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Cover: COMET C/2015 G2 (MASTER) discovered at Sutherland 10 April 2015. This composite image was produced by adding together images from four colour filters. See News Note inside.

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ASSA News

Membership Secretary

Mr Bosman Olivier is now Membership Secretary (see inside back cover for contact information).

New Members

The following new members were ratified at a Council Meeting held on 16 February 2015:

1) Clive Chandler: 11 Thicket Road, Rosebank, Cape Town
2) Rudolf Francois Pretorius , Unit no. 15, Northview Clusters, Malteser Street, Noordhang, Randburg
3) Gerald Muchiri, Jan Smuts Residence, Drosty Road, Grahamstown
4) Angus Burns, P O Box 21106, Hutten Heights, Newcastle

News Notes

Possible ring system found around a minor planet

Astronomers at the SAAO and the Massachusetts Institute of Technology (MIT), USA have recently detected what may be rings around Chiron, a minor planet in our solar system. Though it is well-known that all the gas giant planets have rings, the minor planet Chariklo also has them. Chiron and Chariklo belong to a class of minor planets called centaurs: small rocky bodies that possess properties of both asteroids and comets and are found in a band between the orbits of Jupiter and Pluto. Prior to the discovery of Chariklo's rings, centaurs were thought to be relatively dormant objects. The latest discovery of a possible ring system around another centaur, Chiron, if confirmed, suggests that ring systems are far more common in our solar system than previously thought.

Dr Amanda Gulbis at SAAO and her collaborators were first alerted to the possibility that Chiron has a ring system following observations conducted in November 2011. Chiron was observed occulting a bright star. Using NASA's Infrared Telescope Facility, on Mauna Kea, Hawaii and the Las Cumbres Observatory Global Telescope Network, at Haleakala, Hawaii, astronomers the brightness of the star's light during the occultation was monitored. In addition to seeing the expected drop in brightness as Chiron passed in front of the star. In the data were features that could be explained by either a ring system, a circular shell of gas and dust or symmetric jets of material shooting out from its surface.

There were actually two dips in brightness before and after the occultation, suggesting that there could be two separate rings of material around the centaur. Judging from the dips in intensity of the starlight it was calculated that two possible rings of material are located about 300 km from the centre of Chiron, are around 3 and 7 km wide respectively and are separated by a distance of around 7.5 km.

"This result is particularly interesting because Chiron is a centaur — a relatively small, cold object that has an unstable orbit in the region of the giant planets. How does a body that is only a few hundred kilometers in diameter, and whose orbit is only stable for a few million years, have a ring system?" asks Dr Gulbis. Several explanations have been put forward. One possibility is that another minor body broke up and the resulting debris was captured gravitationally around Chiron. Alternatively, the rings may have formed from leftover material from the formation of Chiron itself.

Another possibility is that Centaurs may have started further out in the solar system and, through gravitational interactions with giant planets, have had their orbits perturbed closer in to the Sun. The frozen material that would have been stable out past Pluto becomes less stable closer in, and can turn into gases that spray dust and material off the surface of a body, according to Jessica Ruprecht a student at MIT, who was the lead author of the discovery paper.

"If we want to make a strong case for rings around Chiron, we'll need observations by multiple observers, distributed over a few hundred kilometers, so that we can map the ring geometry, but that alone doesn't tell us if the rings are a temporary feature of Chiron, or a more permanent one. There's a lot of work that needs to be done." says Ms Ruprecht.

The results from this study have been published in the journal Icarus.

Discovery of a new "luminous blue variable" star

Dr A. Kniazev from the South African Astronomical Observatory (SAAO), and collaborators from the Lomonosov Moscow State University Dr. V. Gvaramadze and Dr. L. Berdnikov have recently discovered a new example of an incredibly rare kind of star known as a Luminous Blue Variable (LBV). Out of the billions of stars mapped in our skies, only sixteen confirmed LBVs are known to date. The star, named WS1, is the latest addition to this group. LBV stars are of interest because they are extremely old and may soon die and blow apart as supernovas.

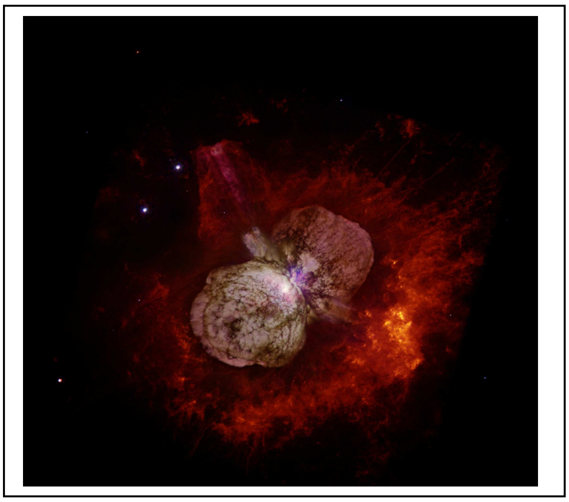
Stars do not live forever. Once their fuel has run out they stop shining and die. Those that are much more massive than the Sun end their lives in powerful supernova explosions which can outshine all the other billions of stars in their galaxy put together. We never know when or where one of these explosions will take place but we can keep an eye on those stars most likely to become supernovae in the near future, namely Luminous Blue Variables. For stars with initial masses of between 20-25 times that of our Sun the LBV stage occurs just they explode. For even more massive stars, they pass through the LBV phase slightly earlier in their lifetimes, but those stars too will eventually explode as supernovae.

LBV stars are much hotter and more luminous than our Sun. They are some of the most luminous known, ranging from 250 000 to 1 million times more than the Sun. As a consequence of their high mass they evolve very quickly and have – astronomically speaking – short lifetimes, typically around a few million years. They spend much less than one million years in the LBV phase. The Sun in comparison has a total lifetime of around 9 billion years. Because the LBV phase is so short-lived one has to be incredibly lucky to catch a star at that stage. Hence they are so rare.

LBV stars are losing vast amounts of mass as their upper atmospheres stream off into space in stellar winds. They undergo random outbursts at their surfaces, spewing their outer atmosphere into space. These outbursts cause variations in their brightness which is one of their key observational signatures. Another consequence of their immense mass loss is the formation of a surrounding bipolar or circular nebulae composed of material lost from their atmospheres. Such nebulae are found enveloping approximately 70% of confirmed LBV stars. For example, Eta Carinae is an example of a LBV star with a beautiful bipolar nebula.

As most LBVs are enshrouded in nebulae, astronomers often look for possible LBV candidates by searching for such nebulae. In the case of WS1, Kniazev and collaborators were alerted to the possibility that it could be a LBV because they found in 2011 that it is surrounded by a circular shell of material that emits light at infra-red wavelengths. This prompted them to make follow up optical observations of the central star to confirm its nature. In 2011, using the Southern African Large Telescope (SALT), they obtained a spectrum and found features typically associated with LBV type stars. However, this information was not sufficient to confirm whether WS1 was indeed a LBV. To do this, it needed to be observed over a long time period to confirm whether its variability in brightness and in spectral features matched those expected from a LBV. Kniazev and collaborators continued to observe WS1 between 2013 and 2014 using the SALT telescope to look for changes in the spectrum. They also monitored its brightness between 2011 and 2014 using the South African Astronomical Observatory's 1.9 m telescope and combined their observations with publicly available data spanning over forty years. They found that WS1 did indeed exhibit all the observational characteristics of a LBV type star.

Kniazev commented that they were very lucky to discover major spectral and brightness changes in WS1 without having to wait too long. With this discovery, they unambiguously proved the LBV status of this star and expect that subsequent spectral analysis will allow them to determine fundamental parameters of WS1, for example its temperature and luminosity. They also hope to find more bona fide LBVs using SALT, which will help them to better understand the evolution of LBVs and their relation to other types of massive, old stars.



This discovery, published as a Letter to *Monthly Notices of the Royal Astronomical Society* brings the total number of LBV stars known to date to sixteen.

Left: Hubble Space Telescope image showing Eta Carinae, the most well studied example of a LBV star. Eta Carinae, the central star, appears as the white patch near the centre of the image, where the two lobes Nebula touch. Credit: NASA/Hubble Space Telescope.

First South African Comet Discovery in 35 years

In the early hours of the 7th April, an unmanned robotic telescope, MASTER-SAAO, situated near Sutherland in the Karoo, discovered a new comet (see front cover of this issue) . This is the first comet to be discovered in South Africa since 1978. The Russian - South African run telescope has been scanning the southern skies since it began operating in late December 2014, looking for “transients” – new objects which appear in the sky for the first time. Since then, over 60 new objects have been discovered, most of them being erupting or exploding stars. Now the MASTER-SAAO telescope has just discovered its first comet.

Left: The robotic telescope MASTER-SAAO, located at Sutherland.

Comets are often described as “dirty snowballs” and are composed of a ball of frozen ice with chemical compounds and dust mixed in. As a comet approaches the Sun it begins to melt resulting in a halo of gas and dust surrounding the solid nucleus called the coma. The Solar wind pushes the gas and dust released away from the comet resulting in the beautiful tails that we see associated with comets. There are actually two tails to a comet, one is made of gas (ions) which comes from the frozen compounds melting, the other is a dust tail again caused by the gases from the nucleus evaporating taking the dust with them. Astronomers are interested in studying comets because they represent the oldest and most primitive objects in the solar system and give astronomers an insight as to what conditions were like at the formation of our solar system.

The recently discovered comet has been officially named “Comet C/2015 G2 (MASTER)” and the discovery was confirmed on 10 April by the Minor Planet Center, based at the Smithsonian Astrophysical Observatory in the USA. It is the 20th comet discovered so far in 2015, and is currently heading rapidly south through the southern skies, brightening as it does so. Currently, the comet is about 180 million km from the Earth. It will make its closest approach to the Sun, at 116 million km (just a little further from the Sun than Venus), on the 23rd May when it is expected to be at its brightest. Although the comet is not particularly bright, the image taken by the MASER-SAAO telescope shows a distinct ion (gas) tail, that should be visible in dark skies (i.e. away from city lights) using binoculars. The last comet discovered in South Africa, Comet D/1978 R1 (Haneda-Campos), was co-discovered by Jose da Silva Campos, observing from Durban on 1 September 1978, and an astronomer in Japan, Toshio Haneda.

The MASTER-SAAO facility is one member of a network of telescopes operated by the Lomonosov Moscow State University's Sternberg Astronomical Institute. Most of the other telescopes in the network are located in Russia but there are two telescopes in the network located in the Southern Hemisphere: the MASTER-SAAO facility just outside Sutherland and a smaller telescope in Argentina. The Sutherland facility is a joint project with the South African Astronomical Observatory, aimed to discover and study southern optical transients – new objects which suddenly appear in the sky. It is the first transient detection system to be situated at Sutherland and will eventually be joined by another similar system, MeerLICHT, later this year. Discoveries from these telescopes will be followed up by more intensive studies using other South African telescopes such as SALT and MeerKAT (once it begins operating) and also the HESS gamma-ray facility in Namibia. See also the Colloquia in this issue.

Hubble Space Telescope is 25

On April 24, 1990, the space shuttle Discovery lifted off from Earth with the Hubble Space Telescope nestled securely in its bay. The following day, Hubble was released into space, ready to peer into the vast unknown. Since then, Hubble has reinvigorated and reshaped our perception of the cosmos and uncovered a universe where almost anything seems possible within the laws of physics. Hubble has revealed properties of space and time that for most of human history were only probed in the imaginations of scientists and philosophers alike. Today, Hubble continues to provide views of cosmic wonders never before seen and is at the forefront of many new discoveries.

Pluto's Atmosphere: What occultations reveal prior to New Horizons' arrival

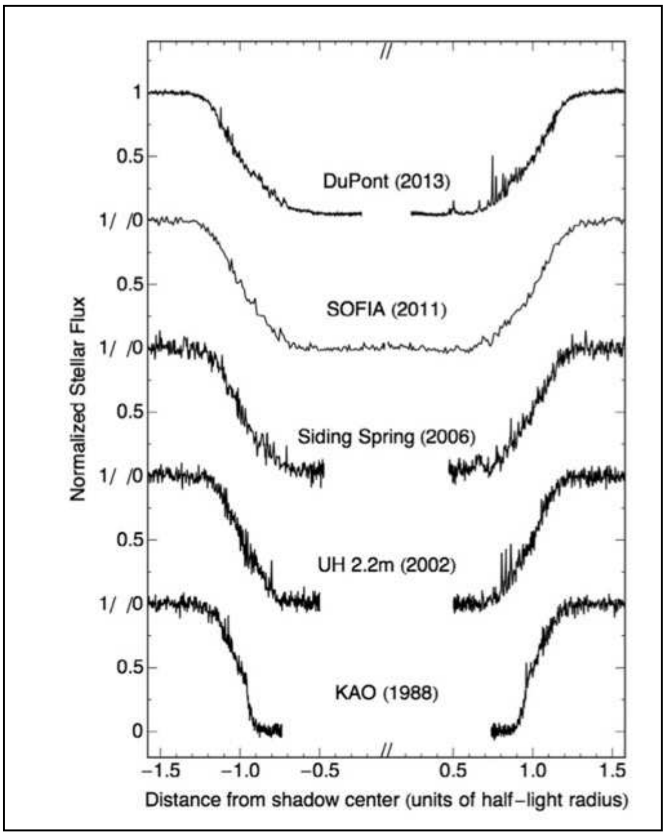
(Compiled by Lia Labuschagne)

Planetary astronomers, including the SA Astronomical Observatory's Head of Instrumentation, Dr Amanda Gulbis, have been investigating Pluto's atmospheric properties and evolution by observing stellar occultations by the planet, and using multiple telescopes in the United States (2012) and Chile (2013). Their results appeared in January this year in journal *Icarus*, under Bosh et al. (2015) and Gulbis et al. (2015). A special issue of the journal was dedicated to the current understanding of the Pluto System on the eve of the arrival of New Horizons at Pluto.

Dr Gulbis explains: "We use stellar occultations to explore in detail the faintest objects in our distant Solar System. Comparing results obtained from the first definitive Pluto occultation in 1988 until recently, we use our data to determine whether Pluto's atmospheric pressure will continue to rise or wholly dissipate before the arrival of the New Horizons spacecraft in July this year. Thus far, the data convincingly show that the atmosphere will hold through July."

Indeed, the occultation light curves show very little change in Pluto's upper atmosphere between 1988 and 2013. However, the portions of the light curves corresponding to the lower atmosphere have changed significantly, exhibiting a distinct change in slope in 1988 and 2011, and a "bowl-like" shape in 2002, 2006, and 2013.

The first detailed stellar occultation observed in 1988 detected a tenuous atmosphere on Pluto. Observations in 2002 surprisingly showed a noticeable change in the light curve that was attributed to a rise in the isothermal atmospheric pressure and atmospheric size. Pluto's eccentric orbit results in significant changes over the course of its 248-year revolution around the sun. At first, the atmospheric increase was attributed to the 1989 closest approach of Pluto to the sun, and was expected to drop as Pluto receded. However, additional occultation results between 2006 and 2013 are enough for astronomers to think otherwise.



Left: Comparison between Pluto stellar occultation light curves between 1998 and 2013. The upper atmosphere (about ~ 0.5 flux level) is constant, while the shape of the lower atmosphere has evolved. Figure from Bosh et al. (2015).

Asked about the impact that the New Horizons mission is likely to have on the understanding of Pluto and other Trans-Neptunian Objects (TNOs), Dr Gulbis says: "New Horizons is expected to reveal information about Pluto's surface composition and geology, and to characterize the atmosphere (through occultations as well as direct observations). The spacecraft will also be measuring the dust environment and energetic particles from Pluto's atmosphere and the solar wind. The moons will be studied, with closer views than ever before."

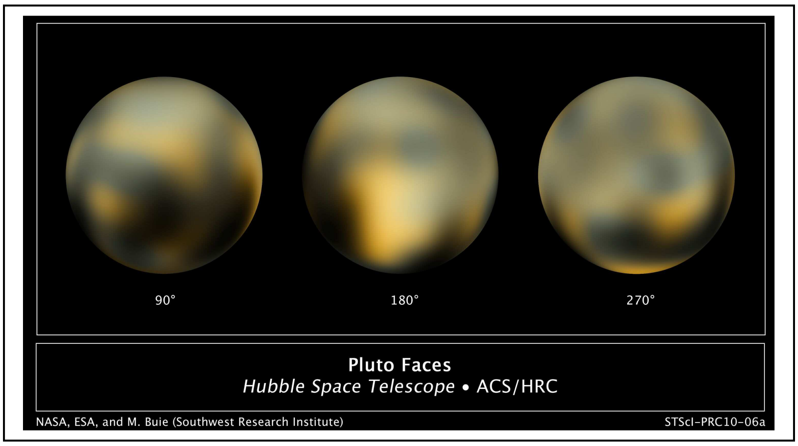
She adds that "increasing our knowledge of the Pluto system contributes to our understanding of the formation and evolution of all of the TNOs. These bodies hold clues to the history of our Solar System: their orbital properties are tracers of dynamical evolution, and their surfaces contain information about formation locations, collisional history, and processing mechanisms."

Dr Gulbis points out that she is not personally a member of the New Horizons team, "although I have close colleagues who are, and I have been involved in ground-based observations in support of New Horizons, such as the occultation work discussed here and taking spectra of Pluto's surface using SALT. Having ground-based data before, during, and after the encounter will provide an invaluable baseline, in which to provide context to the New Horizons results. The *in situ* data will also serve as an important check on the veracity of our interpretations of the ground-based data. I am very much looking forward to the community having the data, and I am certain there will be some surprises!"

Speculation about cryovolcanism

A separate paper by the same team contained a detailed analysis of an observation of a stellar occultation by Pluto in 2011. Consisting of simultaneous visible-wavelength images and low-resolution near-infrared spectra with NASA's 3 metre Infrared Telescope Facility, it showed a full occultation of the star by Pluto's moon Charon, followed by an atmospheric graze by Pluto. The double occultation allows accurate measurement of the distance between Pluto and Charon, as well as accurate calibration of the light curve. The multi-wavelength light curve data match that predicted by models containing micron-sized particles, suggesting that haze was present in Pluto's lower atmosphere at that time.

"Pluto is a very distant, very cold object. The fact that it has an atmosphere, much less an active one, is a bit surprising. In 2007, stellar occultation data detected atmospheric waves. Now, the evolution of the light curves through 2013 and the multi-wavelength data from 2011 suggest that there is intermittent haze in the lower atmosphere. Pluto is much more interesting than we expected," states Dr Gulbis.



Left: Computer-generated images of the dwarf planet Pluto, based on data from the Hubble Space Telescope. Pluto is approximately 2300 km in diameter and is currently 4.8 billion km from the Sun.

The dynamic nature of Pluto's atmosphere prompts some speculation of cryovolcanism - an underground force that causes melted volatiles to shoot up from the surface. Again, New Horizons will provide more clues to solving this mystery.

Dr Gulblis' current work involves among others an analysis of a stellar occultation by the active Centaur Chiron.

"We have a dataset for Chiron that is similar to that presented for the 2011 Pluto occultation, with visible wavelength images and near-IR spectra. Centaurs are outer-solar-stem objects that have been perturbed inward, and are currently on unstable orbits between the giant planets. Chiron is known to have shown cometary-like activity. However, given the recent discovery of rings around the similar-sized Centaur Chariklo, the features we see in the occultation data might be due to either outgassing or rings. For the 2011 Pluto occultation, we were able to show that the light curve is consistent with micron-sized particles in the lower atmosphere. I am analyzing the occultation data to constrain what particle sizes could cause the features we observe."

Centenary of discovery of Proxima Centauri

This year we celebrate the centenary of a famous South African astronomical event - the discovery by Robert Innes of the nearest star, Proxima Centauri.

Innes was the Director of the Union Observatory (UO) in Johannesburg. He had the belief that Alpha Cen, until that time the nearest known star, might be accompanied by one or more others at a similar distance. He blinked a photographic plate dated 10 April 1910 taken for the Franklin-Adams survey with another taken on 30 July 1915. This process took 40 hours spread over two weeks. He indeed found a faint star that had moved about the same amount as Alpha Cen, suggesting that they were at a similar distance. Innes announced his discovery in UO Circular No. 30, sent to the printer on 5 October 1915. The actual publication date was 12 October 2015.

This publication was called "A Faint Star of Large Proper Motion" and did not say anything about its distance.

The circular included a note by WM Worssell in which he says that he examined the star visually on 6 October with the 9-inch telescope and in effect found it to be very red. Worssell was a colleague at the UO and so would probably have been one of the first to hear about the high proper motion star.

On 20 October Innes wrote to W de Sitter of Leiden (a close friend): "You will see the activities of the Observatory in our Circulars which the Government is still willing to print but with long delays - the Blinkmicroscope work is the most interesting and a few days ago we discovered a 12th magnitude star with a proper motion of 5 secs a year."

This seems to imply that the actual moment of discovery was likely to have been nearer 5 October than 30 July.

Innes's later claim that this was the nearest star was made only in UO

Circular No. 40, published in 1917. This remained highly controversial for many years and was really only definitively proved to be the case with the publication of the results of the Hipparcos satellite

DSLR Photometry. How many darks?

Auke Slotegraaf

Abstract: The effect of the number of dark frames subtracted from a light frame on the signal-to-noise ratio (SNR) of stars is investigated. The conclusion is that applying a single dark frame gives a substantial improvement in the SNR of stars, while applying additional dark frames gives only a very small improvement.

Key words: Techniques: DSLR photometry

1 Introduction

When performing photometry on DSLR images, should dark frames be stacked and subtracted from the light frames? If so, how many dark frames should be used, and which stacking method should be employed? This experiment attempts to answer the first question by evaluating the signal-to-noise ratio (SNR) of stars on an image from which different numbers of dark frames have been subtracted.

2 Data Gathering

A Canon EOS 60D fitted with a 50-mm prime lens (Canon EF 50-mm f/1.8 II, giving a measured field of view of 24.3° x 16.2°) was mounted on a tripod and set up in a suburban location. The equipment was left for 15 minutes to cool down before imaging began.

A series (30) of photographs of the field surrounding the nova V1369 Cen (Nova Cen 2013) were taken. The lens was set at f/5.6, the ISO set to 1600, and a 9-second exposure time was selected. The lens was slightly defocussed to better sample the stellar images. The date of mid-exposure of the series was 27 January 2014 at 02:24:31 UT, when the altitude of the centre of the field was ~56° (air mass = 1.2). Soon after, 40 dark frames (ISO 1600, 9-s) were taken.

The camera remained outdoors, the lens cap was put in place, and a dark cloth draped over the camera, covering the lens and view finder. An intervalometer was programmed to take the images with 16 seconds between the start of each frame.

The series was started on 27 January 2014 at 04:51:59 SAST and ended at 05:02:23 SAST.

Both light and dark frames were stored in Canon raw format (CR2). Other camera settings are summarized in Table 1.

3 Data Reduction

The light and dark frames were registered and stacked using DEEPSKYSTACKER (version 3.3.3 beta 47). Table 2 gives a register of the files processed and analyzed.

Dark frames were stacked using Median stacking mode, with "Hot Pixels detection and removal", "Dark Optimization", and "Bad Columns detection and removal" unselected.
The stacks of dark frames were cursorily examined; descriptive statistics appear in Table 3. The effect of stacking is clearly seen by examining the standard deviation columns.

Due to a concern about the possible changing characteristics of a series of dark frames, two dark frames from the beginning of the series and two from the end of the series were stacked – their statistics appear as the last two rows of Table 3.

Three light frames from the series were selected for analysis: the first, the 15th and the last. From each image, 0, 1, 8, 16 and 32 dark frames were subtracted, resulting in 15 images for analysis (Table 2). Each processed image was then split into RGB channels (using IRIS version 5.59) and the green channel images retained for further analysis.

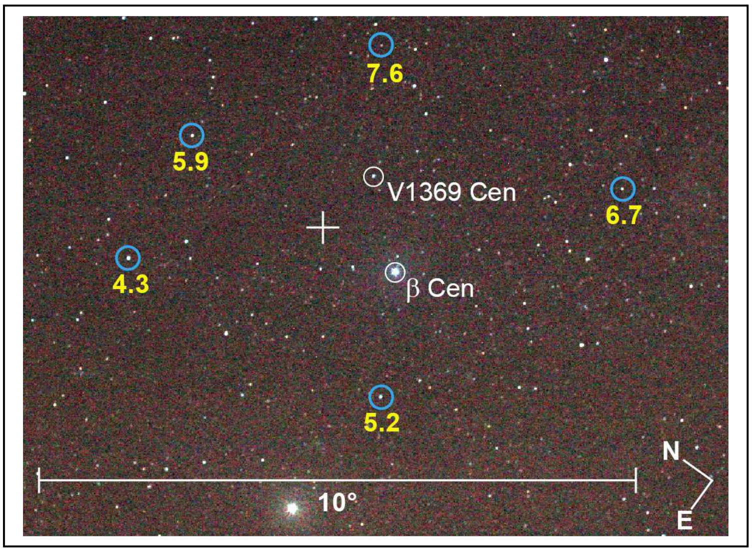


Figure 1. The five stars selected for SNR measurement. Decimal numbers are the rough V magnitudes. The + sign marks the centre of the frame. The background image is a low-resolution JPG.

3 Analysis

Five stars were selected for SNR assessment. The stars are within 5° of the centre of the field (Figure 1) and were free from nearby stars that could potentially interfere with their measurement. The stars range over 3.3 magnitudes in brightness (Table 4).

The SNR of the selected stars was measured using MAXIM DL (version 4.62), which reports the SNR of a targeted star in the "Information Window". According to the software manual (MaximDL Manual, 3-16), signal-to-noise ratio is defined as:

$$\mathrm{SNR} = \frac{S\sqrt{T}}{\sqrt{S + \Sigma(B + D + \frac{R^2}{t}}} \qquad (1)$$

where *S* is the signal, *T* is the total integration time, *B* is the sky background, *D* is the dark current, *R* is the readout noise, and *t* is the integration time per image. Presumably in the instance of analyzing these DSLR images, this relationship reduces to:

$$SNR = \frac{S}{\sqrt{(S+B)}} \qquad (2)$$

SNR measurements were made on the set of raw frames, as well as on a JPG version generated by the camera (neither dark subtraction nor noise reduction applied).

Appendix 1 lists the results of the SNR measures on each image. The SNR of a given star varies from image to image: the largest difference between SNR measures of the same star is 4.3% while the mean difference for all stars is 1.5%. This difference is considered small enough so that the SNR measures for the three light images can be averaged.

Table 5 reports the mean and standard deviation of the SNR of each of the stars as they appear on the six images; Figure 2 illustrates these results.

4 Discussion

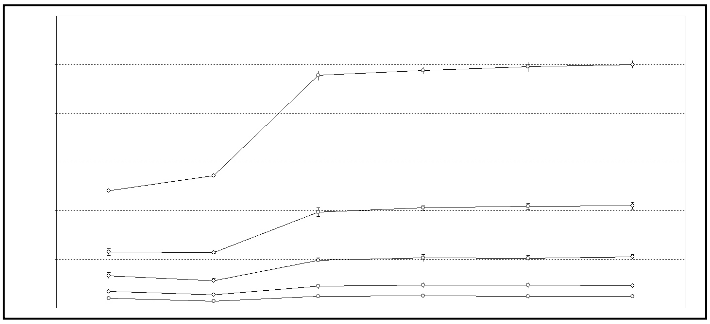


Figure 2. Signal-to-noise of the five programme stars as a function of the number of dark frames subtracted

Figure 2 shows the rather surprising result that the difference in terms of stellar SNR between a JPG and a CR2 raw file is rather small (Series 1 vs. Series 2).
As anticipated, the SNR increase when a single dark frame is subtracted (Series 2 vs. Series 3) is marked, particularly for brighter stars.

Rather surprising is the rapidly diminishing return when additional dark frames are used. Perhaps the light-polluted skies under which the light frames were taken mitigate the efficacy of additional dark frames, since the noise introduced by light pollution is much greater than the noise generated by the camera? It is planned to repeat this experiment from a dark-sky site

While these results may suggest that a single dark frame is acceptable, in practice several dark frames should be captured and combined to remove potential outlying values.

5 Conclusions

The data suggests three results: a single JPG and a single raw image give similar signal-to-noise ratios for stars; a single dark frame gives a substantial improvement in SNR; and applying more than one dark frame gives only a very small improvement in stellar signal-to-noise ratio.

Acknowledgments

Valuable comments were received from Evan Knox-Davies, Jerome Jooste, Dieter Willasch and Brett du Preez .

Table 1 Camera settings

ISO	1 600
Exposure time	9 seconds
Image size	5184 x 3456 pixels
White Balance mode	Daylight
Sharpness	0
Contrast	0
Saturation	– 2
Colour Tone	0
Colour Space	sRGB
Long exp noise reduct	Off
High ISO speed n.r	Disabled
Peripheral illumin.	Disabled

Table 2. Register of Images processed and analysed				
S	Type	IMG(L)[a]	nD[b]	IMG(D)[c]
1	JPG	1720	0	-
	JPG	1735	0	-
	JPG	1749	0	-
2	CR2	1720	0	-
	CR2	1735	0	-
	CR2	1749	0	-
3	CR2	1720	1	1831
	CR2	1735	1	1831
	CR2	1749	1	1831
4	CR2	1720	8	1828 … 1835
	CR2	1735	8	1828 … 1835
	CR2	1749	8	1828 … 1835
5	CR2	1720	16	1824 … 1839
	CR2	1735	16	1824 … 1839
	CR2	1749	16	1824 … 1839
6	CR2	1720	32	1816 … 1847
	CR2	1735	32	1816 … 1847
	CR2	1749	32	1816 … 1847

[a] Sequential image number of the light frame used
[b] The number of dark frames applied
[c] Sequential image number of dark frame(s) used

Table 3a. Descriptive statistics of the dark frame stacks				
	IRIS			
IMG(D)[a]	Mean	Std. Dev.	Min	Max
1831	2 045.8	34.4	1 538.0	15 309.0
1828-1835	0.3	0.7	0.0	255.0
1824-1839	0.2	0.6	0.0	255.0
1816-1847	0.2	0.6	0.0	255.0
1816+1817	0.3	0.8	0.0	255.0
1846+1847	0.3	0.7	0.0	255.0

[a] Sequential image numbers of the dark frames stacked

Table 3b. Descriptive statistics of the dark frame stacks					
Photoshop		Aperture Photometry Tool			
Mean	Std. Dev.	Mean	Std. Dev.	Min	Max
15.98	0.24	2 045.78	34.38	2 045.8	15 309
0.67	0.79	0.2586	0.6731	0.0	255.0
0.66	0.74	0.2152	0.6123	0.0	255.0
0.65	0.71	0.1926	0.5784	0.0	255.0
0.57	0.94	0.3099	0.8083	0.0	255.0
0.51	0.86	0.2433	0.7244	0.0	255.0

Table 4. Selected stars			
ID	**RA(J2000.0)**	**Dec**	**V**
HR 5358	14 20 19.54	– 56 23 11.4	4.3
HR5349	14 19 51.50	– 61 16 22.7	5.2
HR5266	14 03 26.51	– 56 12 48.4	5.9
HD117923	13 35 11.14	– 62 37 50.6	6.7
HD118770	13 40 23.81	– 57 55 33.3	7.6

Table 5. Mean signal-to-noise ratios of selected stars on the 18 images						
S	Image Type	HR 5358	HR 5349	HR 5266	HD117923	HD118770
1	JPG + 0 darks	120.6 ± 2.4	32.9 ± 3.3	10.2 ± 1.9	16.9 ± 2.6	57.7 ± 3.5
2	CR2 + 0 darks	135.9 ± 2.0	28.1 ± 2.4	7.0 ± 0.9	13.3 ± 1.2	57.0 ± 1.1
3	CR2 + 1 dark	238.8 ± 5.1	49.2 ± 2.1	12.1 ± 1.3	22.4 ± 2.8	98.7 ± 4.5
4	CR2 + 8 darks	244.0 ±4.1	12. ± 2.5	12.3 ± 2.5	23.4 ± 2.9	102.8 ± 2.2
5	CR2 + 16 darks	247.8 ± 5.2	51.2 ± 2.8	11.8 ± 2.4	23.3 ± 3.1	104.5 ± 3.3
6	CR2 + 32 darks	250.2 ± 4.3	52.5 ± 2.6	12.2 ± 2.3	23.1 ± 2.6	105.0 ± 3.4

Appendix 1. SNR measures of selected stars on the 18 images

IMG_1720 (first image in sequence)

S	Image type	HR 5358	HR 5349	HR 5266	HD 117923	HD 118770
1	JPG + 0 darks	117.857	57.700	29.216	14.589	12.239
2	CR2 + 0 darks	134.352	57.479	25.653	11.958	7.230
3	CR2 + 1 dark	237.851	100.863	47.171	19.142	12.849
4	CR2 + 8 darks	240.812	102.737	48.389	20.097	13.175
5	CR2 + 16 darks	245.179	103.836	48.877	19.779	12.384
6	CR2 + 32 darks	248.205	103.749	50.773	20.100	12.677

IMG_1735 (15th image in sequence)

S	Image type	HR 5358	HR 5349	HR 5266	HD 117923	HD 118770
1	JPG + 0 darks	121.639	61.210	33.837	16.338	8.555
2	CR2 + 0 darks	138.146	55.712	30.349	14.390	5.996
3	CR2 + 1 dark	244.307	93.565	51.405	24.283	10.596
4	CR2 + 8 darks	248.539	100.702	55.641	24.573	9.529
5	CR2 + 16 darks	253.796	101.607	54.306	25.746	9.102
6	CR2 + 32 darks	255.166	102.412	55.453	24.693	9.742

IMG_1749 (last image in sequence)

S	Image type	HR 5358	HR 5349	HR 5266	HD 117923	HD 118770
1	JPG + 0 darks	122.374	54.143	35.694	19.653	9.666
2	CR2 + 0 darks	135.267	57.741	28.269	13.589	7.788
3	CR2 + 1 dark	234.177	101.657	49.030	23.763	12.831

4	CR2 + 8 darks	242.550	105.025	50.159	25.508	14.231
5	CR2 + 16 darks	244.371	108.012	50.396	24.345	13.858
6	CR2 + 32 darks	247.268	108.899	51.295	24.406	14.180

References

MaxIm DL CCD Imaging Software Manual. Version 4. 2004. Diffraction Limited

Amateur Optical Tracking in South Africa During 1957 - 2017 Part 7

Greg Roberts

Abstract: This article covers the activities of the various MOONWATCH teams in the Durban area. In particular those of Arthur Arnold and Greg Roberts. Because some duplication has been eliminated, please read this account in conjunction with Part 2. The MOONWATCH organization was not interested in observations from amateurs unless associated with a recognized MOONWATCH site so this excluded many from participating in tracking satellites so, as detailed in Part 2 of this series, other organizations came into being up that offered some scope for amateur satellite enthusiasts to make meaningful contributions to the space program. Roberts in mid-1957 volunteered to set up a MOONWATCH station before the first satellites were launched but his offer was declined because of the anti "lone wolf" policy, so initially tracking activities where not MOONWATCH orientated.

PRE Station 0407

Roberts made his first satellite observation using predictions supplied by the Union Astronomer Dr Finsen of the then Union Observatory, Johannesburg, of the Sputnik 1 carrier rocket on 8 October 1957. This was from Glencoe, Northern Natal on a pass lasting from 17h36m to 17h42m UT and reaching a maximum elevation of about 69 degrees at a slant range of 535 km moving roughly south to east and passing just west of the Southern Cross before moving into the Earth’s shadow. Little did Roberts realize that this set the stage for a life-long interest that overruled all other activities.

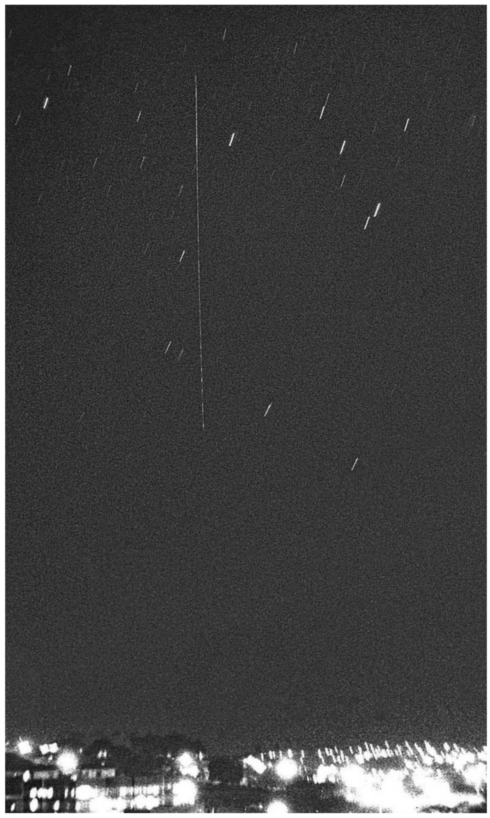
For the next two years many hours were spent looking for satellites but since most of the few satellites in orbit then were too small/faint to be seen with the naked eye the success rate was very low - but one spectacular zenith pass of a very bright secret Discoverer satellite remains vividly in memory.

However with no access to any satellite data, or the knowledge or means of how to predict a satellite pass Roberts had to rely on press reports and the occasional rather infrequent sightings of satellite purely by luck; however on 26 August, 1960 this all changed.

Predictions appeared in the Durban press for the bright newly launched 100 foot diameter balloon ECHO 1 satellite. Along with several other members of the University of Natal Rocket Society this was observed and photographed in the early morning hours from the roof of a building close to the Electrical Engineering Department where a department lecturer, Lee Nattrass, attempted to bounce transmitted radio signals off the satellite without success. Echo 1 was seen the following day but not on the third day so Roberts became engrossed in how to predict a satellite’s position and started teaching himself satellite orbital dynamics which has remained a lifelong interest. Unfortunately this was found to be more interesting than his academic studies which suffered!

Left: The 100-ft diameter ECHO-1 balloon.

Right: The ECHO-1 satellite rising above Durban.



Numerous letters were written to anybody connected to satellites and this slowly bore fruit. On 16 Sept 1960 Roberts received a letter from Norton Goodwin, Project Director of the Volunteer Satellite Tracking Program,(VSTP) 826 Connecticut Avenue, Washington 6,DC which read, in part:

"Dear Sir,
We are delighted to hear of your success in obtaining some 30 photographs of 1960 IOTA-1 (Echo 1 -GR) from date of launch through 28 August 1960"

and thus began a relationship with Norton that lasted till at least 1972 and was instrumental in forming Roberts's satellite tracking interests.

During this period the VSTP changed its name to Independent Tracking Coordination Program (ITCP) before finally closing down around 1972.

As a result of this correspondence a satellite prediction program was written with the help of a fellow student, Leonard Dicks, who had access to the University's new IBM 1620 computer. The first print out had the satellite orbiting beneath the surface of the Earth but this was easily corrected.

In correspondence with VSTP it was suggested on the 15 February 1961 that Roberts contacted MOONWATCH headquarters about establishing a possible MOONWATCH Station at the University and also contacted W P

Overbeck of Aiken, South Carolina who was developing techniques to determine the orbits of appropriate satellites.

MOONWATCH headquarters replied on 12 April 1961 with:

"Although your offer to contribute in whatever way you may to the MOONWATCH Observing Program is greatly appreciated; there is no likelihood as of the present that the MOONWATCH team network in South Africa is to be expanded beyond its present dimension"

Contact was made with a member of the Western Satellite Research Network (WSRN) of North American Aviation and Roberts subsequently became a member of WSRN which lasted until WSRN was disbanded.

Consequently tracking activities were confined to those of VSTP and WSRN and on the 1 September 1961 Roberts requested copies of papers by Overbeck from VSTP on his orbit determination techniques. This was supplied and the decision made to try and emulate these techniques.

Station 0407

On the 18 September 1961 Peter R Janisch of the University of Natal Survey Department provided the "Geographical Coordinates of Satellite Tracking Station, University of Natal Rocket Society" and the coordinates were scaled from a 1:1 200 map in Survey Department as follows:

Longitude 30^{o} 58' 48.70" East
Latitude 29^{o} 52' 07.72" South
Altitude 134 metres

It was subsequently assigned WSRN Station No 078 with the name Durban A.

On 1 October 1961 W P Overbeck (Bill) made contact with Roberts as follows:

“Norton Goodwin sent me a copy of his letter to you of 25 September. I had suggested to him that there might be some value in establishing a cooperative program between observers in opposite hemispheres. The purpose of this letter is to determine whether you are interested in the type of cooperative program that I will describe below....

to which Roberts replied on 7 October, 1961 expressing interest in such a programme.

(Bill Overbeck was a nuclear physicist. He collaborated with Enrico Fermi in setting up the first nuclear reactor and was in 1961 Director of the Savannah River Laboratories which was operated by E I duPont de Nemours & Company, for the United States Atomic Energy Commission where he had access to a mainframe computer.)

Bill responded by documenting his procedures in detail and this was published as two booklets by the VSTP which became a satellite trackers "bible" which even today ranks as a brilliant piece of work. The booklets were distributed to members of the VSTP and described as: "A Letter to Gregory Roberts" in the form of a letter from one amateur satellite tracker to another. In substance, Overbeck, one of the outstanding authors on satellite tracking and orbit analysis from single-station observations incorporated in his "Letter" a draft text for a "Satellite Tracker's Handbook".

In the introduction (11 November, 1961) Overbeck wrote "I promised you a letter on precise calculation of artificial satellite positions. This is it. It turned out to be a bigger job than I had planned because I decided to write it in a form that might be published for use by others.....

Part 1, appeared 11 November 1961 and consisted of 42 pages and described the prediction technique used.

Part 2, appeared 7 April 1962 and described the analytical technique used to reduce observations and derive orbital elements. This contained 92 pages.

In early 1962 Roberts spent two months working at the Royal Observatory, Cape Town, South Africa as a University Vacation student and made contact with the Cape Town MOONWATCH Team. At the same time the first part of "A Letter to Gregory Roberts" appeared and several people at the Observatory received copies from VSTP. Roberts also participated in some of the Cape Town MOONWATCH observing sessions, and in co-operation with Mr W Hirst, leader of the Cape Town MOONWATCH team, observed Glenn's Friendship 7 Mercury space capsule on 20 February at 8.24pm SAST as it passed over southern Africa on its third orbit. It was seen for about 90 seconds.

In a letter to Overbeck in March 1962, Roberts wrote:

"The following will no doubt interest you. One result of your "Letter to Gregory Roberts" is that the Baker-Nunn station here approached me and asked if I would be interested in setting up a MOONWATCH station to which I responded "yes" and I think it will be ideal for tracking of your satellites. At the moment I do not know if we will be getting the 50 mm MOONWATCH scopes or the 5" Apogee jobs - I hope the latter. I also believe we will be supplied with timing devices and suitable star atlases"

So finally a chance to become a MOONWATCH station!

In August 1962 two APOGEE scopes were sent from the Baker-Nunn Station at Olifantsfontein to the University Rocket Society but never arrived. The South African Railways delivered the telescopes to the Paint Research Unit of the CSIR that was on the campus of the University, somebody signed for them and the telescopes "disappeared". Approximately 15 years later Roberts eventually found out who had stolen the two telescopes (two "gentlemen" at the Paint Research Institute -

initials HC and MA) and at last in 2012 was able to recover one of them from HC - so finally delivered after a 50 year lapse! The other telescope, stolen by MA remains lost, perhaps last seen somewhere in the KwaZulu Natal midlands. One thing about this incident that still riles Roberts is that there was no apology or sense of guilt for the theft of the telescopes and the time wasted in trying to locate them.

Left: Len Dicks, Greg Roberts, Geoff Meyer, Derek Woodburg and Selwyn Hamerschlag.

A further three Apogee scopes were subsequently despatched by the Baker-Nunn station and were safely received. The three telescopes were set-up at the Society tracking site which was near a tennis court close to The Ansell May Hall Residence on the University campus with Roberts as Team Leader.

Two or three training sessions were held and some satellites observed but the station never really becoming operational or made any MOONWATCH observations as it still lacked the accurate time signals necessary for positional work. One satellite tracked was Telstar 1. By the time the station was set-up it was already near the end of the University academic year and most of the leading lights of the Society were in their final year of study so examinations finally(!) had to take priority.

Some photographs were taken of the partially developed station in November 1962 by Derek Woodburn for a South African publication South African Panorama but there is no record of the article being published.

As the Team Leader Roberts finally completed his University degree at the end of 1962 an attempt was made to keep the Rocket Society going in early 1963 but failed when the University authorities informed the Society that regulations did not allow a non-registered University person (Roberts) to be chairman of a University Society so since all the main members had graduated at the end of 1962 the Society closed down as no one was sufficiently interested and Roberts retained the 3 Apogee scopes for safe keeping and this marked the end of optical satellite tracking at the University.

There is some confusion as to the station identity 0407 which has the coordinates derived by P R Janisch in September 1961 but on plotting this position using GOOGLE EARTH it does not correspond closely with any location used at the University for satellite observing so possibly there was an error in the original coordinates. To add to the confusion Smithsonian MOONWATCH Headquarters has no record of Station 0407 which was almost certainly assigned by the Baker Nunn Tracking Station. In 1968 the MOONWATCH newsletter reported on observations made at Durban 0407 during the period January 1968 - June 1968 which is impossible since station 0407 closed down in 1963! However it is possible that the observations may have been made by Art Arnold (see later) at station 0411.

STATION 0408

Left: Greg Roberts and Arthur Arnold tracking satellites from the latter's home at 224 St Thomas Road..

In early 1963 Roberts, who now resided in a flat in Durban and worked at Lever Brothers, observed satellites from the 13 story roof and nearby Albert Park (the small balloon satellite Explorer 19 comes to mind), as well as doing some limited radio tracking was contacted by Arthur Arnold one Saturday afternoon by a knock on the door of the Roberts flat, and upon opening the door was greeted with the comment "Are you that mad

Roberts that tracks satellites?" It turned out that Art was a radio amateur, call sign ZS5SU, who was very interested in satellite tracking by radio but knew very little about the optical aspect or predicting.

A strong friendship was formed and soon led to the forming of what was called the Durban Satellite Tracking Station, with Art handling the radio side and Roberts handling the optical side and operated from Arthur's home at 224 St Thomas Road on the Durban Berea, close to the site of the old Natal Observatory in Currie Road.

This site was assigned COSPAR TRACKING Station Number 0408 and WSRN site No 082 with identification DURBAN B with the following coordinates:
Longitude 31^{o} 00' 01.76s East
Latitude 29^{o} 50' 39.48" South

This station operated from 1963 till about March 1966 when the last observation was apparently made on the 17 March, 1966. During this period the station produced more observations of artificial satellites than all the other southern hemisphere amateur tracking stations combined and more than any individual northern hemisphere with tracking carried out every clear night, other factors permitting. It was an exciting time!

Unlike the usual amateur tracking station the station concentrated on all aspects of amateur tracking - optical (visual and photographic) as well as radio tracking, mostly with equipment constructed by the members or even sometimes adapted from equipment intended for something entirely different. Radio tracking was carried out on most of the radio frequencies then in use for satellite transmissions and with new launches occurring almost daily it was an exciting time locating all the new frequencies and satellites.

For a brief period in 1965 Walter (Wally) Scott, a young building society employee, assisted Arnold and Roberts and established a small tracking station at his home in Kloof using a 3-inch wide angle telescope but there is no record of any serious observations being made or being allocated any site numbers. Roberts unfortunately cannot recall what became of Wally.

During that era the vast majority of amateur stations had to generate their own predictions by hand. Computers were very rare and expensive devices not found in the hands of amateurs so mechanical and graphical means had to be used to generate a prediction from essentially scratch using classical celestial mechanics, sometimes taking as much as ten minutes to generate a prediction. Art at that time was a cinema projectionist and spent many hours churning out predictions with his hand desk calculator at work. The station was more fortunate than most in that it did receive some local predictions from organizations in the United States, Australia and England. In addition the station received orbital element summaries of every object currently in orbit from WSRN on a monthly basis.

Left: Arthur Arnold engaged in computations.

Of course there was no internet in those days so one had to rely on the postal service for orbital data and information on new launches. Fortunately in those days the international postal service was superior to what it is today - one case where things have not improved.

Usually 30 to 40 satellites were predicted for a nominal three hour tracking session with about a 50% success rate and using data supplied by the NASA computing centre it was often possible to do a session’s predictions in about 90 minutes using electric adding machines, mechanical desk calculators and tables specifically computed for the Durban station to provide "look angles".

Durban unfortunately is not the ideal location for any astronomical work and only from about May to the end of July were reasonably clear evenings a certainty and during this period some 400 observations per month were secured, whilst for the remainder of the year the average monthly rate was about 30, occasionally being as low as 5.

Frequently satellites were lost to the tracking agencies for one or other reason so the station concentrated on such objects. A classified military launch by the US into an orbit some 2 000 miles above the Earth was "mislaid" and after a world-wide search by several amateur groups, the Durban station being among those to secure observations, the satellite was "recovered". Another example was that radar located a large object associated with the launch of Cosmos 41 and the station received a request to try and track the object - unfortunately without success.

During 1965 the station secured over 2 000 observations on just about every major object in orbit-including satellites, rocket casings and other associated items. In addition some 300 positional observations were secured on about 40 different satellites and the exact orbits determined for about 30 satellites from these observations. Typical examples of such included the Allouette 1 rocket, Anna 1B rocket, Elektron 1, Telstar 1 and several classified satellites and such orbits were reported to interested organizations overseas and in several cases were re-distributed world-wide to other tracking stations.

One interesting case was that of Cosmos 70 which some stations in Europe stating they could hear voice transmissions and that the satellite was suspected of being manned. The Durban station picked up identical signals during the first few orbits of the satellite, the signals stopping at about the same time they were reported to have stopped but the signals heard were telemetry and voice transmissions were not confirmed. From later evidence it is pretty certain that the satellite was unmanned.

All the American manned spaceflights were monitored and tape recorded and most of the Soviet cosmonaut flights were tracked during some stage of their mission and in some cases being optically tracked - eg Gemini 8 and in some cases radio transmissions received. As a result of the latter the station appeared in the weekly cinema feature news African Mirror and had good relations with the local press and supplied information on interesting astronomical and satellite related events.

One Russian Lunik probe on its way to the moon was tracked for several hours when its signal was accidentally picked up and a request was received to track the Russian Lunik 6 moon probe which was expected to impact the Moon in the early evening. The station was asked to use its largest instruments to try and observe any phenomenon that could be associated with the lunar probe firing retro-rockets in anticipation of a soft landing on the Moon's surface and if possible to photograph such. Lunik 6 unfortunately missed the moon due to a malfunction during the mid-course trajectory correction.

Possibly as a result of this activity the station was approached and visited by a representative of the United States Government, one Lt Cmdr Cricchi, at the Durban U.S consulate to find out if the station was interested in a project to track Soviet lunar probes and what equipment the station would need. However nothing materialised subsequently so maybe the stations requests were too expensive!

A severe problem was the problem with the provision of accurate time signals which are essential for precise optical positional work. Radio time signals had to be used from distant transmitters operating on 5, 10 and 15 MHz, but frequently radio conditions were so poor that the time signals were not audible(mainly during the summer months) and especially at this time since sunspot activity was near a particularly low minimum. In addition the South African time signal station - ZUO - went off the air for 10 minutes every hour and it seemed to be that during this time the signals were most frequently required!
As a result of the problems with reliable radio time signals the station was unable to undertake regular positional observations so instead

concentrated on the determination of optical characteristics of artificial satellites as this could provide much useful data for space surveillance.

MNASSA Vol XXIV No 10 (31 October,1965) contained an article by Roberts entitled "The Optical Appearance of Artificial Earth Satellites" which listed all the major satellites, their dimensions, mean variation in magnitude, mean magnitude and general appearance mainly based on observations made at the station. This followed a request from the Western Satellite Research Network and the information collected by this network was subsequently reported to the 1st Aerospace Squadron of the United States Air Force for surveillance purposes.

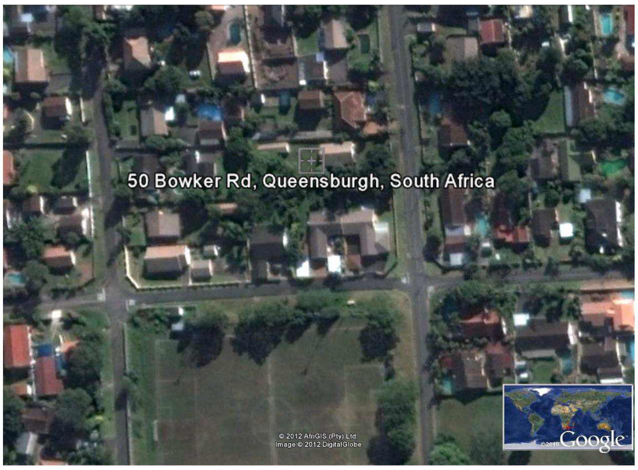
In an article on the Tracking Station that appeared in the South African publication Scientific South Africa (Vol 3 Issue 5 March, 1966) Roberts made the comment "Photographic tracking of satellites by amateurs is not destined to play a major role in amateur tracking as the equipment required to record photographically the fainter satellites is well beyond the average amateurs reach" - this was one prediction by Roberts that turned out totally wrong but then the CCD chip had still to be invented ! Today amateurs can exceed the capabilities of most of the best professional tracking stations at that time.

The August 1965 issue of Sky & Telescope (Vol XXX No 2) contained an article on the Western Satellite Research Network in which the Durban station was mentioned with a photograph.

The operators of the Durban station corresponded with amateur and professional groups with similar interests in various parts of the world. They cooperated with organizations which included the "MOONWATCH" division of the Smithsonian Astrophysical Observatory, the Western Satellite Research Network of North American Aviation, the Independent tracking Coordination program in Washington, the Science Research Council Radio and Space Research Station, England and the Lockheed Aircraft Corporation.

STATION 0411

Arthur and family, along with Roberts, moved out to Escombe around March 1966 and MOONWATCH Station 0411 was set up some time later and assigned COSPAR Satellite Tracking Station Number 0411 and WSRN site 092 with identification Durban C with the following coordinates:



Longitude 30° 54' 16 East
Latitude 29° 52' 33" South
altitude 210 metres

Left: 50 Bowker Road.

From the data available it would appear that station 0411 only made a few scattered observations for MOONWATCH whilst WSRN does list the station, but no observations in its July 1968 report. Art did make an observation of a satellite re-entry and did some radio tracking of interesting satellites as well as optical (but not positional) observations of some classified satellites of special interest as well as several shuttle missions.

The station was visited by MOONWATCH Chief Bill Hirst during his whirl-wind world tour over the period July-September 1966 during which he visited 20 MOONWATCH stations but no observing was possible due to the usual cloudy weather.

Left: Arnold setting up a mount for an Apogee 'scope.

Roberts, around mid/late 1965 met his future wife Maureen whom he found far more interesting than any satellite so the tracking suffered somewhat. In March 1968 Roberts got married and was transferred by his employer (Mobil Oil Refinery) to Cape Town leaving Art as the sole operator of 0411.

It would appear that Art lost interest with the departure of Roberts and he subsequently made few observations, being greatly plagued by the floodlights from a nearby rugby field which seemed to have training sessions virtually every night as well as the continual problem of accurate time signals.

Roberts and Arnold remained in contact and when Art emigrated to England some years later he took his 5-inch Apogee scope with him which was originally one of the three allocated to Roberts and subsequently given to Art when Roberts left Durban.

This ended amateur satellite tracking in Durban

References

1 Blast-Off: Newsletter of the University of Natal Rocket Society and Research Group

2 Phototrack program

3 Volunteer Satellite Tracking Programme publications and correspondence

4 Independent Tracking Coordination Program Publications and correspondence

5 Western Satellite Research Network Newsletters and correspondence.

6 MOONWATCH Newsletter and correspondence

7 Optical Observations Of Faint Satellites (Final Report), Technical Document Report No ESD-TDR-65-155 July 1964

8 Satellite Optical Characteristics Study SID 65-1176, 1 August 1965, North American Aviation, Inc. Space and Information Systems Division.

Contains 11000 observations of 365 satellites made by 26 teams of the WSRN. 175 pages.
9 Western Satellite Research Network, Sky & Telescope Vol XXX No 2 August 1965.
10 The Optical Appearance of Artificial Earth Satellites" by Gregory Roberts MNASSA Vol XXIV No 10 (oct 31,1965)
11 Tracking Satellites is their Hobby by Gregory Roberts
Scientific South Africa (Vol. 3 Issue 5 March 1966)
12 Satellite Optical Characteristics Catalog SID68-629. 20 July 1968, North American Rockwell Corporation, Space Division. Contains 7900 observations of optical characteristics of 574 satellites made during the period 1965 to 1968, 356 pages.
13 Optical Characteristics of Artificial Satellites SID 68-629 1 July 1970. North American Rockwell Corp., Space Division.

Colloquia and Seminars

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, 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.

Note: Due to unforeseen circumstances, this is an edited version of Colloquia. Editor.

SAAO

Title: Bringing Big Data to the Solar System
Speaker: Paulo Penteado
Date: 26 November
Time: 11h00
Venue: SAAO Auditorium

Abstract: Over the past decade, astronomy advanced into the Fourth Paradigm: data-intensive research enabled by the advent of comprehensive archives and new tools and algorithms to make use of the available data. Planetary Sciences, however, were left behind, due to the particularities of Solar System observations: Unlike other astronomical objects, Solar System bodies do not have a fixed position in the sky, and they are not always observed from the same perspective. In this talk, I will present two projects we are developing at Northern Arizona University, which will create archives and tools necessary to make Solar System observations accessible. One project is devoted to standardizing and mapping remote sensing data (taken by probes that go near the objects). The other project looks into archives of ground and space based astronomical observatories, to identify and index all observations that contain known Solar System bodies. These tools will enable research that benefits from all the unexplored data that already exists in the archives.

Title: Global MASTER Robotic Net
Speaker: Prof. Vladimir Lipunov (Sternberg Astronomical Institute)
Date: 1 December
Time: 11h00
Venue: SAAO Auditorium

Abstract: The main goal and structure of the fastest synoptic sky survey up to 20 mag are considered. MASTER Global Robotic Net is the project of Moscow State University. MASTER's goal is the solution of several fundamental problems of modern physics and astrophysics. They are the following: 1) a problem of relativistic collapse (about gamma ray bursts –

the most powerful explosions in the Universe, i.r. the processes accompanying formation of black holes and neutron stars in the Universe), 2) the research of dark energy properties (search and investigations of Ia Supernovae stars), 3) During implementation of the project research problems of mechanisms of thermonuclear flashes, which are very interesting to modern astrophysics, at white dwarfs, a plasma luminescence near supermassive black holes (the flash of galaxies nucleus and quasars), orphan GRB and the bursts of still unknown nature are solved. MASTER Global Robotic Net consists of 4 sites at 4 Russian universities (Amur, with colleagues from Blagoveschensk State university, Tunka – with colleagues from Irkutsk State University, Ural – with colleague of Ural Federal University, Kislovodsk – Lomonosov Moscow State University and Solar station of RAS) and an Argentinian site with colleagues of San Juan University and IAC (Spain). The MASTER Net began operating in full mode in 2010. Up to now MASTER discovers more than 650 optical transients (http://observ.pereplet.ru/MASTER_OT.html), investigated several hundreds GRB (most of them has the first pointing.

Title: Spectral analysis of very hot H-deficient [WCE]-type central stars of planetary nebulae
Speaker: Graziela Keller
Date: 4 December
Time: 11h00
Venue: SAAO Auditorium

Abstract: Central stars of planetary nebulae, or CSPNe, are evolved stages of low- and intermediate-mass stars. They are very hot, with surface temperatures between 20 000 and 200 000 K, and many of them present signatures of strong stellar winds in their spectra. We analysed ultraviolet FUSE, IUE, and HST/STIS spectra of five of the hottest [WCE]-type central stars of planetary nebulae: NGC 2867, NGC 5189, NGC 6905, Pb 6, and Sand 3. The analysis leveraged on our grid of synthetic spectra, calculated with the non-LTE stellar atmosphere code CMFGEN, which accounts for stationary spherically symmetric mass-loss, line blanketing and wind

clumping. The grid includes many ionic species that ha ve been neglected in previous works, is a useful tool to plan observations, and most importantly, enables systematic and uniform analyses of observed spectra. Solid determinations of photospheric and wind parameters are essential to tackle questions concerning low and intermediate mass stellar evolution and possible evolutionary links among different CSPN sub-types, the wind driving mechanism and the properties of the surrounding nebulae. The grids are being made available on-line at
http://dolomiti.pha.jhu.edu/planetarynebulae.html.

Keller et al. 2014, MNRAS, 442, 1379. UV spectral analysis of very hot H-deficient [WCE]-type central stars of planetary nebulae: NGC 2867, NGC 5189, NGC 6905, Pb 6 and Sand 3.
Keller et al. 2011, MNRAS, 418, 705. A new grid of synthetic spectra for the analysis of [WC]-type central stars of planetary nebulae.

Astro-Coffee

Title: Low-frequency radio transients at the North Celestial Pole with LOFAR
Speaker: Adam Stewart
Date: 26 November
Time: 13h00
Venue: SKA office - 2nd Floor Auditorium (CT)

Abstract: In this talk I will present results obtained from a low frequency, image-plane, radio transient search at the North Celestial Pole, which amassed over 2000 epochs over a four-month period using the International LOFAR Telescope. This includes the strongest LOFAR image plane transient candidate to-date - a short, ~20 Jy event which was never seen to repeat. However the origin of this event remains unknown, and we discuss a range of possibilities from a highly scattered Fast Radio Burst to a nearby dwarf flare star. Based on these results, we have also been able to define rates and upper limits of the number of transients expected at this wavelength, and at various different time-scales.

Title: The variability timescales and brightness temperatures of radio flares from stars to supermassive black holes
Speaker: Gosia Pietka
Date: 26 November
Time: 13h00
Venue: SKA office - 2nd Floor Auditorium (CT)

Abstract: We have compiled a sample of ~200 synchrotron flares observed at 5-8 GHz, originating from a wide range of astrophysical objects, from flare stars to supermassive black holes. In this talk, I will present the results from the analysis of this sample, where for each of the flares obtained we measured the rise/decline timescales and compared them against peak radio luminosities. These measured timescales vary from minutes to years, and the peak radio luminosities range over 22 orders of magnitude. Despite very different underlying phenomena, we find a broad correlation between peak radio luminosity and rise/decay timescales, approximately of the form $L \propto \tau^5$. It furthermore demonstrates that variability timescales could be used as an early diagnostic of source class in future radio transient surveys.

Title: CEILING-KAT: Online End-to-End simulator for SKA Phase I and its Pathfinder Missions
Speaker: Sphesihle Makhathini
Date: 27 November
Time: 13h00
Venue: SKA office - 2nd Floor Auditorium (CT)

Abstract
Context: The quantity and complexity of the data that will be produced by the SKA and its pathfinder/precursor instruments poses difficult challenges for processing, storage, reduction and imaging techniques. It is therefore useful to produce quality simulated data for these instruments. Simulated data can be particularly useful for novice reduction techniques (or

experiments) such as HI stacking and weak lensing using radio interferometry.
Aims: The CEILING-KAT project aims to provide quality simulated data for the SKA and its pathfinder missions. The simulated data can be used to test/develop the software, hardware and/or infrastructure that will process, store and reduce the data. In particular, we aim to produce simulated data for the major MeerKAT surveys, and a simulated SKA1-MID weak lensing experiment.
Methods: We use the MeqTrees software and the LWIMAGER package (CASA derived) to produce simulated data. The simulation pipeline is written using the Python eXtensions for Inteferometry Scripting (Pyxis), and the web interface is written using the DJANGO web development framework.

Title: the Jansky Very Large Array
Speaker: Rick Perley
Date: 3 December
Time: 11h00
Venue: SKA office - 2nd Floor Auditorium (CT)

Abstract: The Expanded Very Large Array Project, begun in 2001, was completed in 2012, and the upgraded array -- the Jansky Very Large Array -- is now in full operation with most of the key observational modes working well. The pace of implementing new observational modes has slowed as the array moves into its science production mode. The major challenge now is in the calibration and processing of the very large databases now being produced daily.
With the science production phase of the Jansky VLA now well established, the focus for the radio astronomical community will be on the array's long-term future. The NRAO is now considering a 'next generation' VLA -- to longer baselines and higher sensitivities. A straw-man concept would be an array offering 5 -- 10 times the current resolution, and 5 -- 10 times the current sensitivity, up to a frequency of 50 GHz, or perhaps higher. Such an array would necessarily implement new antennas of modern design,

super-wideband feeds and receivers, and a requirement for minimal operational costs. To establish the necessary science case, the NRAO has established four science working groups. An all-day workshop, titled 'US Radio Futures: Building from ALMA and the VLA' has been set for 04 January, 2015 in conjunction with the AAS meeting to encourage community-wide discussion of this concept.
In this talk, I will review the current capabilities of the Jansky Very Large Array, illustrated with some recent results. I will then discuss some recently completed and ongoing technical improvements, and will finish with a schematic description of one concept of the Very Large Array of the future -- beyond 02020

NASSP

Title: The General Principles of Space Weather
Speaker: Dr Donald Danskin from Natural Resources Canada in Ottawa, Canada
Date**:** 28 February
Time**:** 16h00
Venue**:** RW James, Lecture theatre D (James D)

Abstract: In our modern technological society, reliance on sa tellites and communication systems is typically taken for granted. These services always seem to be available and appear to be have no weaknesses. Space weather is the study of how the sun affects the technology of Earth. In this talk, the fundamentals of Space Weather will be discussed to give a greater appreciation of the potential for interruption to services by extreme events. Some of the affected services encompass radio wave communication, power transmission, and satellites operations.

Title: PULSARS Search, Timing, GR Tests
Speaker: Dr Jeandrew Brink from the National Institute for Theoretical Physics (NITHEP)
Date: 8 April
Time: 16h00
Venue: RW James, Lecture theatre D (James D)

Abstract: The Green Bank Telescope (GBT) is the largest fully steerable radio telescope in the world. Using observations made with this telescope I review some of the basic ideas behind pulsar searches and timing. I comment on future mathematical, data processing and storage challenges that will be faced with telescopes such as the Meerkat/SKA, placing in context what has already been achieved with the GBT. I discuss several tests of General Relativity that can be achieve using pulsar timing, reviewing several key pulsar systems such as: J0737-3039, the most relativistic binary pulsar system known to date, that could soon place limits on the neutron star equation of state. As well as the newly discovered triple system that could potentially lead to precision tests of the equivalence principle. I then explore the requirements of a pulsar to be included in the international pulsar timing array that aims at measuring gravitational waves. Finally, I look at the possibility of carrying out tests of the "No Hair", or uniqueness theorems, around the Galactic Center, Sgr A* using pulsars.

Title: Research Opportunities with Gaia and Spitzer Spacecraft.
Speaker: Prof. Patricia Whitelock from the SAAO/UCT
Date: 15 April
Time: 16h00
Venue: RW James, Lecture theatre D (James D)

Abstract: I will describe various projects in progress or just starting that offer new insight into (1) the transient universe, (2) the structure of our own Milky Way Galaxy and (3) the late stages of stellar evolution. These make use of observations from Gaia and Spitzer, sometimes in

combination with data from the Infrared Survey Facility (IRSF) and the Southern African Large Telescope (SALT) at Sutherland. These exciting international collaborations present opportunities to use the South African facilities to tackle some of the fundamental challenges in astronomy.

ACGC

Title: Degeneracy between primordial non-Gaussianity and interaction in the dark sector
Speaker: Mahmoud Hashim (UWC)
Date: 7 April
Time: 13h00
Venue: M111 Maths Building, UCT

Abstract: If dark energy and dark matter interact via exchange of energy and momentum, then this may affect the galaxy power spectrum on large scales. When this happens, it may be degenerate with the signal from primordial non-Gaussianity via a scale-dependent bias. We consider a class of interacting dark energy models and show that the matter overdensity is scale dependent on large scales. We estimate the effective non-Gaussianity arising from the large-scale effects of interaction in the dark sector. The signal of dark sector interaction can be disentangled from a primordial non-Gaussian signal by measuring the power at two redshifts.

AIMS

Title: Analogue Models of Gravity: The Ubiquitous Space-Time
Speaker: Prof. Stefano Liberati (SISSA, Trieste, Italy)
Venue: AIMS research centre
Date: 26 November
Time: 11h00.

Abstract: Analogies have played a very important role in physics and mathematics, as they provide new ways of looking at problems that permit

cross-fertilization of ideas among different branches of science. An analogue gravity model is a generic dynamical system (typically but not always based on condensed matter physics) where the propagation of excitations/perturbations can be described via hyperbolic equations of motion possibly characterized be one single metric element for all the perturbations. As such it can be used to mimic interesting systems for quantum field theory in curved spacetime such as black holes and cosmology. In this review seminar I will discuss the developments of this field of research and its perspectives.

Title: The power of mathematical dualities in physics and the origin of space

Speaker: Dr Jonathan Shock (UCT)
Venue: AIMS research centre
Date: 10 December
Time: 11h00.

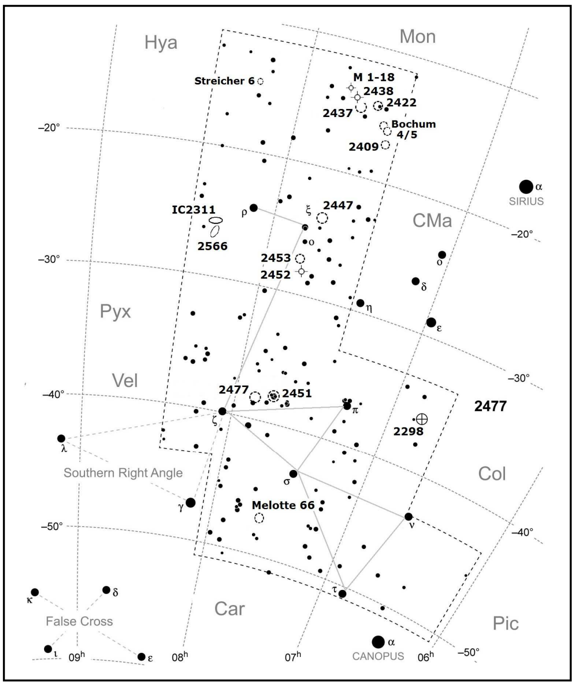
Abstract: The degrees of freedom with which we choose to describe our physical systems seem set in stone, but perhaps there is some freedom in our descriptions. Indeed we can find ex plicit c ases where we can have multiple descriptions of the same system in terms of very different elementary degrees of freedom. One of the most profound insights coming from string theory in the last decades has been that strongly interacting particle systems can rearrange themselves into a completely different picture where gravity appears to emerge from the underlying chaos. Does space itself come from a more basic picture and can we see how the universe arises from a fundamental reality where space doesn't exist at all? These questions are still to be answered but the process of uncovering the truth about space itself is proving fascinating.

The Sailing Ark (Puppis)

Magda Streicher

We are lucky to have a great starry Ark sailing in the southern skies to please our eyes just before winter throws its blanket over us. Puppis and some other constellations were previously lumped together as the constellation Argo Navis. The Germans called Navis the Schiff, the French Navire Argo and the Italians Nave Argo. The ship's four divisions are now known as Carina the Keel, Puppis the Stern, Vela the Sail and the Mariner's Compass Pyxis. From the Bible's reference to Noah's Ark, it was popularly known in the 17th century as the Ark. It was the French astronomer Nicolas Louis de Lacaille who divided up this monster ship in the 18th century.

Some of the original bright stars belonging to the main constellation have now been divided between the four constellations. The brightest star in Puppis is zeta Puppis and the only star in this constellation with a reasonably easy name is Noas, which has a magnitude of 2.2 and is 1 400 light years distant and one of the hottest stars visible. What is so nice about this starry Ark is that our galactic plane cuts through this part of sky, making it even more attractive to us down south.



Right: The constellation Puppis

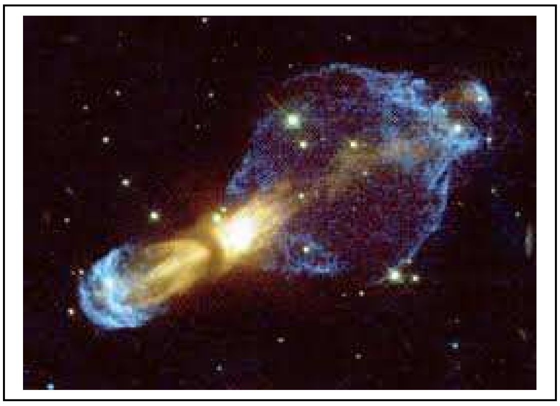
This is a constellation which is home to many clusters and nebulae. The beauty is that even a pair of binoculars will bring to the eye a feast of star groupings. Roughly, the constellation displays a zig-zag impression if viewed with a wide angle such as with the naked eye. The bow comprises 5 stars in the form of magnitude 2.9 tau, the back end, magnitude 3.1 nu, magnitude 2.6 pi, magnitude 3.2 sigma and magnitude 2.2 zeta, which gracefully steers this ship. A shape resembling the elegant curly wooden front part of the ship can be seen in the old-fashioned magnitude 3.3 xi and magnitude 2.7 rho Puppis stars.

It would be only fair to start off with a well-known cluster to do justice to this very well-known constellation. **NGC 2422**, much better known as Messier 47, graces the northern part of the ship's bow. The observer with a pair of binoculars will be treated to a rather large splash of various magnitude stars, mostly sparkling white in colour. The exceptionally bright magnitude 5.5 member takes up its position on the western edge, with fainter stars filling up the surrounding space. Right in the heart of the cluster the double star Struve 555 displays equal white components of magnitude 7.9 and 9.1 in a position angle of 228 and a 95.8' separation. Also to be seen is a strong yellow to orange star between its white counter parts. Barely 40' north the much smaller and weaker cluster NGC 2423 keeps a watchful eye over Messier 47. Covering the area 40' towards the west is the very orange coloured magnitude 4.9 KQ Puppis.
One degree east is another well-known open cluster, **NGC 2437**, also known as Messier 46, which perhaps claims the position, as it were, together with M47 as the southern double cluster. In one word, M46 can be described as very impressive and an outstanding bright grouping with stars curling out into the field of view. Closer investigation will reveal hazy spots and dark voids between the cluster members. A white magnitude 8 member stands out towards the western edge with perhaps a companion on its northern side.

Left: The open cluster NGC2437 (Photo: Dale Liebenberg).

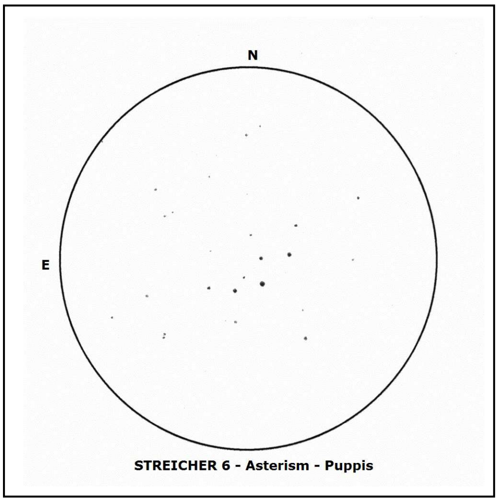
The cluster proudly houses a planetary nebula. **NGC 2438** is situated in the north north-eastern corner among the cluster members and is not that difficult to spot. Add high power to see its shiny grey colour and slightly round halo shape. The central warm magnitude 18 star is nowhere to be seen, but several other faint cluster stars can be spotted in the area. There is speculation that the planetary nebula could be closer to us, but could perhaps belong to the cluster, seeing that both are about 5 000 light years away.

There must always be a challenging object that is not always possible to observe through ordinary telescopes but which one cannot neglect to mention. The so-called Calabash Nebula, or perhaps the Rotten Egg, is only 25' further north of Messier 46. Its technical name is **OH 231.84+4.22**, and it is a proto-planetary nebula also about 5 000 light years distant (I wonder whether this is pure coincidence). The nebula also bears the name Minkowski (M1-18), named after Rudolph Leo Minkowski (1895-1976) who discovered that there are two types of supernova. He called the more common ones which had similar spectra, type 1 supernova, the others he called type 11 supernova. Minkowski discovered a record 188 planetary nebula using objective-prism survey plates while at the Mt. Wilson Observatory during the last half of the 1940's. A large telescope will perhaps show an extremely faint nebulous knot if you are extremely lucky. The beauty of this controversial object can be appreciated only through the eyes of Hubble.



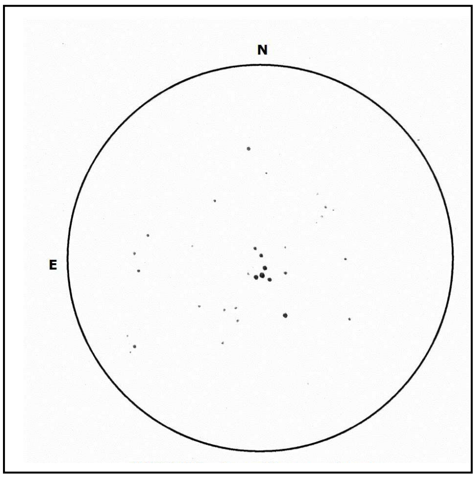
Left: The Calabash Nebula, also known as the Rotten Egg Nebula (HST).

If all fails, the asterism **Streicher 6** can be found 6.5 degrees east of Messier 46 and a degree north-west from the galaxy IC 500. My habit of naming objects is not overlooked with this grouping of stars, which I call the mini-Cassiopiae, as it resembles the glorious constellation Cassiopiae, which also hosts the well-known northern double cluster. It comprises mostly magnitude 8.6 stars in a zig-zag shape from north-west to south-east. Not so easy to find, but a crown jewel in the making.



Left: The asterism Streicher 6 in Puppis

Again turn your gaze to Messier 46 and go due south-west for another 3.5 degrees to what is called a doubtful object. The grouping (**NGC 2409**), which could be described as asterism-like, displays about seven stars which form a clear semi-circle, open on the north-eastern side. The grouping is small and compact, outstanding, and comes to the fore as a dainty get-together of stars.



Left: The open cluster NGC2409 in Puppis .

A pair of star groupings named **Bochum 4 and 5** is situated just north of NGC 2409, but however hard one may try, it is difficult to distinguish the cluster of stars against a busy star field. It does, however, appear as if Bochum 4, which displays something of an X shape of faint stars towards the middle area, is the larger composition. Bochum 5, however, can be found only as 6 faint stars in short string, situated on Buchum 4's southern edge, perhaps creating a larger grouping. Anthony Moffat and Nikolaus Vogt compiled a list in 1970 named "Bochum clusters", after a Dutch university. A keen eye will perhaps spot small pieces of nebulosity just north-east of the Bochum clusters, which is v d

Bergh 97. The Dutch-born Canadian astronomer Sidney van den Bergh published a list of 158 objects, *A study of Reflection Nebulae*, in 1966. The combined objects span only about half a degree.

The magnitude 3.3 star xi Puppis further south, if I may guess at the front bow impression of the constellation, is visible with the naked eye against a dark unpolluted sky. **NGC 2447**, better known as the cluster Messier 93, displays a roughly triangular shape with fainter members filling in the gaps. A short string can be glimpsed on the eastern edge with a few brighter stars, mostly yellow in colour, on the south-western edge. Fainter stars extending north make this part truly a scattered area with splinter star points making it difficult to define the cluster edge. One could describe this cluster as a pretty colourful grouping, one of the southern hemisphere's best.

Sail 3.5 degrees down south on this old wooden vessel and find the open cluster **NGC 2453**, a tight, medium-sized grouping with various magnitude stars. A V-shape with fainter stars stringing out into the north-eastern field of view. On the north-western edge a super-white magnitude 9 star accompanies this delicate cluster. But this grouping points a few brighter stars towards the neighbour, **NGC 2453**, just 8' south, a small, bright, light greenish grey globe near the end of its life. With very high power and averted vision the nebula appears to grow into an oblong shape from north to south, perhaps slightly brighter towards the southern side. The middle area displays a somewhat dark hallow. NGC 2453 is much closer to us than the open cluster NGC 2453, which is about 20 000 light years distant. Colourful stars situated towards the eastern field of view add a nice, special flair with the two objects.

In this busy star-rich stretch of the spiral arm filled with hazy nebulosity and plenty clusters we are still able to find a galaxy with a companion. The pair, **NGC 2566** and **IC 2311**, is situated 3 degrees south-east from the magnitude 3 star rho Puppis which steers the ship in stormy waters. The brighter of the two is the oval NGC 2566 situated in a north-west to south-east direction and a typical so-called barred spiral. The galaxy displays a small, just brighter nucleus, not at all star-like. Again, the much smaller elliptical galaxy IC 2311 is perhaps slightly brighter with an even brighter nucleus. This pair is part and parcel of the now well-known Puppis concentration of galaxies.

The large, bright open cluster **NGC 2451** can be found slightly north and between the stars zeta and pi Puppis, easily visible to the naked eye. This is a lovely group of around a dozen colourful stars with a magnitude 3.6 red star claiming the centre seat.

NGC 2477 is also a naked-eye jewel, about 1.5 degrees east of NGC 2451 and 2.5 degrees west of zeta (Naos) Puppis. In favourable sky conditions the cluster appears as a faint mist in a busy star field. The first thought brings to the fore the appearance of a globular cluster. The magnitude 4.4 QZ Puppis is somewhat distracting, so move the field of view slightly northward to escape the star's glare. The cluster appears as a beautiful dense round grouping filled with magnitude 10 to 11 stars, many of them being resolved. With averted vision, however, it explodes with a mass of fainter stars. Robert Burnham Jr wrote: "Probably the finest of a galactic cluster. It is a striking group, containing about 300 stars crowded into a 15' field." Bordering on the cluster directly to the north is a sort of loose elliptical ring of magnitude 10 stars about the same diameter as the cluster. Use your utmost imagination, and you'll see a diamond ring, with the cluster forming the stone. NGC 2477 is about 4 300 light years away from the Earth.

Puppis is a ship full of surprises. The globular cluster **NGC 2298** is situated only 2 degrees east of the border with Canis Major, in line with pi Puppis in the far western part of the constellation. It is a large bright globular cluster, well resolved and easy to study. First impression is a round irregular globe of haze, but high power reveals faint star outliers scattered around the granular fringes which indicate much fainter stars. The large core is special, slowly getting much brighter towards the middle, covered in faint star dust.

Left: The globular cluster NGC 2298 (Photo: Dale Liebenberg).

Last but not least is another open cluster, **Melotte 66**, situated between a few GN dark nebulae that also host the galaxy NGC 2427 just 1.5 degrees east of the cluster. It is situated within an imaginary triangle east with the magnitude 2.9 tau and magnitude 3.2 sigma Puppis. Not that bright, but special, in a way. The grouping of mainly faint stars displays a boxy shape which edges off quite nicely on the south-western side. Two leggy star strings run towards the north-eastern starry field. The eastern part of the group looks slightly denser, with faint short strings. The brightest star is a lovely yellow-orange 8.3 (HD 59102) situated on the south-western tip of the cluster, which is also home to a few other brighter stars.

Left: The cluster Melotte 66 (Photo: Dale Liebenberg).

This is only the tip of the so-called iceberg. Puppis is a constellation which offers a full shipload packed with surprises. The only way to get to know it well is to unpack the objects one by one.

OBJECT	TYPE	RA	DEC	MAG	SIZE
NGC 2298	Globular Cluster	06h49m.0	-36°00’	9.2	6.8’
Melotte 66	Open Cluster	07h26m.3	-47°40’.8”	7.8	15’
Bochum 4	Open Cluster	07h31m.0	-16°57’	7.3	23’
Bochum 5	Open Cluster	07h31m.5	-17°04’	7	11’
NGC 2409	Open Cluster Doubtful	07h31m.6	-17°11’.4”	7	2.5’
NGC 2422 Messier 47	Open Cluster	07h36m.6	-14°29’	4.4	25’
NGC 2423	Open Cluster	07h37m.1	-13°52’.3	6.7	12’
NGC 2437 Messier 46	Open Cluster	07h41m.8	-14°48’.6”	6	25’
NGC 2438	Planetary Nebula	07h42m.0	-14°44’	10.8	66”
OH 231.84 +4.22 Calabash	Proto Planetary Nebula	07h42m.3	-14°42’.7”	9.7	25”x5”
NGC 2447 Messier 93	Open Cluster	07h44m.5	-23°51’.3”	6.2	15’
NGC 2451	Open Cluster	07h45m.4	-37°58’	3.5	45’
NGC 2452	Planetary Nebula	07h47m.4	-27°20’.8	8.8	183”
NGC 2453	Open Cluster	07h47m.6	-27°11’.7”	8.3	5’
NGC 2477	Galactic Open Cluster	07h52m.8	-38°32’	5.8	15’
Streicher 6	Asterism	08h08m.6	-15°11’.6”	10	4’
NGC 2566	Galaxy	08h18m.7	-25°29’.4”	10	4.1’x2.3’
IC 2311	Galaxy	08h18m.7	-25°22’.3”	12	2.1’x1.9’

ASTRONOMICAL SOCIETY OF SOUTHERN AFRICA

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 electronic journal, the *Monthly Notes of the Astronomical Society of Southern Africa (MNASSA)* bi-monthly as well as the annual *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, Pretoria and Sedgefield district (Garden Route Centre). Membership of any of these Centres automatically confers membership of the Society.

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