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Cover: Thackeray's Globules

The red background glow is hydrogen gas which silhouettes dark clouds of gas known as 'Thackeray's Globules'. They were discovered by the South African astronomer AD Thackeray in 1950 while director of the Radcliffe Observatory, Pretoria. This recent Hubble image clearly shows two dense dust clouds overlapping, each more than one light year across. Young hot stars are radiating intense UV light and it is likely that no further stars will be born here as this radiation will prevent the clouds from collapsing to form any further new stars.

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Letter to the editor

Dear Editor

In a recent issue of *MNASSA* (Koorts 2012), Willie Koorts described the ESO site testing in South Africa and discussed two issues: The decision of ESO not to build in South Africa and the astronomical seeing on the high veld.

In deciding where to locate an observatory, especially an international one, a considerable number of factors need to be considered in addition to the astronomical quality of a site. These include: the quality of local industry, infrastructure and technical skills; ease of access for observers (in this case from Europe); the presence of an established astronomical community; the political stability and international acceptability of the host country; and cost. No doubt all these factors were weighed up by the ESO Council.

In this connection it is perhaps worth repeating something which I have recorded elsewhere (Feast 2002). In March 1963, I was told by Bertil Lindblad, a key Swedish member of ESO (see e.g. fig 2 of Koorts 2012) that it would be difficult if not impossible to get approval for Sweden to be involved in building a major observatory in South Africa under the prevailing apartheid political dispensation. As Willie Koorts points out, the decision not to come to South Africa was taken by ESO on 15 November 1963. It thus seems rather unlikely that ESO would have built in South Africa whatever the results of the seeing survey has been.

As regards a marked deterioration of the seeing in the second half of the night, this was apparently a significant problem at the Boyden Observatory (Bloemfontein) as noted by Bok who had experience there (see Koorts 2012). In my experience this was not such a severe problem at the Radcliffe Observatory, Pretoria. Presumably this can be, at least partly, attributed to the height of the observatory above the surrounding country which generally placed it well above the, frequently present, inversion layer.

Yours Sincerely
Michael Feast

References:

Feast M. W. 2002, in, *Organizations and Strategies in Astronomy III*, Kluwer, Dordrecht, p.153
Koorts W. 2012 *MNASSA* 71, 248

LCOGT News

In his June 2012 survey of telescopes at Sutherland (see MNASSA Vol. 71, Nos 5 & 6, June 2012, p125), Willie Koorts mentioned three new domes belonging to the Las Cumbres Observatory Global Telescope Network (LCOGT) project. They just got one step closer to reaching their goal with the three 1-m telescopes achieving first light, paving the way for science operations to start soon.

The Las Cumbres Observatory Global Telescope Network (LCOGT) is a privately owned non-profit observatory committed to time domain astronomy (studies of astronomical phenomena changing with time) and public awareness of science. It was founded by Wayne Rosing, a leading engineer in the computer business.

The observatory is committed to building telescopes all over the world to enable uninterrupted observations of many types of object, including that of extra solar planets, supernovae and the optical monitoring of other time-variable sources. The data will be stored and made available on-line to all those interested.

Across the globe, the Las Cumbres Observatory has seven sites with almost 40 telescopes whose apertures range from 0.4 metres to 2 metres. They are equipped with imaging and spectroscopic instruments. All the telescopes work remotely and robotically. The Observatory headquarters are located in Santa Barbara in the United States of America.

At the South African Astronomical Observatory in Sutherland three 1-metre telescope buildings have been erected thus far. The three telescopes, first built and tested at the company's Santa Barbara headquarters, were delivered to the SAAO in Sutherland on Monday, 18 February 2013. Their bases were installed early the next morning after which the telescopes structures were assembled, the mirrors installed and

aligned, the instrumentation mounted and connected up. By 22 February, all three telescopes saw first light: a truly remarkable achievement! The telescopes have a C-ring equatorial mount, with an optical design comprised of an f/2.5 Hextek lightweight primary mirror and a 330mm diameter Hextek secondary. These were optically finished by LZOS in Russia, providing an f/8 modifed Ritchey-Chretien system, with the addition of a doublet corrector in front of the instrument package. The system is designed for 80% enclosed energy within a circle of diameter 0.6 arcsec.

Science will commence once the telescopes and instruments have been installed, during the first half of this year. Upon completion, the Sutherland site of the Observatory will comprise six telescopes, three 1-m telescopes will be dedicated to science observations, while the other three, 0.4-m telescopes, will serve mainly outreach and education. In exchange for hosting the Las Cumbres Telescopes, South Africa will have ten percent of the total observing time in order to carry out new astronomical research and will be able to access the online data.

The three 0.4-metre telescopes will be dedicated to "citizen science" and public understanding of astronomy and ensures that the LCOGT offers a huge outreach component, Dr Abiy Tekola, an Ethiopian Postdoctoral Fellow holds a joint position at the Las Cumbres Observatory Global Telescope Network and South African Astronomical Observatory has, already piloted the outreach project with learners from two Sutherland primary schools at the recently inaugurated Sutherland Community Development Centre.

According to Dr Tekola, "These telescopes will contribute magnanimously towards creating a scientifically literate younger generation countrywide, also in the development of astronomy in the continent. Anyone interested in participating in the project needs to have a computer with internet access. The astronomical data are freely accessible on the LCOGT website http://lcogt.net/". Detailed instructions for participation are available from: http://lcogt.net/education. ☆

SAAO's Mechanical Workshop and Optics Lab Upgrade

Lisa Crause

The SAAO's Mechanical Workshop in Cape Town recently took a huge leap forward with a R10 million infrastructure upgrade. All computer controlled, the workshop floor is now dominated by a huge 5-axis Milling Machine, surrounded by two Lathes, a Spark Eroder and Wire Cutter. The Optics Lab was also refurbished, enabling sophisticated optical work to be carried out in-house. The capabilities of these new machines have already been demonstrated with some technically challenging work produced for iThemba Labs and MeerKAT.

The Workshop's two CNC lathes – the larger, new one is in the background.

In late 2010, the National Research Foundation (NRF) notified the South African Astronomical Observatory (SAAO) of a generous grant from the Department of Science and Technology (DST). Approximately R10M had been made available and was to be committed (and, ideally, spent) before the end of the Financial Year! The only conditions were that the money be used exclusively for infrastructure and that items exceeding half a million Rand would be subject to a rigorous tender process.

Fortunately the Mechanical Workshop had a comprehensive wish-list on hand that could consume more than half the allocation, although tenders would have to be sought since the various machines exceeded the R500k limit. Fast-forward through endless sequences of eye-wateringly painful meetings and flaming bureaucratic hoops, to where we are now – relishing a host of amazing new machines and other fantastic toys!

Machining in the computer era

The Workshop's bold entry into the modern age actually came a few years ago with the acquisition of its first Computer Numerical Control (CNC) machines, in the form of a 4-axis CNC mill and a CNC lathe. While operating on much the same principles as conventional lathes (fixed

The 5-axis CNC milling machine. The cutting tool comes down from the grey turret at the top while the part (a copper piece in this photo) gets clamped to an assembly that can translate in X and Y and rotate about two axes.

tool, spinning part) and mills (fixed part, spinning tool), the CNC versions are hugely more versatile and efficient due to computers handling the core business of "removing excess material".

The steps that follow uploading a 3D Computer-Aided Design (CAD) file to a CNC machine are non-trivial, particularly as one has to simulate the entire tool-path to ensure that no collisions could occur during the machining process. However, once that has been done – any number of such parts can be produced without further investment, other than the operator having to physically set up each new block of material. This makes CNC machines ideal for mass-production environments, which, admittedly – the SAAO generally is not. The sorts of parts we need tend to be complex and are often unique. Even so, the remarkable "agility" of CNC machines calls for fewer setups for a given part and allows more ambitious designs to be manufactured. Furthermore, onboard metrology gear allows *in situ* measurements to be made during machining. This eliminates wasted effort in terms of removing the part to measure it with other devices and then having to meticulously set it up again before being able to continue.

The utility of the Workshop's original two CNC machines prompted the selections made possible by this latest funding tranche. Top of the list was a 5-axis CNC mill (since the additional axis vastly increases the machine's capabilities), followed by a substantially larger CNC lathe. The other two machines were chosen to provide an entirely new capability, namely Electrical Discharge Machining (EDM). The EDM machines are also of the CNC variety, but rather than relying on mechanical means to shape parts, the Spark Eroder and Wire Cutter do so using electrical energy. Both also have four axes and thus are extremely dexterous.

Electrical Discharge Machining principles

In the EDM game, the tool and the work-piece act as electrodes and the two are immersed in a bath of dielectric fluid which provides insulation. A large voltage is applied to the system and the two electrodes are brought close to one another. At a given threshold separation, the electric field strength overwhelms the dielectric, causing electrical breakdown within the fluid and this allows a spark to jump across the gap. The spark erodes both the electrodes and so by using an appropriately shaped tool electrode, one can electrically "carve out" the desired shape in the work-piece electrode. This process is also known as die-sinking. In the case of the Wire Cutter, ~250 micron thick wire is continuously spooled from a large reel to serve as the tool electrode, rather than the shaped piece of copper that is typically employed in the Spark Eroder. In the latter case, it may be necessary to replace or reshape the tool electrode as it gets worn down, to ensure that it continues to spark out the appropriate shape.

EDM is a slow, repetitive process as the gap between the electrodes has to be opened again after each spark. This refreshes the dielectric and flushes away the fine particles liberated by the spark. Increasing the current can speed up the removal of material, but this produces a rougher finish. Also, one's material selection is of course limited to substances that can conduct electricity. The advantages to this approach are significant though as the process allows for much more complex shapes to be machined – including sharp (e.g. 90°) corners and deep pockets that conventional cutting tools cannot produce. EDM is also safe to use on extremely delicate parts such as

(left) The CNC Spark Eroder. The blue turret holds the tool electrode and moves it up and down (in the Z-direction). The blue door seals the work volume that gets filled with dielectric fluid and the part gets clamped to a platform that can move in the X and Y directions. The electrode can also be angled to allow side-sparking and the 4th axis is provided by the ability to rotate the tool electrode.

(right) A variety of intricate copper parts (belonging to the detector system for one of the MeerKAT antennas) that were manufactured in the Workshop.

thin (sub-mm) flexures as there is no physical contact between the tool and the part. It works equally well on hardened materials that would require special heat treatment processes to allow conventional machining and then to relieve the mechanical stresses that this introduces.

The Integration Room side of the optics lab during the removal of the old floor (left). This room now includes a new 1.6 ton overhead crane with an electric hoist, an environmental chamber for temperature-testing equipment and a large removable hatch in the wall shared with the Workshop to allow large instruments to be moved in and out.

External work

Until recently, the Mechanical Workshop only serviced the needs of the Observatory – for projects related to the small telescopes and to SALT. The introduction of this highly complementary set of machines will allow the production of extremely specialised parts, even in large numbers. This provides an exciting opportunity for the SAAO to participate in a broader range of scientific endeavours, both in astronomy and beyond. The completion of a number of technically challenging contracts for iThemba Labs over the past few months offered a steep learning curve for Craig Sass and his team and has resulted in a great symbiosis between two National Facilities. Interesting work has also been done to produce parts for the MeerKAT detector assemblies. This success bodes well for the SAAO's future involvement in South Africa's contribution to the Square Kilometre Array (SKA).

Optics Lab Upgrade

Although this may seem like a strange deviation from the SAAO Workshop's traditional focus, taking on these sorts of jobs is an excellent way to hone the many skills required to use these machines to their full potential. This of course will be crucial if the Observatory is to grow its capacity to develop more ambitious astronomical instrumentation. In support of this vision, the old Optics Lab next door to the Mechanical Workshop was also given a thorough overhaul. Ian Glass kindly guided us through the daunting process of sorting through every item that had made its way into the lab over the past few decades. Having cleared out and then removed all of the less-than-ideal wooden storage spaces, a 1.6 ton overhead crane with an electric hoist was installed in the Integration Room section. Fresh paint was applied throughout and then the old, damaged floor tiles were removed and replaced with a durable, easy-to-clean epoxy floor. The required grinding of the surface beneath the old tiles generated *epic* amounts of incredibly fine dust that perfectly coated every conceivable surface within the lab. This subsequently provided many hours of "team-building" for future lab users who spent a day washing and cleaning. Everything. At that point, the new furniture and equipment could at last be unpacked and installed in the completely transformed space.

Projects lined up

The new lab has been used for various small projects already, but we look forward to the year's main challenge, namely aligning and integrating replacement optics for the collimator of SALT's Robert Stobie Spectrograph (RSS). The RSS optics have caused their fair share of misery in the past and this time we are determined to deal with the issues ourselves, rather than sending the lenses back to California for further repairs. This affords the Observatory a great opportunity to develop capacity for handling large optical elements made of challenging materials like calcium fluoride and sodium chloride in our lab. Furthermore, all of the replacement opto-mechanics will be manufactured in the Mechanical Workshop using the CNC machines described above.

In the meantime, SALT's new High Resolution Spectrograph (HRS) is due to be delivered around the middle of the year and so the Workshop is churning out parts for the Fibre Instrument Feed (FIF). The FIF, to be housed within the SALT payload, will provide the interface between the focal plane and the optical fibres that will feed the instrument (which will be situated in the spectrometer room below the telescope).

Second in priority to the Workshop's current FIF work is the manufacturing of parts for a major upgrade to the SAAO 1.9-m telescope's Cassegrain Spectrograph. This ancient workhorse instrument will receive new camera optics, a new detector and cryostat, various new mechanisms and the software will undergo a substantial overhaul to improve the efficiency of observing and data reduction. The upgraded lab facilities will be essential for the alignment and integration of the optics and the new hardware before the instrument can be returned to Sutherland for full on-sky commissioning.

Other than the need for more staff to take full advantage of the new equipment, the SAAO's Instrumentation Division is superbly placed to tackle exciting challenges and grow from the experiences. We very much look forward to working with the SAAO's new Director, Prof Ted Williams (a self-confessed instrumentation junkie!) to realize this potential. ☆

Johannesburg Moonwatch Recalled

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Source: Dirk J Vermeulen, 2006, *Living Amongst the Stars at the Johannesburg Observatory*

South Africa played a very important role at the dawn of the space-age because of its strategic position on the globe, being the first land mass over which satellites launched from the US, would pass. It is thus logical that America invested in tracking stations here. One such method was called Moonwatch where an "optical fence" was set up, detecting the satellite as it passed through it. However, this required a lot of manpower, which was supplied by keen volunteers who wanted to be part of the space age. Prof Peter Spargo, then a WITS student, was the youngest member of the Johannesburg Moonwatch and shares his memories of this experience here.

The **International Geophysical Year** (IGY) – actually an eighteen-month period, running from 1 July 1957 to 31 September 1958 – was a most remarkable undertaking, involving thousands of scientists from 67 countries (although, most notably, China did not participate in protest at the inclusion of Taiwan). Its purpose was to undertake collaborative research into eleven of the most important earth sciences: the aurora, cosmic rays, geomagnetism, gravity, ionospheric physics, the determination of latitude and longitude, meteorology, oceanography, seismology and solar activity.

Artificial Earth Satellites

Among the numerous research activities arising from the IGY unquestionably the one that most caught the public imagination was that of the launching of artificial Earth satellites. The idea itself was not new, having been first proposed by Newton in his *A Treatise of the System of the World*, (1728), and kept alive after that by a number of writers such as Jules Verne, the great Russian rocket pioneer Konstantin Tsiolkovsky and, most notably, the extraordinarily original and imaginative British science fiction writer Arthur C Clarke, who predicted the role and importance of satellites in global communication.

The Space Race

In the United States discussions relating to Earth satellites had gone on from the 1940's involving both the US Navy and Air Force – including a 1946 design for "An Experimental World-Circling Spaceship"! Finally, on 29 July 1955 the White House announced the intention of the United States to launch one or more satellites by early 1958 under the operational title of Project Vanguard.

Two days later the Soviet Union announced that it planned to launch a satellite by late 1957. Although the Russian claim should have served as a warning to the United States, it appears that few in the US took seriously the Russian claim of an intended first launch – or even seemed aware of it – as the belief on the part of the Americans of their scientific and technical superiority was overwhelming.

Tracking Satellites

If Earth satellites were to serve any useful scientific purpose, such as measuring the density of the upper atmosphere or the strength of the Earth's gravitational field, it was obvious that they needed to be tracked with care and their orbital elements determined with as much precision as possible. In order to do this, three methods were planned. First, using the 108 MHz radio signals which the US satellites were planned to emit, and which would be received by a worldwide network of 'Minitrack' radio stations[1]. Secondly using complex, high-quality, professionally-managed Schmidt telescopes, widely known as "Baker-Nunn" cameras,[2] (see also *MNASSA* Vol 71 Nos 5 & 6 June 2012). Or thirdly, using teams of amateur observers equipped with special, relatively simple telescopes. The latter

Early Baker-Nunn camera. Peter Smits

[1] The Minitrack system, a worldwide network of radio-receiving stations operated by the Naval Observatory in Washington, was primarily intended to receive and record scientific information from US satellites and not 'track' satellites in the usual sense of the word. It was not yet operational when Sputnik was launched in October 1957. The South African Minitrack station, located in the grounds of the [then] South African Railways Training College at Esselen Park, was located a short distance to the west of the now R21 between Johannesburg and Pretoria It became one of the most successful stations in the world. In 1960 it moved from Esselen Park to Hartbeesthoek.

[2] Baker-Nunn 'cameras' (actually large, short-focus Schmidt telescopes designed to track fast-moving objects and standing almost two metres high and weighing nearly a ton!) were located in Argentina, Australia, Japan and South Africa. In South Africa the 'camera' was located on a site adjoining the [then] South African Post Office's Radio Transmission Station at Olifantsfontein, a few hundred metres to the west of the now R21 between Johannesburg and Pretoria. It consisted of the temporary, virtually roofless metal building housing the large camera, two or three metal rondavels and a radio mast. The buildings were set on a bare piece of flat veld and the bitter, windswept Highveld winter nights must have made observing a less than happy experience. (see also *MNASSA* Vol 71 Nos 5 & 6 June 2012)

undertaking, officially named Operation Moonwatch but usually referred to simply as 'Moonwatch', was organised and managed by the Smithsonian Astrophysical Observatory (SAO), located in Cambridge, Massachusetts, the director of which was the well-known astronomer Dr Fred Whipple.[3]

Moonwatch

Moonwatch teams, usually consisting of between ten and twenty volunteers, many of whom were experienced amateur astronomers, were therefore set up some time before the anticipated launching of the first US satellite in early 1958. Although the majority of these 150 teams were based in the United States, others were in countries as widely distributed as Greece, Cuba, Zambia, India, Australia, Iran and South Africa. In order to assist Moonwatch teams in building the appropriate telescopes, the July 1956 issue of *Sky and Telescope* included the first of a series of supplements, "Bulletin for Visual Observers of Satellites."

As South Africa would be the first landmass to be crossed by a satellite launched in a SE direction from Cape Canaveral, the role of Moonwatch in this country was particularly important!

Teams were soon established in Johannesburg (based at the Union Observatory [UO]), Pretoria (based at the Radcliffe Observatory) and Cape Town (based at the Royal Observatory)[4]. The team leaders were at the UO, Dr CN ('Neil') Williams (with UO astronomer 'Joe' Churms as his deputy), at Radcliffe, Mr RF Smith and Dr DS Evans at the Royal Observatory at the Cape. (Later a team was established at Bloemfontein, based at the Boyden Observatory under the leadership of Dr J Stock. A request to establish a similar team in Port Elizabeth had to be turned down due to a lack of funds.) A general Satellite Management Committee was also established. Components for the small telescopes used initially were slow in coming from the US but they eventually arrived and the telescopes were assembled by the team members.

Call for volunteers

Although at the time I was an engineering student at WITS, and hence living a pretty pressurised life, when a call went out to join the Johannesburg team – I think through the medium of a local ASSA

[3] For a detailed account of the whole Moonwatch operation, see W Patrick McCray, 2008, *Keep Watching the Skies – The Story of Operation Moonwatch and the Dawn of the Space Age*; Princeton and Oxford, Princeton University Press.

[4] For a description of the South African Moonwatch operation as a whole, see J Hers, *Moonwatch in South Africa 1957-1958.* The only copy of this undated but critically important 13-page typed document that appears to have survived in the public domain is that in the library of the SAAO, Cape Town. Appended is a seminal three-page article by Dr Finsen entitled 'IGY REMINSCENCES.' For a briefer account devoted largely to the operation of the Cape Town Moonwatch team, also see RF Hurly, 'On the Role of Moonwatch', 1964, *MNASSA*, 23, 38-40.

Newsletter – I at once volunteered. At last I was truly part of the great world of scientific research! I lived in Kensington, about 4 km from the UO, but as observations were well outside normal working hours I could almost always borrow my Father's 1948 Chev Fleetmaster – although I do recall on more than one occasion cycling to the UO along the dark streets on a chilly Highveld morning.

Sputnik

We met for training sessions on a Saturday afternoon. I recall one being led by Joe Churms, where an attendee argued very vocally that the satellite's orbit could not be independent of the Earth's rotation but would surely rotate with it. We waited patiently for the first US satellite to be launched in early 1958. It therefore came as a stunning surprise, not only to us but also to both the United States and the world at large when we learned on Saturday, 5 October 1957 that Russia had launched its first satellite, Sputnik ("Fellow Traveller"). A

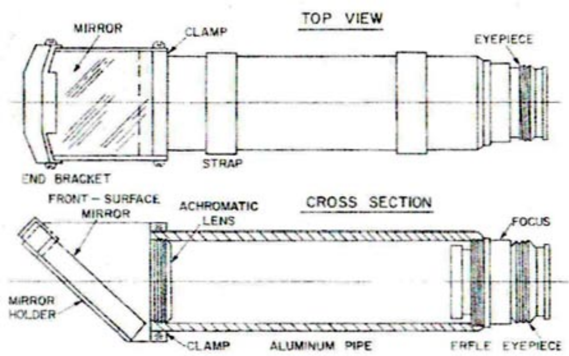
Sputnik, exploded view right.

shiny aluminium sphere 58 cm in diameter and weighing 84 kg, it was not instrumented but equipped with a radio transmitter which broadcast a regular series of 'beeps' $^{1}/_{3}$ of a second in length on frequencies of 20 and 40 MHz. Circling the Earth every 96 minutes it had perigree and apogee distances of 223 and 950 km respectively. (The first US satellite, an 8 kg cylindrical object named 'Explorer 1' although officially designated as 1958α, was only launched on 31 January 1958.)

On reading of the launching in that evening's *Star* I at once 'phoned Neil Williams, the leader of the Johannesburg Moonwatch team, dropped what I was doing, and drove in haste up to the Observatory. I only remember two or three people gathering in the time service building, situated on the kopje above the main observatory buildings, that evening. I do recall most vividly how thrilled we all were to hear the famous 'beep-beep-beep's', which were faint but unmistakeable.

Tracking Equipment

After early observations with the naked-eye or binoculars we began to use the small 2-inch (50 mm) telescopes which were designed for this purpose but the components of which were very slow in arriving from the US. It turned out, however, that they were too small for the purpose and were later replaced by the much more



Schematic view of the original Moonwatch telescopes.
Source: McCray, *Keep Watching the Skies*

powerful 5-inch (125 mm) apogee telescopes, which were used from then on. All observations took place with observers seated in a N-S line along the lawn which sloped down to the north from the main observatory building. If I recall correctly the small telescopes stood on tables but of course the much heavier and more sophisticated apogee telescopes had to be firmly mounted on steel poles anchored in concrete foundations. Timing was provided using a portable radio broadcasting the 'time pips' emitted by station WWV, located at the Naval Observatory in Washington. I continued as a regular member of the team until the end of September 1958, when the looming final exams severely restricted my 'free' time. Although the IGY officially ended on 31 September 1958, the Johannesburg team continued observing until the end of December. Moonwatch had cost many people much time but it is gratifying to note that the Johannesburg Moonwatch team made a total of 467 observations (393 of Russian satellites and 74 of American). In the same period the Pretoria, Cape Town and Bloemfontein teams made 195, 91 and 52 observations respectively (Hers, p.10).

Coffee at the Finsen's

The human atmosphere on the Moonwatch team was delightful in every way and, as the youngest member of the team, I was always made especially welcome. Dr and Mrs Finsen were warm and gracious hosts and an evening's observing often ended with coffee in their home in the Observatory grounds. There I would sit spellbound listening to experienced

The Cape Town Moonwatch team using the Apogee scopes.
Source: Dirk J Vermeulen, 2006, *Living Amongst the Stars*

observers, both amateur and professional, recounting numerous stories astronomical. I also recall Dr Finsen showing me how, using his powerful Hallicrafter short-wave radio, he could receive transmissions from anywhere in the world – an instrument with a receiving power I could only dream of compared to that of our Pye radiogram at home!

Keeping Diary

At the beginning of my matric year in 1954 I decided to keep a detailed page-a-day diary. This I continued without break for more than ten years and my diaries therefore cover the Moonwatch period.

More than one writer on the history of science has commented on the fact that the overwhelming majority of scientific papers lack a human dimension, being essentially dry, unemotional accounts of results obtained and conclusions reached. The human side rarely intrudes and the joy and excitement, as well of course as the frustrations and setbacks, of the scientific process are rarely recorded. Given this, hopefully it will be of some interest to reproduce here a number of the diary entries relating to my participation in Moonwatch.

Some Diary Extracts

Wednesday, 2 October 1957 – "After dinner I went to the first meeting of the Artificial Earth Satellite Group "Moonwatch" at the Union Observatory. It was very enjoyable."

Saturday, 5 October 1957 – "I worked [on calculus] until about 7.30 P.M., when I fetched the paper off the verandah. Staggered by the news of the Russian Earth Satellite. I rang Dr Williams & went up to the Observatory. We picked up the radio signals from the satellite at about 9.05 P.M. Today is a big day, but I am sorry the Russians got in first. I got to bed at about 1.30 A.M."

Monday, 7 October 1957 – "This evening I eagerly read all newspaper reports on the Satellite."

Wednesday 9 October 1957 – "At about 5.30 P.M. I came home and then went to the Union Observatory. Here the Earth Satellite Team was photographed by "Life" Magazine photographers. We set up for an observation and at 7h 42m 52s three of the team sighted the Earth Satellite for a few seconds. Success! The RDM [Rand Daily Mail] also took some photographs. We all had coffee and Sandwiches at Dr Finsen's house. I got home at about 10.15 P.M."

Thursday, 10 October 1957 – "After dinner I drove over to the Union Observatory. We observed the 7.42 transit of the Russian satellite "Sputnik", but saw nothing due to obscuring cloud."

Friday, 11 October 1957 – " . . .saw the Earth Satellite at 7.42 P.M. It was eerie and beautiful to see it glide past. I then went on to the Observatory. Here I stayed until about 11.30 P.M. Dr Finsen took a fine photograph. I got to bed at about 12.45 A.M."

Saturday, 12 October 1957 – "This afternoon I spent at the Observatory assembling telescopes for the Moonwatch. I had a quick supper and returned to the Observatory. We observed the satellite at about 7.39 P.M. Afterwards we all had coffee at Dr Finsen's house. I got to bed at about 12.00 P.M."

Saturday, 19 October 1957 – "[During the afternoon] I went up to the Observatory, where the "Moonwatch" Team were photographed by the African Mirror."

Monday, 4 November 1957 – "At 10 P.M. I listened to the B.B.C. News. The Russians have put up another satellite. I fear greatly that their technological lead is greater than we imagine."

Tuesday, 5 November 1957 – "After lunch I listened to the 1.15 P.M. B.B.C. News. The dog in the Russian Satellite is doing well. Two years ago I would not have believed such technological progress possible but our science & technology is advancing in a logarithmic curve I think."

Saturday, 1 February 1958 – "I learned with satisfaction [on the lunchtime SABC News] that the U.S.A. have launched an earth satellite. May this mark the beginning of an era of scientific advance by the West over the East."

Saturday, 1 February 1958 – "I was awoken at about 2.55 A.M. this morning by the harsh chatter of my alarm clock. Getting up I put some milk on the stove to warm before washing and dressing. I drank the milk, had half a slice of toast and drove up to the Observatory, arriving at about 3.25 A.M. It was a cool, fresh morning, although still quite dark. Our Satellite Observing Team was assembled in the Leyden Building at the Union Observatory. We began observing at about 3.45 A.M. and finished at about 4.30 A.M. We looked in vain for the Satellite, although its radio signals were received at 108 Mc's. I arrived home at about 5.00 A.M. and went to bed again. Getting up at about 9.30 A.M. . . . "

Tuesday, 4 March 1958 – "This evening after dinner I read the paper before going up to the Union Observatory where there was a meeting of satellite observers. I got to bed at about 11.30 P.M."

Wednesday, 26 March 1958 – "This evening I … went up to the University. There I attended a lecture-meeting of the Astr. Association of S.A. where Dr Robert Cameron, of the U.S.A., spoke on "Satellite Tracking in S. A." V. interesting."

Wednesday, 2 April 1958 – "This evening after dinner I went up to the Observatory. There we had a "Moonwatch" session for the American Satellite 'Gamma', but without success."

Sunday, 20 April 1958 – "I left the house at about 3.50 A.M. and drove up to the Observatory. There six of us, including the Union Astronomer, Dr Finsen, attempted to make an observation of the first American satellite: 1958α. However, due to inaccurate setting of the apogee telescopes, we missed the satellite. Six hour's calculations of Dr Finsen were thus wasted.

I came home at about 5.30 A.M. and got back into bed. I slept until about 9.00 A.M."

Thursday, 8 May 1958 – This evening after dinner I read the paper and went up to the Observatory. There a team of Dr Finsen, (U.A.), Mr Botham, Mr Nel & myself observed the American Satellite 1958α. We all sighted it! I got to bed at about 11.00 P.M."

Saturday 17 May 1958 – "I had a quick supper and went up to the Observatory. There Dr Finsen and myself attempted to view one of the American Satellites. However, cloud defeated us. He is a great man, but oh so much of an 'old woman.'"

Monday, 26 May 1958 – "My alarm clock awakened me at about 4.30 A.M this morning after a few hours restless sleep. Getting [up], I dressed and made some cocoa before taking the Morris and driving up to the Observatory. There five of us, including Dr Finsen, the Union Astronomer, attempted to sight Sputnik III, the third Russian earth satellite. We saw the rocket casing clearly at about 5.12 A.M. but the satellite, due at about 5.58 A.M., did not appear. I got to bed at about 6.15 A.M. After getting up at about seven o'clock ..."

Sunday, 1 June 1958 – "At about 9.20 A.M., I went down to the bottom of the street. There Dr Williams, of the Moonwatch, called for me. We went up to the Observatory, where we picked up some more passengers, and then went out to the Satellite Tracking Station at Olifantsfontein.[2] This is run by the Smithsonian Institution, employing a large Baker-Schmidt camera. On the way we stopped at the "Minitrack" Radio Tracking Station at Esselen Park.[1] Mr Cameron showed us around at Olifantsfontein. Altogether a most interesting morning. My admiration for Americans is growing."

Sunday, 27 July 1958 – "I was awoken at about twenty to five this morning. After getting up, I dressed and had some hot milk and biscuits. I Left for the Union Observatory soon afterwards, travelling by car. There we attempted the visual observation of the earth satellite 'Delta II'. We had a good view of it at 5.09 A.M. I Read astronomical journals for a while before attempting to see a further satellite at 6.03 A.M. However, the approaching dawn ruined this attempt."

Friday, 8 August 1958 – "This evening I went up to the Observatory to look for the Satellite 'Epsilon'. However, due to causes unknown, we did not see it."

Tuesday, 26 August 1958 – "This evening after dinner ... I went up to the U. Observatory at about 8 P.M. to look for satellites. However, the moon was too bright."

Thursday, 4 September 1958 – "This evening at half past five I went to my first cocktail party. It was in honour of Dr Allen Hynek, an American 'Moonwatch' Astronomer, & was held in the Staff Common Room at 'varsity. I cannot say much for this form of entertainment."☆

North Korea's Controversial Satellite Launch

Greg Roberts

After several previous unsuccessful launch attempts, a new country just joined the ranks of the elite few that have managed to launch and orbit their own satellites. North Korea's recent launch caused some mild hysteria and is quite controversial, even deemed illegal under international law! The launch itself was quite tricky, requiring some complicated maneuverers, to avoid flying over populated landmass. Space authorities and amateur satellite trackers have been following the satellite with great interest, trying to establish if the payload is operational or not, since it may be spinning out of control. As usual, Greg Roberts was well equipped and strategically situated to get the best data to unravel this puzzle.

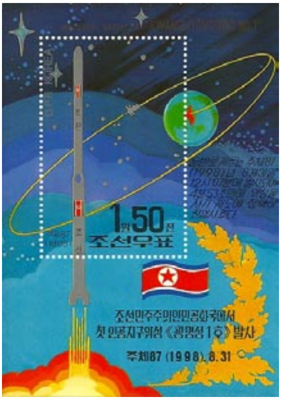
Earlier N. Korean Launches

North Korea has been pursuing a program of developing and launching their own satellites for at least fourteen years, despite intense opposition from other countries such as South Korea, Japan and the United States who considered this a veiled attempt at developing long range ballistic missiles capable of carrying a nuclear warhead.

North Korea calls their satellites KWANGMYONGSONG (KMS), meaning "Bright Star" and regards it as an experimental satellite. KMS-1's launch took place on 31 August 1998. It was hailed as a success by North Korea despite there being no evidence of any object actually achieving orbit. A special commemorative stamp was even issued.

The KMS- 2 launch attempt took place in April 2009 and again was hailed as a success. But once again no object entered orbit despite North Korea playing recordings of signals received from the "satellite" and again issuing a special commemorative stamp.

Their third attempt (KMS 3-1), on 13 April 2012, was an obvious failure when the first and second stages did not



Commemorative stamps for North Korea's launches of KMS-1 on 31 August 1998 (left) and KMS-2 in April 2009 (above).

separate cleanly. Due to the strict control of news, the North Korean public believe that they have satellites in orbit but no western tracking system could detect anything in orbit. It was all a figment of imagination by the North Korean government.

Strong Opposition

North Korea faces intense opposition to their space program although they insist it is for peaceful exploration. Two resolutions adapted by the United Nations Security Council (UNSC) demanded that North Korea refrain from further launches using ballistic missiles. Resolution 1718 of 14 October 2006, levied sanctions against North Korea as a result of their test of a nuclear weapon earlier that month and demanded that they cease testing and development of its ballistic missile program. The second resolution – UNSC Resolution 1874 of 12 June 2009 – implemented further sanctions after North Korea's second test of a nuclear weapon in May 2009 and repeated the same restrictions as Resolution 1718, including a demand for North Korea not to conduct any launch using ballistic missile technology.

The position adopted by North Korea is that it is simply exercising its rights to the peaceful exploration of outer space according to Article I of the 1967 Outer Space Treaty to which North Korea is a party. The important part of this document is the clause "in accordance with international law". This then means North Korea is in contravention since UNSC resolutions are considered binding international law on countries that are members of the United Nations – which includes North Korea.

Since a rocket is a rocket, these resolutions effectively mean that North Korea cannot launch anything. The distinction between a satellite launching rocket and a purely ballistic missile comes into effect once the rocket leaves the launch pad and is decided by the trajectory followed by the rocket.

Surveillance Decoys

In mid-November 2012 US reconnaissance satellites spotted rocket components being transported from the North Korea missile production plant to the launch site. It thus came as no real surprise when on 1 December 2012, North Korea announced it would make a second attempt to launch its KMS 3-2 satellite into a polar orbit from its Sohae Launch Centre in Cholson province using its UNHA-3 ("Milky Way 3") carrier rocket sometime in the period 10 December to 22 December. There was again intense foreign opposition.

Western and South Korean intelligence sources now concentrated on the launch site to see what would happen. It would appear that North Korea led them on a "merry chase" with disinformation. On 8 December a train was observed carrying what appeared to be missile components to the launch site. Then on 9 December North Korea announced that due to a technical glitch the launch window was being extended. Satellite images showed part of the rocket being dismantled and this convinced western observers that the launch had been scrapped. Subsequent satellite spy photos however showed all parts assembled on the launch pad and eighteen hours later the launch took place. Apparently the rocket was in the process of being disassembled during a US spy satellite overfly and then being re-assembled when no satellites were around.

An in-depth analysis by Marco Langbroek – a Dutch hobbyist satellite observer – clearly showed that launch occurred at the end of a one-hour gap during which there was no coverage by any known American, Japanese, or commercial imaging satellites in low earth orbit. A US military source is reported to have said that the US relied too heavily on overhead satellite imagery for warnings about the launch. However the United States does have satellites in high orbit and amateur satellite observers have pinpointed the locations of these satellites, some of which are over Asia. These satellites would have been able to monitor the launch site. The important issue in the case of North Korea is that the existence of these satellites is highly classified and very few people have access to the information from them. So when the press clawed for information on this launch, one got the impression that North Korea had fooled everyone.

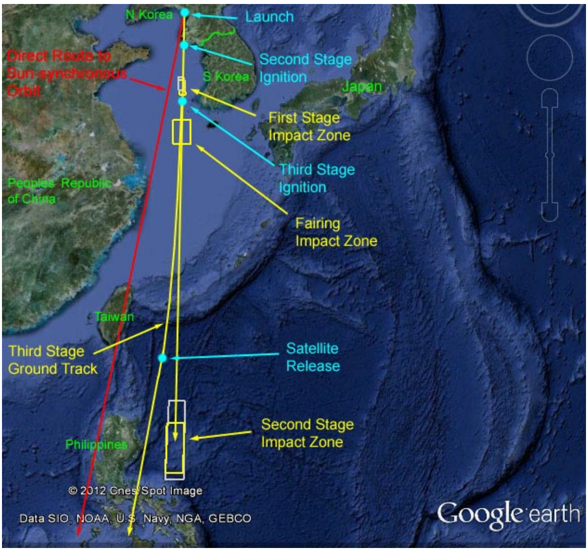
Dodgy manoeuvres

Most countries try to avoid flying launches over populated areas and other nations. This obviously limits what orbits one can achieve from a particular launch site. The original launch site used by North Korea on its east coast overflew Japan. This created a lot of political problems, so a new site was set up on the west coast to avoid flying over Japan. However North Korea was still blocked by China, Taiwan or the Philippines from direct access to a sun-synchronous orbit, requiring an inclination of about 97.4° for the planned 500 km altitude.

Despite this, launch took place on 12 December at 00:49 UTC, heading southward.

Bob Christy, a highly skilled hobbyist space analyst, provided extensive analysis of North Korea satellite activity on his excellent website. He clearly showed that in order to avoid flying over the Philippines, North Korea solved the problem by launching the rocket in a direction that kept it away from other countries during the most dangerous part of the launch phase. After separation of the second stage, the third stage was turned before igniting. This led to a new trajectory that placed the satellite in the correct orbital inclination to achieve a sun-synchronous orbit.

There is no doubt that this is quite an achievement for a country that has never had a successful space launch before. Jonathan McDowell pointed out that yawing the third stage required something like a change of 50° in flight direction before ignition of the third stage. Without this, the predicted impact zones indicated the satellite would have gone into a 90° inclination orbit.



This diagram by Bob Christy shows how North Korea satellite did a "dog-leg" around the Philippines and avoided passing over China and Taiwan (the red trajectory).

The objects from the launch then flew on a trajectory that took them south past the Philippines, Western Australia and the South Pole before moving northwards along the east coast of South America, over the eastern United States and over the North Pole before heading southwards again. It was observed by North American Aerospace Defence Command (NORAD), which maintains 24/7/365 surveillance of space. They used radar as there was no optical visibility due to the objects being in Earth's shadow for most of its orbit. NORAD stated that its missile warning systems had detected a launch and that the rocket had apparently placed an object in orbit. Less than three hours after launch, four objects were catalogued from the launch. What is somewhat surprising is that initially the rocket was mistaken for the actual satellite. This is difficult to understand as the rocket is considerably larger and would have given a much larger radar reflection.

Initially there was very little information available and some of the popular press articles were highly sceptical/critical of what had been done. Statements such that the satellite was tumbling wildly out of control, presented a hazard to other satellites, was a box wrapped in tin foil, launched by a rickety rocket, etc. were made. However, I felt that these did injustice to what I considered was a major achievement. Not only had North Korea executed a complicated "dog leg" manoeuver, but it had also placed the satellite in a near circular orbit.

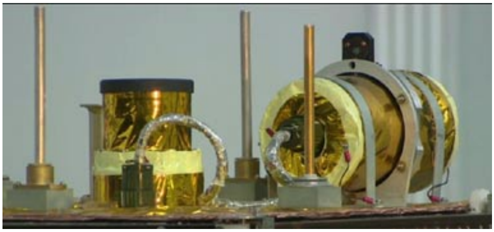
Mild Hysteria

Reading some of the press articles written, it would appear there was a case of mild hysteria. It reminded of the film *The Right Stuff* where government officials were frantically dashing down corridors and waving papers after the launch of Sputnik 1. There was strong condemnation that it was a ballistic missile test and statements that the US was under threat of nuclear attack. But was this a ballistic missile test? The arguments against this are adequately covered in some of the references given, concluding that it was certainly a space launch and NOT a ballistic missile test.

According to international law and the UNSC resolutions, the launch was illegal. North Korea however did everything "by the book" in announcing beforehand the splashdown zones for the first two stages and the payload shroud which corresponded to a space launch trajectory and not a ballistic missile trajectory. The first stage was indeed recovered in the pre-announced splash zone by the South Korean Navy.

What was put in orbit?

North Korea has not said much about this so there is little concrete evidence as to what the satellite is. In April 2012, prior to the failed launch of KMS 3-1, western journalists were shown a model (?) of the KMS satellite. Since North Korea referred to the new launch as KMS 3-2, it is logical to think that what was shown may have been the same satellite. If this is the case, the satellite is a cube with 0.65m square sides and about 1m long, weighing about 100 kg. The three sides shown to journalists were covered in solar cells (the fourth side was never shown but probably identical to the three visible). They appeared to be hinged, which some think might indicate that the solar panels could be extended in flight, but more likely



(above) Close-up of top of the model shown in April 2012. Note the use of "duct tape" and the red electrical connectors!

(left) A "model" of the KMS satellite shown to western press in April 2012.

are purely there to allow the solar panels to be moved out the way to allow technicians access into the spacecraft body.

The bottom of the cube had a circular adapter plate which was probably used for attaching to the launch vehicle. There is some speculation that it may also have carried two antennae at the bottom. The more interesting bits are on top of the cube and is presumably the side that would point earthward, once in orbit. This side carried sensors, cameras and perhaps as many as six antennae and it is possible to make reasonably intelligent guesses as to what is what.

First there were four rods vertical to the base plate, consisting of two pairs of differing lengths. The longer pair is apparently used for up-linking commands on around 400 MHz, whilst the shorter pair are probably for transmission at around 470 MHz. There is also a cylindrical housing which may the X-band downlink (around 9 GHz) for image transmission. The final antenna is a small disk on a stalk which may be a GPS receiver. There also appears to be two sensors: One, about 10 cm wide, protruding upwards from the base plate, which may be a wide field video camera with about 100 m resolution. The other, lying horizontal on the top base plate, could be a horizon/sun or star sensor, so that the orientation of the space craft could be maintained to ensure that the camera points correctly.

Dead or Alive?

Despite much monitoring of the frequency region around 470 MHz by many amateurs, in particular Bob Christy in the UK and Robert Oler of Texas, no positive transmissions have yet been received. This raises the question as to whether the satellite is a dummy, or the transmitter(s) have failed … or activity has still to come. Presumably intelligence organisations and amateur satellite trackers in the vicinity of North Korea would have looked for transmissions on any of the anticipated frequencies (up or downlinks) but so far indications are that none have been received. The general consensus is that the satellite has failed, probably during launch.

However it is not unusual for satellite activity to only occur some time after launch, especially if the satellite is spinning or possibly tumbling which prevents communication taking place.

Spinning out of Control?
Shortly after launch I was requested to try and observe the four objects identified from the launch in an attempt to determine what the objects were and whether they had been correctly identified. In addition it was thought important to determine the spin rate which might indicate whether the satellite was in a stable attitude and also possibly whether the satellite was under control. Due to the geometry of the satellites orbit and its proximity to Earth's shadow there was only a narrow strip in latitude in the southern hemisphere from which the satellite could be optically observed. I happened to be the only recognised optical tracker, either amateur or otherwise, that could possibly obtain observations.

Before launch North Korea stated that the satellite was to be three axis stabilized, meaning it would not have significant rotation in any of the three axes of movement relative to the earth. This is typical of what is required for a satellite that needs to keep a camera pointing at the Earth and away from the Sun. This can be achieved in several ways ranging from gyroscopes, reaction wheels to simpler ways such as gravity gradient booms that use Earth's gravity to orientate a satellite towards Earth.

Visual Tracking
My first task was to observe the four objects. This established that the objects were correctly identified. The rocket was easily the brightest object and relatively stable, rotating/tumbling very slowly which is quite normal so not much attention has been paid

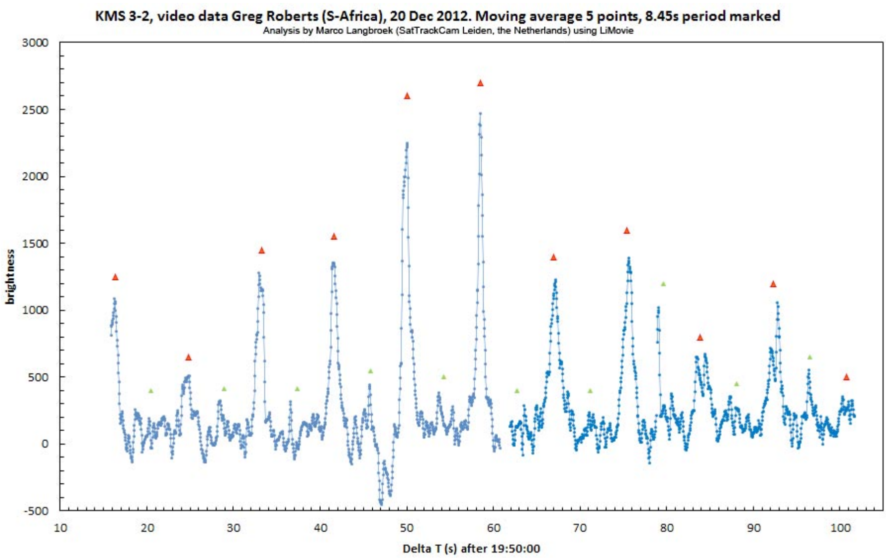
Image of KMS 3-2 satellite being tracked, extracted from video taken 20 December 2012 at 19h 50m 25.1s UT.

to it since the initial observations. Two of the objects are small but quite dense. I was only able to briefly observe one of them when it produced a few faint flashes – probably part of the separation mechanism. The other small object was not seen in three attempts so is obviously small, probably identical to the other small object.

The satellite is of course of main interest. Initial observations showed it was tumbling/rotating at about four revolutions per minute - this was based on a brightish flash being produced roughly every 17 seconds, initially to about magnitude +5 or +6. However as the satellite got higher in elevation, it became possible to see smaller fluctuations about every 8 seconds or so with the flashes now about magnitude +7. As the satellite passed culmination (thus at minimum distance from the observer), it was possible to see small variations roughly every 4 seconds or so, but magnitude now around +7.5 or +8.

Analysing the Data

This raised the question; which is the true period of the satellite? I interpreted what I saw as a bright flash every 17 seconds, to be coming from the same item that produced the ~8 second flash. So the spin period was ~17 seconds. When I observed the ~4 second period, I suspect I was seeing a reflection from each of the four surfaces of the cube. Marco Langbroek did a careful analysis of one of the earlier video recordings and derived a period of about 4.23 seconds. This



Light curve of KMS 3-2 obtained by Marco Langbroek on 20 December 2012.

has served as the baseline for any further changes. It would therefore appear that the satellite is tumbling/rotating at about four rotations per minute. This is quite normal for a satellite and it could take many weeks for the stabilization system to slow the satellite spin rate enough to acquire gravity lock and maintain a constant orientation such as is required for the camera to operate.

Spinning Down?

Consequently the satellite has been observed on a fairly regular basis and attempts made to determine whether the spin rate is changing. In the meantime, for some unknown reason, the flashing seems to have become less pronounced, usually around mag +7.5 to +8, which makes it more difficult to get an accurate spin rate. The data seems to indicate that the spin rate is decreasing very slowly. Whether this is due to a system "actively" decreasing the spin rate or just simply gravity is not known. Whilst mag +7.5 or so is bright in terms of satellite magnitudes, it is not that easy to get an accurate video record with exposures as short as possible - typically 1/50th or /160th sec. The shorter the exposure, the more accurate the period that can be determined.

Unfortunately suitable optical visibility ceased at the end of January 2013 as the satellite moved into Earth's shadow after which it is only perhaps optically trackable from very high northern latitudes. But there are no observers there which means the only other possible way to determine if the satellite is slowing down is maybe possible from the radar reflection. The last determined spin rate was about 4.6 seconds, possibly decreasing very slowly.

Conclusion

The situation at the moment is that the satellite appears dead and there is no evidence that it was ever operational. It is tumbling but not at an excessive rate and this appears to be slowing down, but is going to take a LONG time, if ever, to stop spinning.... so my guess is that the satellite is well and truly dead.

The United Nations Security Council unanimously adopted a resolution on 22 January 2013 condemning the rocket launch and expanded existing UN sanctions. They also threatened "significant action" if North Korea stages a nuclear test. North Korea replied by saying it planned to carry out a third nuclear test and more rocket launches aimed at its "arch enemy", the United States, stating that "settling accounts with the U.S needs to be done with force, not with words". No time frame for the nuclear test was given but it is believed that it could be soon.

Acknowledgements

I would like to sincerely thank my colleagues for allowing me to freely use whatever material they had on their very informative websites or what they had published. I would highly recommend that people interested in more details visit the following websites:

www.wired.com/dangerroom/2012/12/launch/all
"Almost Everything You've Heard About the North Korean Space Launch is Wrong" - Brian Weeden - Technical Advisor to Secure World Foundation. A very comprehensive summary of the entire event.

http://blogs.wsj.com/korearealtime/2012/12/19/a-week-after-launch-the lowdown-on-north-koreas-satellite where Bob Christy gives the lowdown on what had happened.

http://sattrackcam.blobspot.nl
Marco Langbroek details the absence of spy coverage and possible North Korean spooks on his weblog. He also gives a report on the optical behaviour of the satellite and rocket, complete with videos from The author and analysis of the light curves. There is also much other interesting material of interest to space enthusiasts.

www.zarya.info
Bob Christy's comprehensive outstanding site, full of information on ALL satellite related activity. To reach the material related to the North Korean launch go to www.zarya.info/Diaries/NKorea/Kwangmyongsong32.php
Make sure to also check out the various links in blue on the left hand side of the page. This site is the best one that I know of and I cannot recommend it highly enough.

www.northkoreatech.org/2012/03/19/stamps-of-previous-satellite-launches/
shows pictures of stamps of previous (failed) orbiting missions

www.northkoreatech.org/2012/12/25/caught-on-video-north-koreas-satellite/
shows several of the videos of the tracking of the satellite by the author

http://38north.org/category/sat-analysis/
Latest on activities in North Korea

www.nytimes.com/2012/12/18/world/asia/north-korean-satellite.html?_r=0
"Astronomers say North Korean Satellite is most likely dead"

www.planet4589.org/space/jsr/jsr.html
Jonathan McDowells reports on current satellite activity. For back issues, go to planet4589.org/space/jsr/back and for a report on the North Korean launch, download report No 672. ☆

UFO becomes IFO

Greg Roberts

December 2012 proved to be a frantic period with some interesting space activities, including the predicted end of the world on 21 December 2012. A spectacular event occurred that gave rise to numerous UFO reports and terrified those that believed Doomsday was at hand.

Composite of some of my CCD images, read bottom right to top left.

UFO or IFO?

Despite what hundreds of people, in particular Flying Saucer enthusiasts, would like to believe that the spectacular event, widely sighted in the Western and Southern Cape sky at about 20:40 SAST on the 11 December 2012, was nothing more dramatic that the de-orbit burn of the Centaur rocket that had just launched the third mission of the Orbital Test Vehicle, also known as X-37B. An Unidentified Flying Object (UFO) thus became an Identified Flying Object (IFO)!

In gathering material for this article I did an internet search and was dismayed to discover that it would appear that the general public are still unaware of the true identity of what they saw and it has gone down in UFOLOGY as a well observed Unidentified Flying Object sighting. It has even been quoted as the best UFO sighting of the month by one UFO network. It is quite eye-opening and mind boggling(!) to read some of the reports of people who saw this and what they believed it was. In some cases people were convinced an alien invasion was taking place, or that the end of the world was nigh – especially if we recall that Earth was predicted to end on the 21 December 2012!

Now I would like to keep an open mind about the subject of UFOs. But after seeing the garbage spewed forth on the Internet and the refusal by some to accept the explanation of the true nature of the event, just proves to me once again that the vast majority of reports of so called UFOs by the mass public are hardly suitable for any kind of scientific study. It actually destroys the case for the existence of any such phenomena. Of course matters are not helped by the numerous programs on television about UFOs and alien visits to Earth in the distant past, fuelling the fertile imagination of some people. So, for future UFOlogists who (hopefully) will refer to back-issues of *MNASSA* when investigating reports of strange lights in the sky, it is necessary to document events.

Slightly off-topic, I was recently asked to investigate an old report of what was possibly a satellite re-entry that had been found in a UFO magazine. After searching through *MNASSA,* I found the original report which proved it was indeed a satellite re-entry.

Launch of OTV-3 - photograph United States Air Force.

Third OTV mission

On the 11 December 2012 the United Launch Alliance (ULA) – which sounds like an alien alliance but certainly not the case – launched the third mission of the Orbital Test Vehicle (known as OTV-3), also known as the X-37B. This is a miniature unmanned "space shuttle" (full details of this vehicle will be found in "Sleuthing the New Spaceplane", *MNASSA* Vol 69, Nos 5&6, June 2010).

As usual with the X-37B, being a classified mission, very little information was available before launch. The amateur tracking group's orbital expert, Ted Molczan, estimated a probable orbit. As luck would have it, it was to pass over Cape Town 35 to 40 minutes after launch with excellent optical visibility, being shortly after sunset and at a reasonable elevation. On my Facebook page I gave details of the launch, giving details of when and where to look. This at least educated some of the viewers to interpret what they were seeing.

Surprise!

Despite this I do not think anyone, including myself, were prepared for what we did see. My video- and CCD cameras were aimed at a predicted position. I was busy watching the video monitor, when suddenly, about a minute before the predicted time, a very bright light started crossing the field of view! Initially I thought it was

Brilliant light crossing field of view- initially mistaken for aircraft lights!

Two views extracted from the video recording.

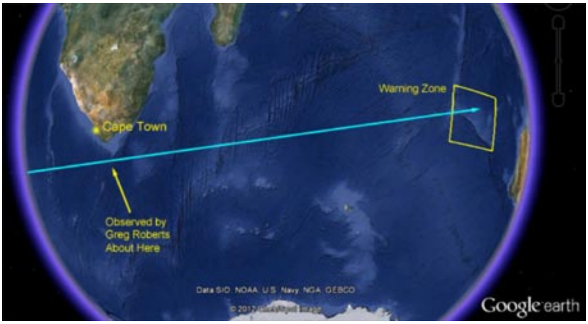
an aircraft flying over my house (I could hear one at the time) as they frequently do, complete with flashing lights. I actually swore at it!

I continued waiting for my satellite after the 'nuisance object' left the camera field. After a couple of seconds it suddenly dawned on me that this spectacle might have been the satellite! I rapidly stepped the mount ahead to the next predicted point and quickly caught up with the objects. I now knew that it was the satellite and managed to follow the two visible objects until they disappeared behind some local obstructions. Fortunately my video- and CCD cameras had been imaging the entire time. So, despite my rather hap-hazard tracking, I actually managed to record some unusual footage which contained very useful data.

Analysing the Footage

Examination of the video recording and the CCD image stills, revealed two objects, each preceded by a "light cone". As this was a classified mission, no information was available as to the identification of the individual objects. There was some initial confusion as to which was the satellite and which was the rocket and why each object appeared to have a "cone" associated with it. After careful analysis of the positional observations from my footage, Ted Molczan was able to determine which was the Centaur rocket and which was OTV-3. His analysis in fact showed that the Centaur was decreasing height above the earth, explaining the presence of the two retro-burn cones.

It would appear that there was in fact only one object being active. The Centaur rocket had in fact done two burns in quick succession to de-orbit the rocket. The leading cone was from the first burn and a short time later (by which time the rocket had fallen behind the OTV3), did a second burn. Hence the separation and appearance of two cones were in fact due to two spaced burns by the same object. Initially ULA had indicated that the Centaur would be de-orbited roughly two hours after launch and provided the approximate area over the Indian Ocean where it would re-enter. This actually confused amateur trackers – perhaps deliberate mis-information by ULA? – since it was quite difficult to find an orbit that would



Impact zone for the Centaur rocket - courtesy of http://www.zarya.info/Diaries/US/OTV3Impact.php

match this impact zone. However, it now appears that the de-orbit was in fact done during the first orbit, just 35 minutes after launch, which is what was observed over Cape Town.

YouTube Video

As mentioned earlier this event was very widely observed – one report as far away as Kimberley – and also quite well photographed by several people. With the kind assistance of Willie Koorts, my video was edited into a usable form, some of the photographic stills added and then all uploaded to YouTube (http://youtu.be/b-VIwheIPPw). The video appears to have been an instant hit, but unfortunately, in many cases, to the wrong people! The UFO believers had a field day! One person extracted selected footage, ignoring the text explaining what it was, and presented it as a genuine UFO sighting. This got Willie pretty excited and he complained about this, both to YouTube and the author of the "UFO" video document. All Willie achieved was to be blocked from seeing any of this author's YouTube postings! Fortunately the Johannesburg Planetarium used part of the original video in their December Christmas show, presenting the true facts. Hopefully this has undone some of the "damage" caused by UFO fans.

IFO Indeed

As is usually the case with alleged UFO sightings, there is mostly a rational explanation given by equipped and knowledgeable observers around the globe, thereby turning them into IFOs. If readers do observe "strange" lights in the night sky, try and make your observation as detailed as possible. Things like time, compass direction, direction of movement, colour, angular distance above the horizon (a fist at arm's length is about 10°, and an open palm with fingers spread, about 20°), your geographical location as accurately as possible, etc. ☆

Photograph of OTV3 moving from bottom to top, obtained on 20 Dec. 2012 by the author.

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, UWC 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: Nature or Nurture - Neutron Stars in Be/X-ray Binaries
Speaker: Prof Malcolm Coe (University of Southampton)
Venue: SAAO Auditorium
Date: 13 December 2012
Time: 11:00
Abstract: The population of Be/X-ray binaries in the Small Magellanic Cloud is proving a superb, homogeneous sample of this type of HMXBs. They are all at the same distance, the same extinction and probably born around the same time. As such we can use this sample of over 50 systems to explore evolution and accretion processes in these systems. In particular, recent results we have just published in Nature suggest the existence of two types of neutron stars, possibly linked to the two proposed types of SN explosions. So is it birth, or the environment, that is important in dictating how they behave when they are grown up?

Title: The IAU's Commitment to Education, Development and Public Outreach
Speaker: Sarah Reed (OAO) & Kevin Govender (OAD)
Venue: SAAO Auditorium
Date; 20 December 2012
Time: 11:00
Abstract: The IAU founded the Office of Astronomy for Development (OAD) in March 2011. Recent developments have further shown the IAU's commitment to education and public outreach (EPO). Firstly, at the IAU General Assembly in Beijing this summer, a restructuring of the organisation was approved, in which 'Education, Outreach and Heritage' is listed as one of seven new 'Divisions'. Furthermore, in September

2012, the IAU Office for Astronomy Outreach (OAO) was founded at the National Astronomical Observatory of Japan (NAOJ) in Tokyo, Japan, under the leadership of the IAU's new Astronomy Outreach Coordinator, Sarah Reed. In this talk, Kevin Govender and Sarah Reed will briefly outline the history and future plans of the OAD and OAO, respectively, and how the offices fit into the IAU's organisational structure. We will then present how the OAD and OAO plan to work together and share resources to support the missions of both global offices and ensure synergies between them.

Title: Unwinding the secrets of a dying star

Speaker: Shazrene Mohammed.
Venue: 1896 Building
Date: 17 January 2012
Time: 11:00
Abstract: The asymptotic giant branch star R Sculptoris is surrounded by a detached shell of dust and gas. The shell originates from a thermal pulse during which the star had a brief period of increased mass loss. It has hitherto been impossible to constrain the timescales and mass-loss properties during and after a thermal pulse parameters that determine the lifetime on the asymptotic giant branch and the amount of material returned to the interstellar medium. I will present Atacama Large Millimeter/submillimeter Array (ALMA) CO observations of the circumstellar envelope and shell around R Sculptoris. These high angular resolution observations revealed that the thin, clumpy shell contains a spiral structure. Spiral structures have been seen previously in the outflows of evolved stars and are associated with binary systems. I will discuss the formation of spiral sculpted outflows and how they can be used to conclude (by combining the ALMA data with hydrodynamic simulations) that R Sculptoris is a binary system that underwent a thermal pulse ~1800 years ago, lasting ~200 years.

Title: Binarity and final stages of massive star stellar evolution: the high spatial resolution view in the infrared

Speaker: Olivier Chesneau (Observatoire de la Côte d'Azur)
Venue: 1896 Building
Date: 31 January 2012
Time: 11:00
Abstract: Progress in high angular resolution techniques in the infrared (Adaptive Optics and Optical Interferometry) provided a wealth of new observations of the circumstellar environment of evolved stars in their immediate vicinity. I shall focus on the detection companions and examples of the deep influence of binarity on the fate of evolved stars. I shall present studies some spectral type thought to be directly connected to binarity (B[e] supergiants and dusty Wolf-Rayet stars). I will also discuss the rapidly growing field of intermediate luminosity transient phenomena.

Title: The Symbiotic path to SNe Ia
Speaker: Joanna Mikolajewska, N. Copernicus Astron. Center
Venue: SAAO Auditorium
Date: 14 February
Time: 11:00
Abstract: Symbiotic stars are interacting binaries in which the first-formed white dwarf accretes and burns material from a red giant companion. I will present physical characteristics of these objects and discussing their possible link with progenitors of type Ia supernovae.

ACGC

Title: Lumps and bumps in the early universe
Speaker: Mustafa Amin, Cambridge
Venue: M111, Maths Building, UCT
Date: 22 January 2013
Time: 13:00
Abstract: Our understanding of the universe between the end of inflation and production of light elements is incomplete. How did inflation end? What did the universe look like at the end of inflation? In this talk, I will discuss different end of inflation scenarios. I will concentrate on a particular case: the fragmentation of the inflaton into localized, long-lived excitations of the inflaton field (oscillons), which can end up dominating the energy density of the universe. I will argue that oscillons can be produced in a large class of well-motivated inflationary models that are consistent with CMB anisotropy measurements. I will discuss conditions for their existence, emergence and stability. Finally, I will discuss theoretical and possible observational consequences of different end of inflation scenarios in general as well as oscillons in particular in the early universe.

Title: Averaging the luminosity redshift relation: from theory to observations.
Speaker: Giovanni Marozzi
Venue: M111, Maths Building UCT.
Date: 5 February 2012
Time: 13:00
Abstract: I will show a general gauge invariant formalism for defining cosmological averages that are relevant for observations based on light-like signals. Such averages involve either null hypersurfaces corresponding to a family of past light-cones or compact surfaces given by their intersection with timelike hypersurfaces. Afterwards, using such formalism, together with adapted "geodesic light-cone" coordinates, I will show as backreaction effect emerges in the evaluation of observables related to the luminosity distance-redshift relation in an inhomogeneous Universe. To conclude, considering a realistic stochastic spectrum of inhomogeneities of primordial (inflationary) origin, I will show the magnitude and behaviour of such backreaction effects.

NASSP

Title: Gravitational dynamics near the Galactic Centre.

Speaker: Dr Jeandrew Brink.
Venue : RW James Lecture Hall C
Date : 13 Feb 2013
Time : 13:00

Abstract: There is substantial evidence for the existence of a quiescent super-massive black hole at the rotational centre of our Galaxy, denoted Sgr A*. The advent of the Square Kilometre Array, and gravitational wave detectors such as LIGO and LISA will enable us to experimentally probe the strong field region around Sgr A* with greater precision than ever before. With this information we should be able to test certain fundamental theorems that underlie our understanding of General Relativity such as the no-hair theorems. I discuss some of the theoretical and experimental infrastructure required to make a conclusive test of the cosmic censorship and causality conjectures on which these theorems are based. I also summarize a number of the experimental challenges that will need to be overcome before a conclusive measurement of the quadrupole moment of the black hole can be made. ☆

Hydra the multi-headed Serpent

by Magda Streicher
magdalena@mweb.co.za

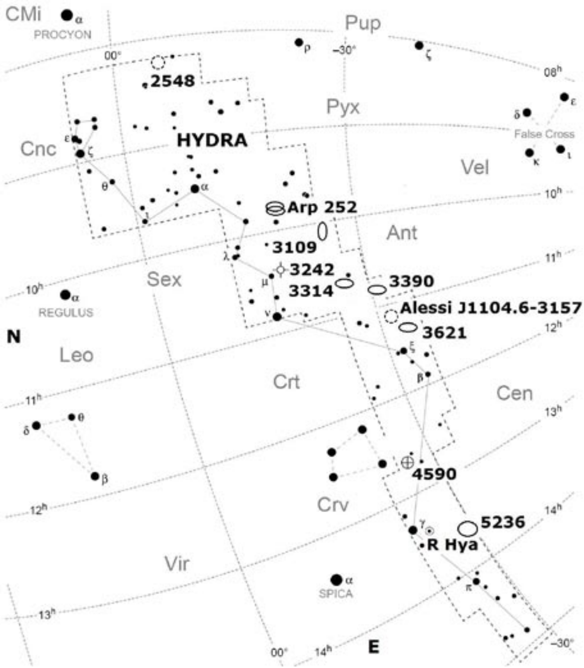
Hydra, the female Water Snake, is the longest of today's 88 known constellations, stretching from the Libra up to the northern constellation Cancer – more than 3% of the entire night sky (see starmap). It is quite a challenge to deal with this expansive constellation in one article, especially as it contains exceptionally magnificent objects that make a visit to the constellation decidedly worthwhile.

Of course, what makes the constellation all the more interesting is the fact that it raises the question, why the name – why a female snake? According to legend Hydra was the multi-headed snake which had the ability to grow two new heads for every one that was cut off. The constellation was associated with the goddess Tiamat the ruler of the seawater who according to legend kills her offspring. However slightly softer on the tongue is the German name *Wasserschlange*.

The northern part of the constellation is characterised by the magnitude 3 to 4 stars eta, sigma, delta, epsilon and zeta Hydrae, which could be seen as making up the head shape with a sharp-pointed nose.

The star Alphard, also known as alpha Hydrae, could easily seen as a yellow-white diamond hanging on her slender neck (remember she is a woman). Sometime also referred to as the Water Snake's heart line, it is located 180 light years away from us. The Arabic name for this star is The Solitary One, referring to the lack of bright stars in its vicinity.

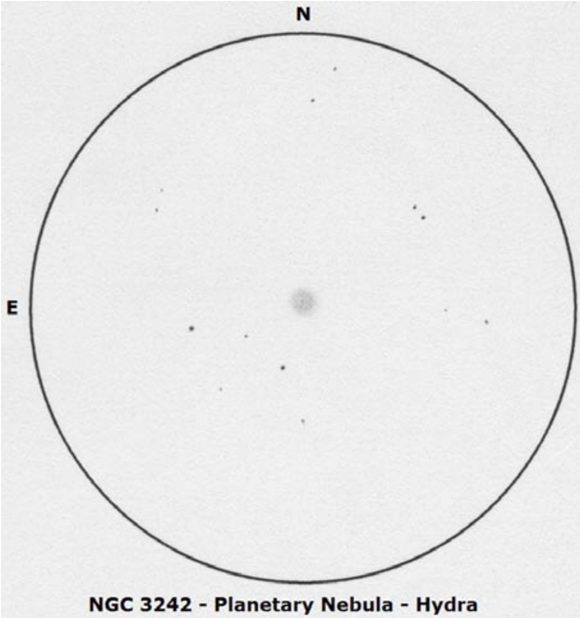
The well-known open cluster **NGC 2548**, perhaps better known by the name Messier 48, is situated due west of alpha Hydrae right on the constellation Monoceros boundary. Caroline Herschel and Charles Messier independently discovered this large, bright and loosely expanded cluster of around 50 stars displaying circles, pairs and triplets (see picture). A prominent crooked string of stars runs through the cluster in a north-south direction. Numerous outliers mingle with the star field, although the middle area is slightly condensed.



For the purpose of this article, however, it is best to concentrate on the southern area of Hydra. In the middle area of the constellation it is quite easy to locate the very orange-red magnitude 3.8 mu Hydrae and then to star-hop 1.8 degrees south to the planetary nebula **NGC 3242**, also known as the Ghost of Jupiter. The outstanding, slightly oval nebula displays a soft outer envelope, a noticeable washed-out blue colour and a glimpse of the magnitude 12 star towards the centre (see sketch). Through a somewhat larger amateur telescope it appears mottled and resembles a human eye, in contrast with the inner dark envelope around the star. A faint darkish area can be seen in the southern section, with a brighter northern side. William Herschel described this nebula as just a faint puffball during observations in 1785. Jenni Kay noted a soft, diffuse edge wrapped in multiple soft, layered shells with a strong response to the OIII filter.

M48, also known as NGC2548 is a large, bright and loosely expanded open cluster. Photo: Dale Liebenberg

Hydra is rich in galaxies, and a few interesting facts are attached to several of them, even though through amateur telescopes they would prob-



NGC 3242. Planetary Nebula in Hydra.

ably appear to be mere patches of light.

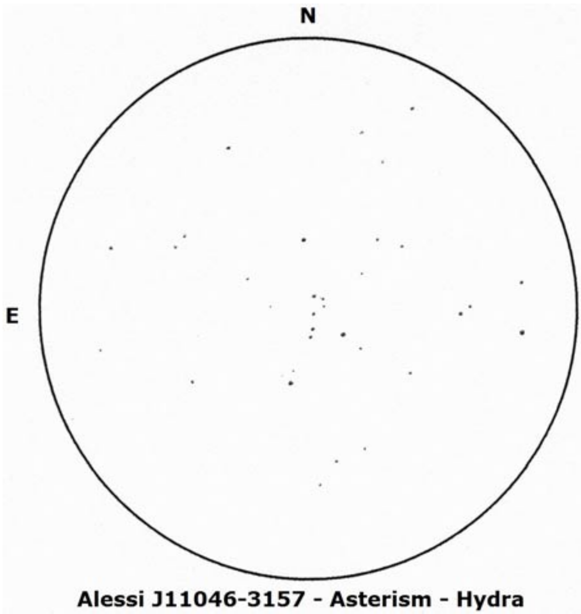
A very special galaxy is **Arp 252** (PGC 27928 and PGC 27929), which is situated a few degrees west of NGC 3242 and has also been popular known as the Question Mark Galaxy. It can be seen as a pair of interacting spirals, which the Hubble deep picture reveals in a unique way. This special pair is situated only 1.2 degrees south-east from the galaxy NGC 3028. The small spiral galaxy **NGC 3109** is situated about 7.5 degrees further south-west from Arp 252. Astronomers pointed KAT, the Karoo Array Telescope (picture), towards this galaxy, which allowed them to see the HI radio emission and moving of the galaxy. Where the gas is moving towards us the frequency of the spectral line is Doppler shifted upwards, whereas where the gas is moving away it is shifted down. A few degrees south-east the tight knot of about a dozen galaxies also known as the Hydra 1 Galaxy Cluster shares a field of nearly 2 degrees. However, the

southern member in this group, **NGC 3314**, has a nice twist to it. The galaxy is also indicated both as NGC 3314A and NGC 3314B. Hubble pictures show two galaxies appearing to be head on, while they are actually tens of millions of light years apart and it is only from our perspective that they appear to line up. Further south-east, on the border with the constellation Antlia, the spiral galaxy **NGC 3393** contains a pair of super-massive black holes. In the midst of the galaxy cluster the magnitude 4.8 lovely red colour star (HD 92036) can serve as a good indication to locate this group.

So, as can be see, there is a lot more to discover and explore, so next time when you try to only glimpse these above-mentioned galaxies to remember the interesting facts woven around them. Sadly, only the most beautiful Hubble pictures show them in anything like their full glory.

The lovely double star chi 1&2 Hydrae, quite bright with magnitudes 4.8 and 5.7, point the way 4.5 degrees south to the asterism **Alessi J11046-3157** – five magnitude 12 to 13 stars in a short string from north to south, with two fainter ones topping the scale to the west (see sketch). Not at all an easy task to find this compact, faint and small asterism, but when found, it is nicely lifted out against the star field. However the book star clusters (Archinal and Hynes) indicate a larger C-shaped group which may be part of this faint string.

About 3 degrees south-east is the galaxy **NGC 3621**, which in combination with field stars displays a special character. The galaxy, lying in an elongated north-west to south-east direction, looks somewhat mottled, gradually getting brighter towards a wide, dense nucleus. The periphery is shrouded in mistiness, with faint splinter stars embedded on its northern sur-



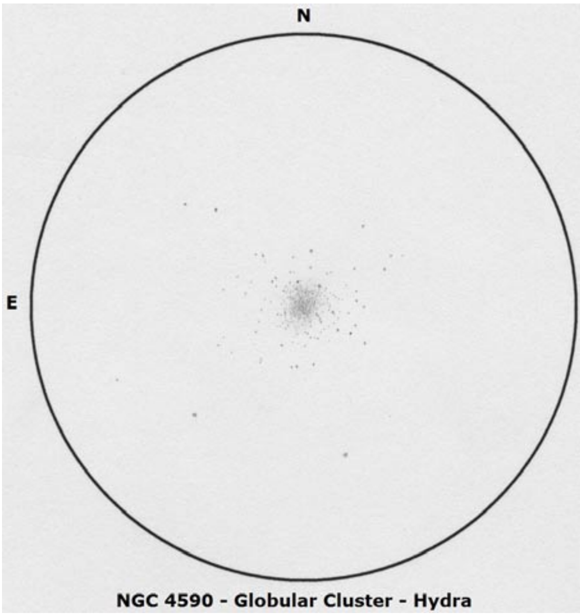
THe Alessi J11046-3157 Asterism.

NGC 3621 or the Crux Galaxy. Picture by Dale Liebenberg.

face. It has become a habit of mine to name an object according to the very first thought that strikes me when I look at an object. My notes indicate the "The Crux Galaxy" for this one guarded by a trapezium of stars closely surrounding the galaxy with a memorable impression of the Crux constellation.

The bright globular cluster **NGC 4590**, also known as Messier 68, can be found about halfway between beta and gamma Hydrae. The globular cluster appears somewhat oval in a north-west to south-east direction with an obscure compressed core with faint mist indicating a star-rich cluster (see sketch). I suspect that its apparently elongated shape might be attributed to the fact that there are faint clumps of stars visible on the north-western edge. The eastern side of the globular is slightly more edged, whereas the western part filters out with faint star trails. But it is not at all easy to resolve the cluster, except with higher magnification.

The magnitude 2.9 star gamma Hydrae shines with a lemon-yellow colour and could be seen as indicating the last curve towards the tail-end of the constellation. Hop 2.5 degrees south-east to the variable star **R Hydrae**, one of the brightest long-period variables in the sky. It is an M-class Mira type star that reaches a maximum



Globular Cluster NGC 4590, also know as M68.

of magnitude 3 and magnitude 11 near its minimum. The reddish-orange colour star (HD number 117287) with a period of 389 days classed with a spectral type M6 – 9, and a parallaxes of 8.05 milli arc-second according to Christopher Middleton.

But the real show stopper in the Hydra constellation is the magnificent galaxy **NGC 5236**, better known as Messier 83, discovered by Nicolas Louis de Lacaille at the Cape of Good Hope in 1752. The galaxy is situated barely 30’ from the northern border with the constellation Centaurus and is also part of the Centaurus galaxy group. It is a large, bright, face-on galaxy with a soft, flimsy edge quite outstanding against the star field. The bright nucleus is obvious, and with careful observation it displays a soft halo around a more bar-like east-west core. Really high magnification through larger amateur telescopes will bring out the delicate arm extensions which can be glimpsed curving out from the east end of the nucleus going south and the other arm from the western end going north. Faint stars peek through the glow, with a few brighter ones sighted just off the extreme eastern edge of the galaxy. Since 1923, more than a handful of supernova explosions have been found in this galaxy.

Never underestimate a woman, even if she is a constellation against the starry skies – she will show you a thing or two that are unbeatable! ☆

Object	Type	RA (J2000.0)	Dec	Mag	Size
NGC 2548 M 48	Open Cluster	08^h13^m8	-05°48	5.8	54’
Arp 252	Galaxy	09 44 8	-19 43	15	1.5’x0.4’
(PGC 27928/9)	Galaxy	09 44 9	-19 43	15.3	0.9’x0.4’
NGC 3109	Galaxy	10 03 1	-26 10	9.8	15’x2.9’
NGC 3242	Planetary Nebula	10 24 8	-18 38	7.8	16”
NGC 3314	Galaxy	10 37 2	-27 41	12.8	1.5’x0.8’
NGC 3390	Galaxy	10 48 1	-31 33	12.4	3.1’x0.7’
Alessi J11046-3157	Asterism	11 04 6	-31 58	8	3.3’
NGC 3621	Galaxy	11 18 3	-32 49	8.9	9.8’x4.6’
NGC 4590 M 68	Globular Cluster	12 39 5	-26 46	7.7	12’
R Hydrae	Variable star	13 29 7	-23 17	3-11	389.6 d
NGC 5236 M 83	Galaxy	13 37 6	-29 53	7.6	15.5’x13.0’

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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