.

Astro-coffee

Title: "An optical study on the Southern high mass star forming region RCW 34"
Speaker: Robert J Czanik, NWU-Puk Post-graduate student
Venue: 1896 Building
Date/Time: 1 Oct/11:00
Abstract: RCW 34 is an HII region which is located in the constellation of Vela and only visible from the Southern hemisphere. The gas is excited by an O8.5V and two B type stars and forms a geometric bubble. A few studies have been performed on an embedded cluster that is in the clearing of the

bubble shape. In 2009 a NIR study by H.M. De Villiers showed a vast number of embedded objects that stretched much further that was previously anticipated. These objects showed signs that they may be embedded T Tauris/PMS stars. An independent optical study was performed to test the basis of the previously obtained results. From the optical study 5 H-alpha emitters were discovered and many showed photometric properties of PMS stars.

NASSP

Title: 3D SPH Models of Stellar Interactions and Explosions
Speaker: Dr Shazrene Mohamed.
Venue : RW James Lecture Hall D
Date/Time: 29 Aug 2012/13:00
Abstract: Smoothed Particle Hydrodynamics (SPH) is a Lagrangian technique particularly suited to studying hydrodynamical flows with arbitrary geometries. I will briefly highlight the physics behind the method and discuss its applications to some stellar astrophysics problems, e.g., the outflows of single and binary stars, novae and supernovae.

Title: Shedding Light on Dark Energy
Speaker: Caroline Zunckel.
Venue : RW James Lecture Hall D
Date/Time: 12 September 2012/13:00
Abstract: The critical issue in cosmology today lies in understanding the unidentified ingredient in the cosmic energy budget that acts against the gravitational attraction of normal matter making up the stars and galaxies, leading to an expanding Universe that is speeding up. With our current best guess of this "dark energy", namely Einstein's cosmological constant, at odds with our particle physics predictions, we are tasked with finding an alternative theory. However, our profound lack of intuition of the physics behind dark energy places severe constraints on our ability to make progress, forcing us to make assumptions about the time evolution of dark energy as well as the other cosmological parameters that could, if incorrect, render our results meaningless. In this talk, I will review the standard cosmological model, the evidence for dark energy, current approaches in dark energy cosmology and will present novels ways of tackling this problem.

Title: The MASSIV Survey.
Speaker: Dr Benoit Epinat
Venue : RW James Lecture Hall D
Date/Time: 21 September 2012/12:00
Abstract: The MASSIV survey is composed of 84 star-forming galaxies at $0.9 < z < 1.8$ selected from the VVDS. I will present its selection and focus on the main results of this survey: the kinematic diversity, the discovery of inverse metallicity gradients, the evolution of scaling laws and the role of environment on galaxy evolution as deduced from the study of the merger

rate from MASSIV.These results will be put in regard to other integral fields surveys at larger (e.g. LSD/AMAZE, SINS or OSIRIS) and lower redshifts (e.g. GIRAFFE).

Title: The Universe in three dimensions
Speaker: Dr Maciej Bilicki
Venue : RW James Lecture Hall D
Date/Time: 26 September 2012/13:00
Abstract: The Universe on the largest scales resembles a 'cosmic web'. Galaxies are organised into a network of interconnected filaments and walls that encompass huge voids of dozens of megaparsecs across. By analysing this large-scale distribution of galaxies and their motions, we are trying to answer several questions important for physical cosmology, such as if the general relativity is valid on the largest scales and what is the dark energy driving the accelerated expansion of the Universe. These studies require detailed observational knowledge how the galaxies are distributed not only on the celestial sphere, but also in the third dimension (distance from us), the latter obtained through precise measurements of galaxy redshifts. Wide-angle redshift surveys are expensive and time-consuming, so a trade-off is usually made between large angular coverage of the sky and the depth of the survey. For some cosmological applications we need however to map the 3D galaxy distribution on the whole sky. For instance, an all-sky redshift survey is essential to test for the isotropy and homogeneity of the Universe, an assumption that underlies the currently accepted cosmological concordance model. I am involved in a project aiming at compiling the largest all-sky redshift catalogue that will include roughly 1 million galaxies with a median distance of ~400 Mpc. For that purpose, we are using the Two Micron All Sky Survey (2MASS) - a galaxy catalogue based on observations in the near infrared. Less than half of the 2MASS galaxies currently have precise (spectroscopic) redshift measurements. As for the remaining ones, we are estimating them from other distance-dependent parameters, such as observed fluxes in various photometric bands - a method known under the name of "photometric redshifts". For that purpose, we are using an artificial neural network algorithm - the ANNz - that has been proven to work successfully in similar applications.

Title: Tracing Galaxy Evolution and Mass Assembly in Galaxy Groups
Speaker: Dr Kelley Hess
Venue : RW James Lecture Hall D
Date/Time: 3 October 2012/13:00
Abstract: Galaxies exhibit a wide range of morphological characteristics and it is clear that the environment in which galaxies live is a good predictor of their morphology, color, age, and star formation rate. Despite the correlation between galaxy properties and their environment, it is still unclear to

what degree the environment drives evolution (nurture) versus being a passive tracer of innate galaxy properties (nature). Detailed work at optical and radio wavelengths suggests galaxies undergo transformation on the outskirts of clusters. However, the majority of galaxies reside in groups, intermediate-sized gravitationally bound structures of a few to a hundred members, and may be where they undergo the majority of their evolution. As the component of galaxies most easily disturbed by changes in environment, the cold, neutral hydrogen gas (HI) is a tracer for recent and ongoing interactions between galaxies and their surroundings, as well as a measure of the star formation potential of a galaxy. I will give an overview of galaxy evolution and environment, and present recent results which combine optical and HI observations to reveal direct evidence for the ‘’pre-processing’’ of gas, and mass assembly in groups in the nearby Universe.

Physics

Title: Characterising the transient radio sky with the SKA precursor MeerKAT
Speaker: Patrick Woudt, UCT Astronomy
Venue: Duncan Elliott Seminar Room, RW James Building
Date/Time: 10 October 2012/12:00
Abstract: The Square Kilometer Array (SKA) will be the world’s most sensitive radio telescope and will operate at two frequency regimes: the mid-frequency (0.45 - 10 GHz) and low frequency (70 - 450 MHz) range. MeerKAT is South Africa’s SKA precursor telescope and will consist of 64 SKA-ready radio dishes. This array of telescopes is currently under construction near Carnavon in the Northern Cape and is expected to start full scientific operations in 2016. In this talk I will outline the general science case of the SKA and discuss the impact of the SKA site decision on astronomy and physics in southern Africa. I will furthermore present an outline of the large legacy survey projects that have been defined for MeerKAT. One of the ten MeerKAT Large Survey Projects (ThunderKAT) is focussed on the study of radio transients and relates to understanding accretion processes and accretion-related outflow in compact binaries (accreting black holes, neutron stars and white dwarfs), supernovae and gamma-ray bursts. I will present details of the ThunderKAT project and show first results obtained with KAT-7. Through novel, computationally-intensive techniques, a new window on to the transientradio sky will be opened by the SKA precursors and ultimately by the SKA itself. ☆

Cetus a Monster Whale

by Magda Streicher
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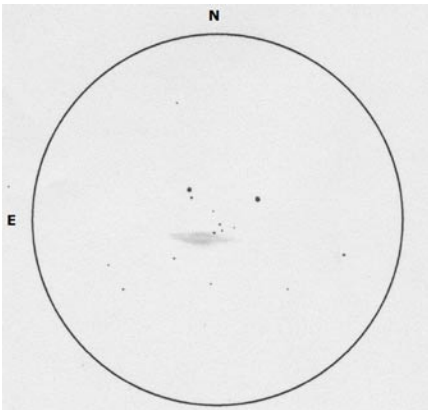
Image source: Stellarium.org

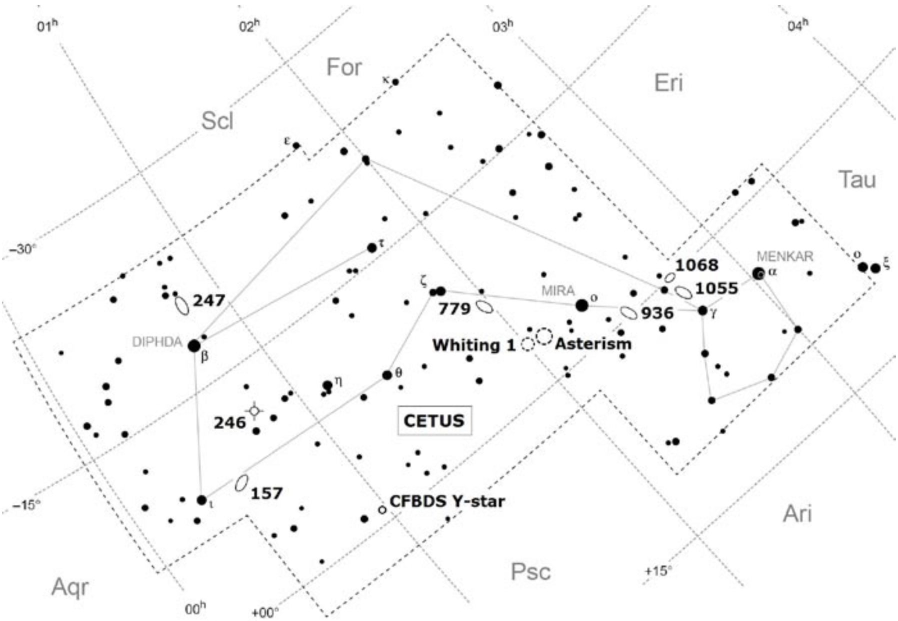
The Cetus constellation is situated in the northern part of sky and ranked as the 4th largest among the documented 88. Cetus in mythology represents the sea monster sent to kill the princess Andromeda, but legends also point a finger of concern to Draco, another northern hemisphere constellation. The constellation occupies a part of sky that houses mainly galaxies and, sadly, few known clusters or nebulae; but it is famously situated at the south pole of the Milky Way.

About 5° from the Taurus border in the north-eastern corner of Cetus, magnitude 2.5 alpha Ceti (also known as Menkar) appears to be the watchful eye of the whale. The lovely red-orange giant star can be appreciated through binoculars as a double star with a magnitude 5.6 visible partner, but it is not a physical companion of alpha Ceti.

The magnitude 4 delta Ceti star points the way barely 35' east to **NGC 1055,** one of the most outstanding objects to be found in this constellation. The galaxy displays a soft elongated east-west oval with the middle part slowly brightening to an intense glow. With averted vision the eastern part displays a fade-out tip. The western section again is somewhat slimmer, a fraction longer with a defined tip and a small triangle of magnitudes 12 to 13 stars close by (see sketch). With higher magnification the dusty dark lane nearly touches the northern edge of the galaxy. This star city forms a nice triangle a few arc-minutes to the south of two similar stars, a slightly yellow magnitude 6.7 and a plain cream-white magnitude 7.5 which also pairs with a magnitude 10 star to its south. It is a very exceptional star field that rounds off this showpiece galaxy in a very distinctive way.



NGC 1055 - Galaxy - Cetus



Another galaxy, quite different in shape and impression, is the well-known **NGC 1068** (Messier 77), half a degree south from NGC 1055, and the only Messier object in the constellation Cetus. NGC 1068 is a peculiar Seyfert galaxy displaying a misty appearance with an irregular shape and a very bright star-like nucleus. With a mottled brightness of about magnitude 8.2 one gets the impression of a faint globular cluster rather than a galaxy. Higher magnification, however, reveals soft, barely visible, wisps of nebulosity around the edge. The galaxy is just west of a magnitude 9 foreground star gives the impression of two wide open eyes in the dark of night. Even the stars in the field play the game in pairs, which is quite pleasing. This Seyfert system, which exhibits unusually intense and variable ultraviolet emissions from a tiny star-like nucleus is probably the sign of gas spinning into a super-massive black hole. It was also one of the first galaxies found to have a large red shift, thus implying that it was receding rapidly along our line of vision. The spiral structure in NGC 1068 (M77) was first noted by the Earl of Rosse.

To the east, forming a triangle with the above two galaxies, is NGC 1072, a very faint north-south spindle which is a real challenge to search out.

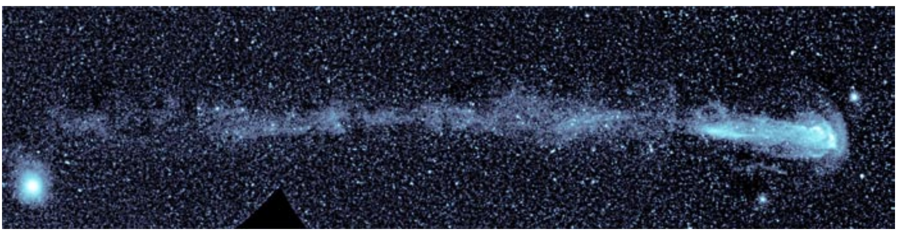
An easy way to find objects is to look out for triangles among the stars. **NGC 936** is situated west in a long, thin triangle with the stars delta and omicron Ceti. The galaxy appears to be just a faint, roundish glow lying south of a group of four stars.

Higher magnification offers no improvement of the view with any sign of the fainter companion galaxies either. The area is packed with galaxies, but if you want to search for them you will need really high magnification, a very dark, transparent sky and a lot of patience.

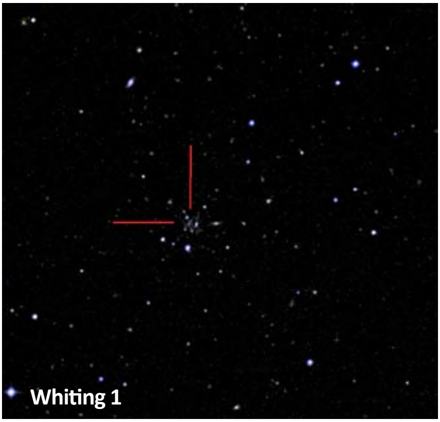
The collar on the mighty whale's neck indicates the famous magnitude 6.5 red giant star **omiron Ceti**, better known as Mira, which means "the wonderful", a name bestowed on it in 1662 by Johannes Hevelius (1611–1687). The star undergoes actual pulsations in size and brightness and varies from as dim as magnitude 9 to as bright as magnitude 3 – 4 and even as high as magnitude 2. The Greek astronomer Hipparchus became the first person to spot the star's light, but recognition as a variable star was credited to David Fabricius (1564 – 1617), who spotted it rising in 1596 and again in 1609. The cycle is now estimated to be 11 months or close to the value of 332 days. In 2007 astronomers imaged Mira's ultraviolet smoke trail of about 2° long left behind in its 30 000 years of travel through space. Mira, known as a Mira-type star, appeared in Johann Bayer's 17th – century catalogue, where it was assigned the Greek letter omicron. A magnitude 12 companion star can be found in a PA of 90. Another lovely red magnitude 9 star can be seen north-east of Mira, which lends a special effect. However the system was previously identified as multiple in the *Hipparcos Input Catalogue*. The astronomer William Herschel refers to Mira as a star with a deep garnet colour.

Mira's comet-like tail stretches a startling 13 light-years across the sky (see picture). Mira's tail also tells a tale of its history – the material making it up has been slowly blown off over time, with the oldest material at the end of the tail having been released about 30 000 years ago.

Globular clusters are concentrated old stellar groups that can be found in the outer Milky Way disc. **Whiting 1** was found on a survey done by Alan Whiting (Cerro Tololo Inter-American Observatory) in 2002 that identified it as a compact cluster of blue stars which he believes could possibly be a very young globular cluster due to an abundance of low metals. The object was later classified as an open cluster only



Mira appears as a small white dot in the bulb-shaped structure at right, and is moving from left to right in this view. The shed material can be seen in light blue. The dots in the picture are stars and distant galaxies. The large blue dot at left is a star that is closer to us than Mira.


Whiting 1


NGC 246. Picture credit, Dieter Willasch

about 5 billion years old (see picture). This object is situated 4° west of Mira, but do not expect to make an observation of this very faint and illusive object.

Barely a degree to the south a grouping of seven relatively bright stars forming a sort of triangle impression pointing south-west. The name "the pointing seven" crossed my mind the moment I laid eyes on this **asterism**, which is best seen in low magnification with a wide-field eyepiece.

A further two degrees south, more or less in the middle part of the constellation, is **NGC 779**, a relatively bright, quite large, thin ray of light in an elongated north-south direction, with a bright stellar nucleus. Again you need very dark, transparent skies and relatively high magnification to spot this galaxy, as is the case, sadly, with most of this category objects.

Quite outstanding are the three stars eta, iota and beta Ceti, which form the tail part of the graceful, mighty whale, which can be easily identified in the south-western part of the constellation. Situated in the middle area of the indicated triangle is a very exceptional planetary nebula which truly creates an unusual impression. **NGC 246** is well known as one of Cetus's special jewels, and is indeed out of the ordinary. The planetary nebula displays a soft, round-dish smoke ring that engulfs five foreground stars, with the hot central star very obvious (see picture). Filters will bring out a knotty structure on the planetary surface, which sometimes refer to in the appearance of a human skull. If you want only one object that is worth a visit then you need not look any further. The very faint galaxy NGC 255 is situated only 30' to the north.

Another special Cetus galaxy **NGC 247** can be found 2 degrees south of the magnitude 2 beta Ceti also known by the name Diphda. The spindle in a north-south direction is quite outstanding against the background star field with a relatively bright nucleus (see picture). With careful observation and higher magnification distinct markings and perhaps a few star points can be spotted on the dusty surface.


NGC 247 Picture credit, Dieter Willasch

NGC 247 belongs to the Sculptor Group of Galaxies and is about 7 million light-years distant.

The galaxy **NGC 157** is situated virtually on the western tip of the whale's fin just slightly north-east of the star magnitude 3.5 iota Ceti. The galaxy lies in a north-east to south-west direction and displays a quite prominent nucleus covered in haziness. With larger backyard telescopes and really high magnification it is possible to spot perhaps a few markings on the surface if you are fortunate to have transparent dark skies.

The Canada-France Brown Dwarf Survey (CFBDS) has found the coolest brown dwarf yet, not even 350^o Celsius – cool enough to show ammonia in its spectrum (*Sky and Telescope*, August 2008). This star, known as **CFBDS J005910.90-011401.3**, has now been put into a new proposed spectral class of Type Y stars and is situated about 40 light-years away in the Cetus. The special star is situated in the far north-west of the constellation, a degree north-east of the galaxy NGC 307, but spare yourself the effort of looking for it.

Why not swim with the monster whale and discover some of the special objects sharing the waves in the seas of Cetus! ☆

Object	Type	RA (J2000.0)	Dec	Mag.	Size
NGC 157	Galaxy	00^{h}34^{m}8	-08°24′	10.4	4.1′x2.4′
NGC 246	Planetary Nebula	00 47 0	-11 53	8	225″
NGC 247	Galaxy	00 47 1	-20 46	9	19′x5.5′
CFBDS J005910.90-011401.3	Type Y Brown Dwarf	00 59 1	-01 14	-	*
NGC 779	Galaxy	01 59 7	-05 58	11.2	3.4′x1.2′
Whiting 1	Cluster	02 02 9	-03 15	-	-
Star Group	Asterism	02 04 8	-04 16	7.2	40′
Omiron Ceti	Mira-type Star	02 19 3	-02 59	9-2	*
NGC 936	Galaxy	02 27 6	-01 09	10.2	5.7′x4.6′
NGC 1055	Galaxy	02 41 8	+00 26	10.6	7.3′x3.3′
NGC 1068 (M 77)	Galaxy	02 42 7	-00 01	8.9	8.2′x7.3′

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

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

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

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

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

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