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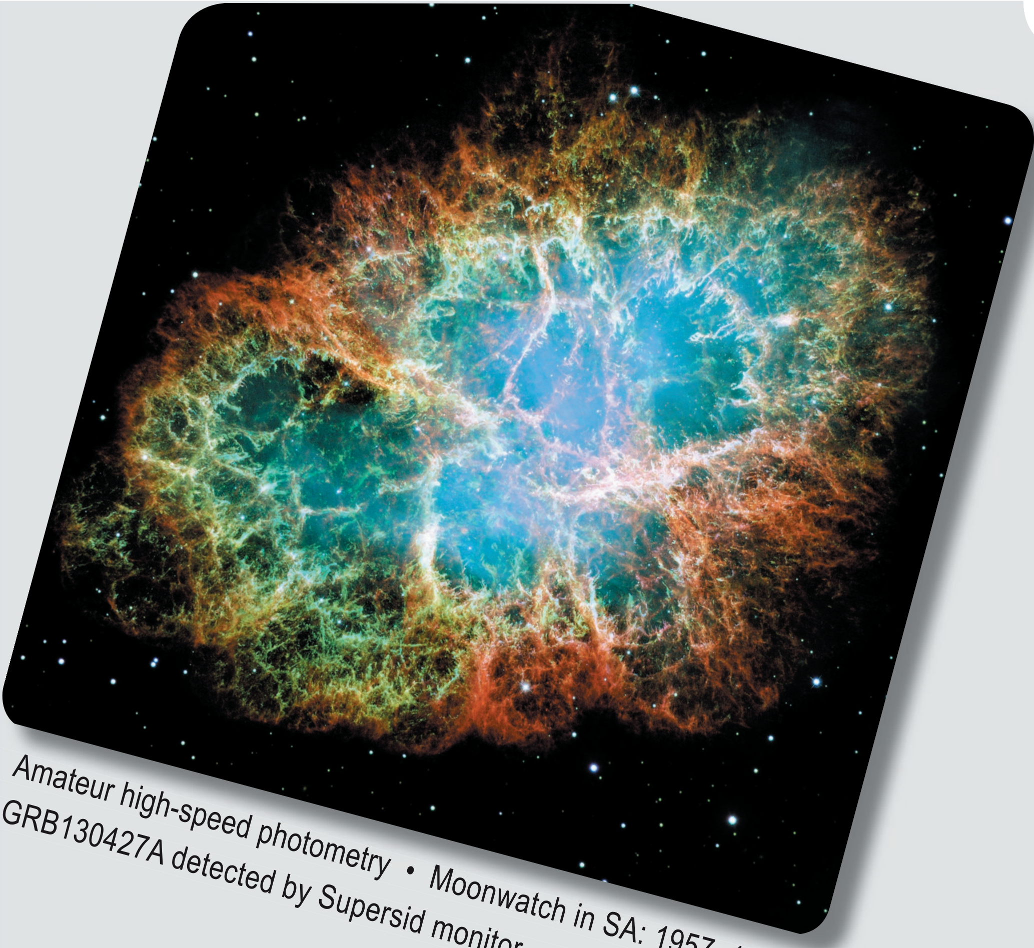

• Amateur high-speed photometry • Moonwatch in SA: 1957–1958 •
• GRB130427A detected by Supersid monitor • IGY Reminiscenes •

monthly notes of the astronomical society of southern africa

Cover: M1, the Crab Nebula

This Hubble Space Telescope image of the Crab Nebula, M1 or NGC 1952, shows the remnants of SN1054. It is currently about 10 light years across and has a rapidly rotating neutron star, or pulsar, at its centre. See article on High Speed Photometry, p.91.

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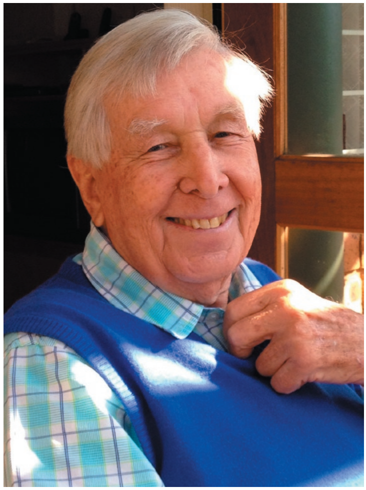
Roy Smith (1930 – 2013)

by Greg Roberts



Roy Duchesne Fairbridge Smith was born on 26 April 1930 in Kraaipan, Mafikeng where he grew up on a farm. He matriculated from Pretoria Boys High School and started work as a scientific assistant at the CSIR's National Physical Laboratory (NPRL) in 1948. Here he was involved (amongst other things) in the development and maintenance of the National Measuring Standards (NMS) of Mass, Pressure and Length.

During the 1950s Roy became a familiar face at the Radcliffe Observatory through ASSA meetings. He used to store his 10-inch telescope (mirror made and signed, "Calver '02") in Mike Feast's garden. The Director of Radcliffe Observatory, Dr Andrew D Thackeray, asked if he would assist at Radcliffe, earning some extra pocket-money. On occasions Roy assisted Dr Wesselink, usually up to midnight and sometimes all night over weekends! Since he could start-up and operate the 74-inch Radcliffe telescope, he was asked to help American astronomer, Dr Tom Gehrels, during his 3-week visit to the observatory in July 1956.

In early 1957 the CSIR approached the ASSA amateurs for optical satellite tracking. Thackeray gave Roy permission to set up a tracking station at Radcliffe. He took three weeks leave to assemble about 15 telescopes based on the Union Observatory design and spent a lot of energy establishing the Radcliffe Moonwatch station. When Sputnik 1 was launched in Oct 1957, some visual observations were made by Roy and the Radcliffe astronomer, Joe Churms, who took some photographs. In 1969 Roy used a 12-inch reflector, set up at the Moonwatch site at Radcliffe by the Pretoria branch of ASSA, to track Apollo 11 out to a distance of 160 000 km, on its way to the Moon.

Early in 1958 Pretoria Moonwatch was supplied with five Apogee telescopes of which four were set-up in Jack Bennett's backyard, from where Pretoria Moonwatch operated. They did very well, totalling about 190 observing sessions during the IGY (International Geophysical Year). The fifth Apogee was mounted by Roy on the Baker-Nunn camera to replace the very small 2-inch aperture finder telescope, enabling the observers to see the satellites they were tracking with the camera.

The CSIR had promised the Smithsonian Astrophysical Observatory a South African observer for the Baker-Nunn camera which they operated at Olifanstfontein during the IGY. They seconded Roy there in March 1958 where he worked with Dr RC Cameron (station manager) and Claude Knuckles who were the American staff during the IGY. Roy usually observed the evening passes, whilst Claude, who lived closer to the camera, did the early morning ones until December 1958.

At the end of the IGY, the CSIR requested Roy to set up a permanent station to ensure that optical tracking would continue. In 1959 a Moonwatch station was set up on top of a building in the CSIR grounds from where they operated until about 1964.

In June 1961 Roy resigned from the CSIR and returned to work at the Baker-Nunn camera until May 1964. In June 1964 he returned to work at the NMS after receiving a request/invitation from the CSIR/NPRL to do so. From July 1961 until 1964, the CSIR station had been run by LN Martins who had worked with Roy in the NPRL. On Roy's return to the CSIR this station got closed as Louw Martins had moved to the Cape. Until the official closure of the Moonwatch programme in 1975, Jack Bennett and Roy continued visual tracking alone at Moonwatch stations Riviera and Murrayfield. Although Roy officially retired in 1990, he continued working under contract in the Light Standards Section until early 1994.

Roy did some car rallying in his younger days, the old Lourenco Marques Rally. He also enjoyed motorbikes but gave it all up after his children were born.

Roy was a long term member of the Astronomical Society of Southern Africa from about 1954 to 2007 and was a Fellow of the Royal Astronomical Society, elected in May 1974, proposed by Thackeray.

Roy was married to Margaret Anwyl Smith for 55 years. She passed away five years before him. He passed away on 19 June 2013 and is survived by two daughters, Moira Sellers and Gillian Fouche and three grandchildren, Justin Christie (26), Kayla Christie (25) and Kieran Fouche (13).

... continue on p. 126

Synchronizing High-speed Optical Measurements with amateur equipment

Andre van Staden (*andre@etiming.co.za*)

The purpose of this investigation is to demonstrate a low-cost method for measuring weak, rapid variable stellar flux with standard amateur class telescopes and CCD cameras. The nature of the flux under discussion is optical, periodic and in the millisecond time frame. Combining measurements spaced over a period of days to improve *signal to noise* (S/N) ratio is possible, but requires unprecedented timing accuracy, not common to optical astronomy (Eastman, J. et al. 2010). A typical related application is measuring signals from a pulsar in optical wavelengths. A low cost system will be introduced to demonstrate this technology, capable of resolving the light curve of the 16.5 magnitude pulsar in the Crab Nebula, with a 20cm telescope.

Introduction

High speed photometers (Straubmeier, C. et al., 2001; Nilsson, R. 2005) on large telescopes are the most common method for measuring high speed flux variability. Various Instruments and modes for using CCDs were also successfully applied for high-speed astrophysics in optical wavelengths. A list of such CCD techniques was compiled by Dhillon V.S. (2007). Unfortunately, this type instrumentation and technology is basically research related, associated with high cost and applied mostly by the professional domain. Another method is to use a stroboscopic system and a standard CCD and was thought to have potential for the amateur astronomer.

A stroboscopic system in terms of astronomical observations will periodically capture a timed fraction of the emission by means of a synchronizing shutter in front of the CCD. The shutter may be any controllable light interrupter but is usually a rotating wheel with cut-outs, synchronized to the frequency of the source. By controlling the frequency and phase of the shutter wheel, it is possible to resolve the phase or light curve by means of accurate CCD photometric measurements.

Stroboscopic systems were successfully applied to optical pulsar measurements in the past. A more recent paper by Cadez, A., et al, (2003) demonstrated resolving of the Crab pulsar light curve with a 2.12m telescope to a high degree with 9 degree cut-out widths on a chopper blade. The remainder of this paper will focus on a low cost, amateur version of the stroboscopic system with the necessary related tasks, capable of resolving the light curve of the Crab pulsar. The author believes that accurate timing is an essential ingredient associated with almost all high-speed photometry. This strobing system will provide an ideal opportunity to challenge and test the stringent timing accuracy.

The Crab Pulsar in the geocentric centre of the Crab Nebula (M1) rotates at approximately 30 revolutions per second and produces rapid fluctuations in intensity as the E-M beam sweeps across Earth. At a mean optical magnitude of 16.5, it was estimated to be a measurable target with a 20cm telescope and a ST9e CCD camera. Timing ephemeris for the Crab pulsar is published monthly and available from Jodrell Bank monthly ephemeris (Lyne, A.G.).

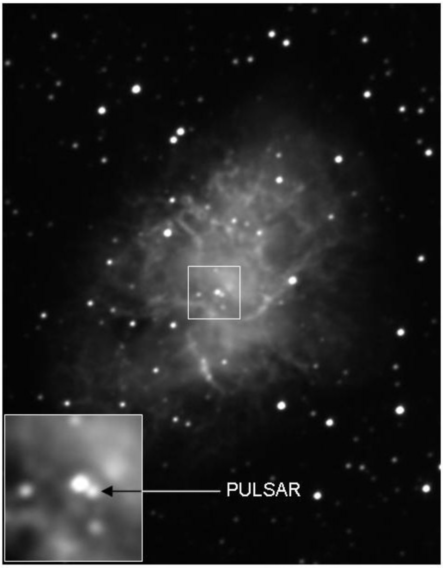


Fig.1 Crab Nebula also known as M1. This image was captured by Axel Martin from Germany with a 30cm Newtonian Telescope and ST8XME CCD + CLS-Filter. The unprocessed image is the sum total of 3.5 hours of exposure time and shows the 16.5 Mag. pulsar (PSR 0534+2200) in the centre.

Concept

In principle, the frequency of the shutter has to be synchronized with the frequency of the pulsar at the telescope. Once the system is synchronized, it is possible to shift the phase of the shutter relative to the received signal and observe different fractions of the emission period. The size of the fractions or samples is determined by the open-to-close ratio of the shutter wheel. If for instance an open-to-close ratio of 1:2 is used, the measured flux will be an integral part of which the pulsar rotates an angle, 1/3 of its rotation period. The resolution of the pulsar light curve will be determined by the open-to-close ratio and the overall timing precision of the shutter phase over the accumulation period of many cycles.

In practice, the instantaneous phase of the shutter will always deviate from the assumed phase due to systematic errors. The shutter phase ϕ_S at time (t) can be written as:

$$\phi_S(t) = \phi_P(t) + T_{CORR}(t) + \delta T \phi_{CORR}(t) + \delta T_{sys} \quad (1)$$

Where $\phi_P(t)$ is the spin-down corrected phase of the pulsar at time (t) derived from ephemeris, $T_{CORR}(t)$ is the timing correction at time (t) to compensate for not observing from the Solar System Barycentre and other smaller timing issues, $\delta T\phi_{CORR}(t)$ are systematic errors involve to estimate $T\phi_{CORR}(t)$ and δT_{sys} are various system errors, e.g. mechanical tolerances. Constant errors resulting in a bias of $\phi_P(t)$ can be neglected for now but any variations or drifts from milliseconds to days must be dealt with and are discussed under **Shutter System** and **Timing Principals**, see below.

The design criteria were to keep ($\delta T\phi_{CORR}(t) + \delta T_{sys}$) < 1/100 of the Crab pulsar rotation period which relates to ~0.33 milliseconds timing error of $\phi_S(t)$. If this criterion can be met, it will be a possible to have a high number of narrow sampling windows spread over one period to resolve the light curve in great detail. For first trials a much lower sampling resolution was used with a shutter open-to-close ratio of only 1:2, but still try to maintain the 0.33 milliseconds timing precision.

In theory the design incorporates a closed-loop system that does not accumulate timing errors (Fig. 2). The system starts with an estimated shutter frequency ($f_{EST} = 1/P_P(t)$) where $P_P(t)$ is the spin-down corrected period of the pulsar at time (t) derived from the ephemeris. The shutter optical interrupter produces a signal (S_i) on each rotation (i) of the disk that coincides with the mid-position of one of the four windows. The exact universal time, *Ts*(*i*) for the signal is derived from a GPS Clock (Van Staden, A., 2013) smoothed by a αβ - smoothing algorithm and the corresponding phase $\phi_S(t)$ is calculated. This is compared to a pre-selected phase of interest, ϕ_{REF}. The difference ϕ_{REF-S} is the correction phase needed for f_{EST} to maintain the shutter synchronization with the pulsar. To explore a new phase region simply means to dial-in a new reference phase, ϕ_{REF} and the closed-loop will automatic track on ϕ_{REF}.

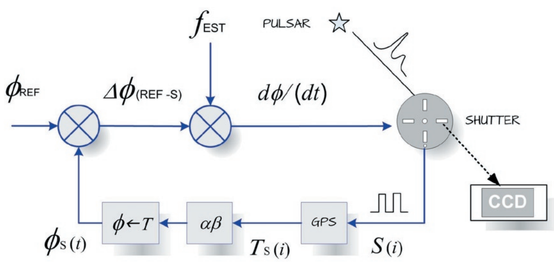


Fig.2 Concept diagram.

Shutter System

The Shutter disk, 170mm diameter was made of a piece of Closed-Cell PVC foam board, also known as Forex (Wikipedia, 2013). A brushless DC (BLDC) motor from the hard drive of an old PC was stripped for the shutter

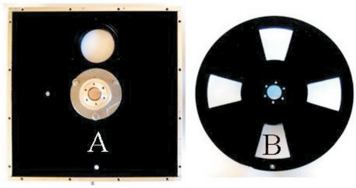


Fig.3 Shutter Housing and Shutter disk.

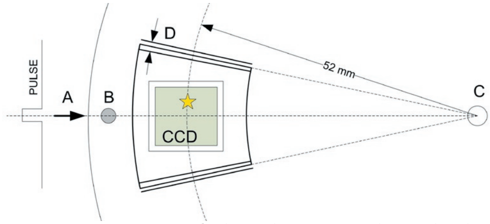


Fig.4 Drawing of the Shutter disk with the CCD Chip in the background.

motor. BLDC motors is a type of synchronous electric motor, small, lightweight, have high speed ranges are acoustically quiet and can be controlled almost like a stepper motor (Yedamale P., 2003).

The blade has four cut-outs equally spaced and translates to ~7.5 revolutions per second (~450 rpm) rotation speed when synchronized to the Crab pulsar frequency of 30 Hz (30 Hz/4 = 7.5 Hz). A pulse is produced once per revolution when sensor, **A** in the shutter housing coincident with a small hole **B** in the rotating disc.

In theory the centre of the pulse should reflect the instant when the geometric centre of the shutter window overlays the CCD and the image of the pulsar coincides with a line between AB and C (Fig. 4). Assuming the CCD centre coincides with the telescope optical axis then amount of phase error $\delta T\phi_\psi$ resulting from the offset of the pulsar can be approximate by:

$$\delta T\phi_\psi \approx \left(\frac{4pF}{\pi r}\right) tan\left(\frac{\delta\psi}{2}\right) \qquad (2)$$

where, p is the period of the pulsar, F is the effective focal length of the telescope, r is 52mm and $\delta\psi$ is angular offset of the pulsar from the CCD centre in the direction of rotation. Depending on the CCD orientation, mechanical tracking errors in the telescope drive system will modulate timing errors onto $\delta T\phi_\psi$. The same guide star at the same CCD position and orientation of the shutter-CCD assembly were maintained during the course of the measurement period to avoid phase errors.

Tolerances in the window dimensions (D) will also affect the expected and actual opening of the shutter. At a radius distance, *r* of 52mm from the centre of the disk and in the direction of rotation, the estimate timing error, δT_{dim} is:

$$\delta T_{dim} \approx \left(\frac{4p}{2\pi r}\right) = 0.42\ msec/mm \qquad (3)$$

where, p is the period of the pulsar. All measurements and cut-outs were made with tolerances kept in mind to agree with the design criteria of δT_{sys}.

Timing data *Ts*($_i$) (see *Fig 1*) were recorded and analyzed to measure random excitations of mechanical resonance in the motor-shutter system. The RMS error over a period of 30 minutes was 38.3 µsec. A frequency spectrum of the timing noise shows most of the power tends towards zero with a significant resonance peak at 1.78Hz.

It was assumed that the excitations of the mechanical resonance originated from the hand-made disk and slight flexing of the disk. A laser-cut disk will probably be more suitable. The supply voltage on the BLDC motor also contributes to a constant phase offset and was calibrated before each observation session.

Timing Principles

Radio Observatories doing pulsar measurements are equipped with atomic time standards and modelling of accurate timing is a complex process. In support of this, the pulsar community has developed a state of the art (UNIX) program (over the past 40 years) called TEMPO II which models pulsar arrival times up to a accuracy of 1 ns. (Hobbs et al. 2006; Edwards et al. 2006). For this accuracy, the exact positions of solar systems bodies must be known, only available through the online JPL Ephemeris system (Markwardt. C. JPL HORIZONS). However, for the proposed demonstration the computed (much less accurate) timing information in real-time with a program on a PC was used and only includes the most significant timing contributions.

The aim here is to determine the phase, $\phi(t)$ of the pulsar at a instance (t) related to the local UTC Clock. The phase of the pulsar can be determined from the monthly ephemeris but is only valid in the pulsar frame of reference (Lyne, A.G., et al.). An observer on Earth will measure a pulsar (close to the ecliptic) with a constant change in frequency due to the Doppler shift caused by the Earth's motion around the Sun and the spin of the Earth on its axis. Keeping book of timescales during observations is also important, for example the most common time standard, UTC

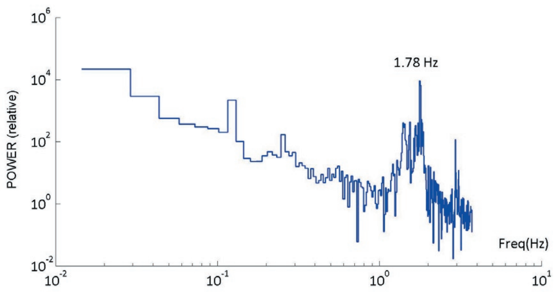


Fig.5 FFT Frequency spectrum on logarithmic scales of the "mechanical" timing noise.

is discontinuous and drifts with the addition of leap seconds (Eastman, J., et al., 2010). Also clocks on Earth are subject to relativistic effects and solar system gravitational influences will affect the timing.

The general approach here is to transform the measurements to the barycenter of the Solar System (Eastman, J., et al., 2010). The apparent time of an event has to be adjusted to be what it would be as if we were observing at the barycenter, which is the coordinate origin of all modern, precise astronomical positional calculations. If the source of the events is stationary with respect to the barycenter, this gives us a steady clock with which to measure when each event happened.

Transformation to the rest frame of the pulsar is achieved by transforming TOA (Time of Arrival) pulses to the barycentre and is the sum of various time corrections classically defined by

$$t_b = t + \Delta_C + \frac{\boldsymbol{r}\cdot\hat{\boldsymbol{n}}}{c} + \frac{(\boldsymbol{r}\cdot\hat{\boldsymbol{n}})^2 - |\boldsymbol{r}|^2}{2cd} - \frac{D}{f^2} + \Delta_{E\odot} + \Delta_{S\odot} + \Delta_{A\odot}\,, \tag{4}$$

Where Δ_C contains various clock corrections, **r** is a vector from the barycentre to the telescope, $\hat{\boldsymbol{n}}$ is a unit vector pointing from the barycentre to the pulsar, *c* is the speed of light, *d* is the distance to the pulsar, *D* is the interstellar dispersion constant, *f* is the radio frequency, $\Delta_{E\odot}$ is the Einstein delay comprised of the gravitational red shift and time dilation, $\Delta_{S\odot}$ is the Shapiro delay characterising the curvature of space time near the Sun and $\Delta_{A\odot}$ is the aberration delay as a result of the Earth's rotation (Bell, J.F., 1996; Kaspi V.M; Lorimer D., 2008)

Terms three and four together make up the Roemer delay $\Delta_{R\odot}$. The 4th term can be ignored for now which applies only to nearby sources. The Roemer delay is the classical light travel time across the Earth's orbit, with a magnitude of ~500 **cos**β seconds, where β is the ecliptic latitude of the pulsar (NRAO). With the Crab pulsar close to the ecliptic, the Doppler Effect is significant as the Earth passes through a couple of cycles during one evening (depending on the season). It is also interesting to note that a 0.1 arc second directional error can produce a timing error as high as 240 microseconds and it is therefore important to keep the pulsar's position in the same coordinate frame as the ephemeris. The geometric timing modulation due to the Earth's spin was compared between observations from the geocentric Earth and the (topocentric) observing site (Eastman, J., 2010). A portion around zero Hour Angle was plotted (Fig. 6) and reveals a substantial timing error if not corrected.

The dispersion delay, $\frac{D}{f^2}$ contributes at less than 1 μs in the optical band and can also be discarded (Eastman, J., et al., 2010). The $\Delta_{S\odot}$ and $\Delta_{A\odot}$ terms have magnitudes below the resolution of the design criteria and can be omitted as well. The Einstein delay can contain corrections as large as 1.6 milliseconds and have to be included.

Having made the above transformations, the observed phase is calculated. The frequency of the pulsar changes since the the pulsar loses energy through magnetic dipole radiation. By incorporating the spin-down parameters from ephemeris of one epoch, it is possible to calculate the phase $\phi(t)$ of the pulsar at a new time by the Taylor expansion

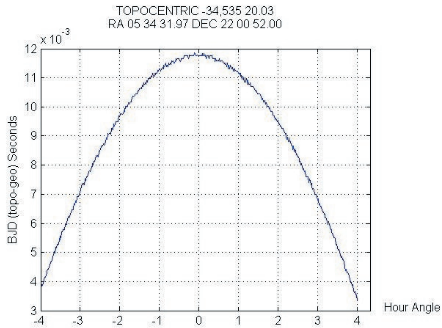


Fig.6 Timing difference between topocentric and geocentric observing.

$$\phi(t)= \phi(0)+ \nu(t - t_0)+\frac{1}{2}\dot{\nu}(t- t_0)^2 +\frac{1}{6}\ddot{\nu}(t - t_0)^3 + ... \quad (5)$$

where ν = 1/P is the rotational frequency, and $\dot{\nu}$, $\ddot{\nu}$ are the frequency derivatives corresponding to the spin-down parameters available from the ephemeris (Bell, J.F., 1996; Kaspi V.M; Lorimer D., 2008). Essentially, this formula calculates the integrated number of cycles over period ($t - t_0$) from a arbitrary reference t_0 and phase $\phi(0)$ where the phase is reflected in the fraction of the cycles.

Measuring Results

The concept was put to test on the Crab Pulsar during January and February 2013. Observations were made with the author's SBIG ST9e CCD camera and 20cm LX200 telescope. (Fig.7)

The cut-out shutter ratio of 1:2 produced a much lower resolution curve compared to the well established reference profile done with high speed photometers. The expected smoothed curve was calculated by convolving the window function with a reference profile of the Crab Pulsar, shown in Fig. 8. Photometric measurements at various phases of the pulsar period were performed and the resulted light curve was compared against the calculated profile.

Due to limited sky, and bad weather, only a maximum of about 5 measurement runs per evening was possible. A measurement run consists of 30 images with

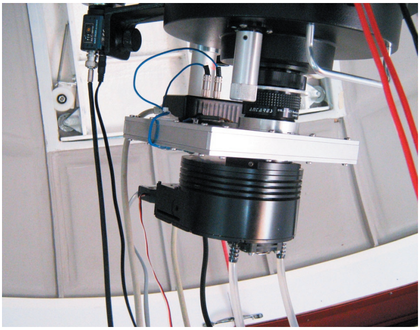


Fig.7 The strobing assembly shown mounted between the 20cm SCT and ST9eCCD.

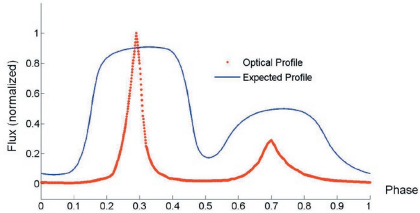


Fig.8 The Optical Light curve of the Crab pulsar. The spatial integration function of the strobing Windows will result in measuring a smoothed light curve compare to measurements by high speed photometers. The expected smoothed curve is based on a 1:2 window opening.

30 second exposure each (total of 15 minutes) measuring a particular phase of the pulsar. The pulsar and the close companion star were not fully resolved in the 20-cm telescope: consequently photometry was performed on the combination with the pulsar periodically contribute to the photometric flux.

All images were calibrated to standard protocol without the use of filters. It was found that images done above -15°C and effective exposures less than 900 seconds become unreliable for photometric measurements with the current system. Evening temperatures were around 24°C and the heat exchanging coolant had to be fed continuously with ice. Photometric measurements were performed with Astroart 5.0 (Nicolini,M., et al., 2013) and the USNO-B1 Catalog. This method had the disadvantage that the automatic centroid calculation by

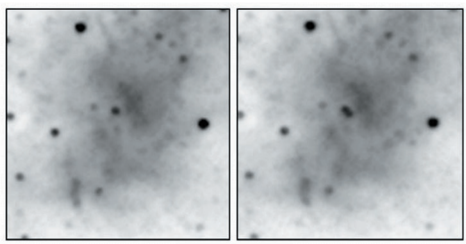


Fig.9 CCD showing pulsar OFF and ON: 15 minute exposures with the stroboscope and the author's 20 cm / f10 telescope. Only 1/3 of the photons were collected making the effective exposure time actually 5 minutes. The left-hand panel shows the absence of the pulsar with about 9000 sample in its off-state. The pulsar, not fully resolved but visible in the right-hand panel resembles an accumulation of about 9000 pulses from the main lobe. Note that the pulsar is now almost the same magnitude as the close companion and disagree with other visual images of the pulsar. This is due to the fact that most of the pulsar's flux was captured while capturing only 1/3 of the "background".

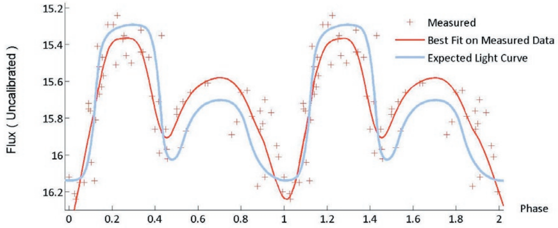


Fig.10 The Crab Pulsar light curve compiled from 12 hours of photometric measurements during Jan/Feb 2013. The Cycle was repeated for illustration.

AstroArt 5.0 for the pulsar companion, slightly changed position during the "on" and "off" state consequently overlays had different background areas on the nebula. A differential ensemble photometry was also performed where the centroid was only calculated once for the first image of the range of images (Henden, A., et al. 2009; Nicolini,M., et al., 2013; Romanishin, W., 2006). The instrumental magnitudes were then further processed and compared.

About 50 photometric measurements were performed during January and February 2013 and plotted (Fig. 10). A best fit through the data points was created and compared to the expected light curve. The expected light curve was scaled in the Y-Axis. The flux reading on the Y-Axis is not fully calibrated and is only an approximate magnitude. (At time of writing, there is still an unresolved issue where a correction for a 1 millisecond per day timing drift is manually applied in the light curve compilation.)

Conclusion

Initial attempts during 2011 and 2012 failed to converge in a light curve. This was mainly due to software issues and too low photometric S/N ratios. By further reducing the CCD temperature from -5°C to -15°C with a third stage cooling results in acceptable S/N ratios.

The BLDC motor and shutter disk performed above expectations considering its cost. A single desktop PC did all the timing calculation tasks, CCD captures and telescope control. The fast and accurate timing of the GPS clock played a key role in the system and effectively simplifies the concept.

The measured light curve (Fig. 10) shows an acceptable correlation and is therefore considered to be proof of the concept as presented. Although there is still room for timing improvements, it was shown that the timing was accurate enough to synchronize data over a two month period. It will be interesting if this period can be extending to have light curve continuity on following apparitions.

Additionally, the possibilities of detecting the pulsation of an object in particular star field were investigated. A Flux map was constructed for this purpose of 60 x 45 pixels, representing the normalized photometric measurements of 60 selected stars in 45 images of M1. The variability of the Crab pulsar shows up clearly as a vertical line in Fig. 11.

Acknowledgments

I would like to thank Axel Martin (Das Turtle Star Observatory, Germany), for his long standing support, especially when it comes to photometric measurements. Thanks also to Ude Hertel, Hertel Precision Engineering (hertel@telkomsa.net) for his excellent job on the shutter housing and couplings.

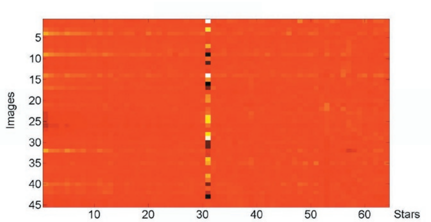


Fig.11 Flux Map. By scaling Flux values it is easy to detect star fluctuations. The map consists of 45 images and 65 measured stars/image. The Crab pulsar is in star position 31.

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☆

GRB130427A detected by Supersid monitor

Brian Fraser, Henley on Klip

For many years amateur astronomers have been using simple radio receivers to monitor the effects that solar flares have on the Earth's ionosphere and the knock-on effect that this has on the propagation characteristics of low frequency radio stations. These systems are variously known as SES recorders (Sudden Enhancement of Signal) or SID recorders (Sudden Ionosphere Disturbance) and operate at frequencies around 20 kHz. Stanford university have developed a system that does not require a radio receiver and utilizes the power of a sound card in a small computer, which they call the Supersid. Software supplied monitors up to ten transmitting stations on a continuous basis. The radio stations that are monitored are used by the military to communicate with submarines out at sea. It is only the carrier wave strength that these receivers are interested in. SID recorders run 24 hours a day, require very little maintenance and work whether it is rainy or clear. All they require is an antenna, a small amplifier circuit and an old computer with a sound card.

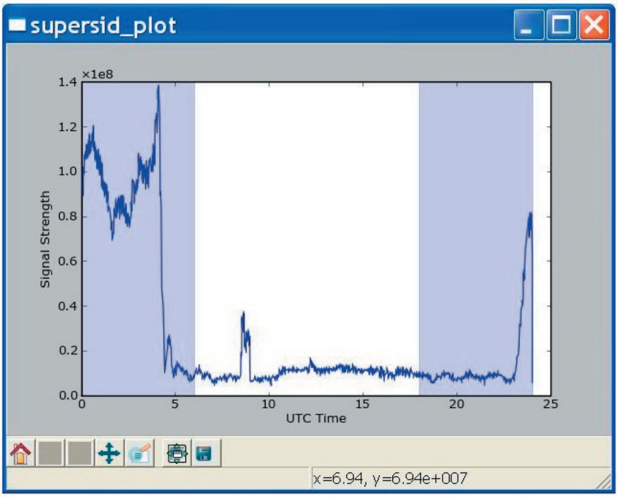
Solar Flares

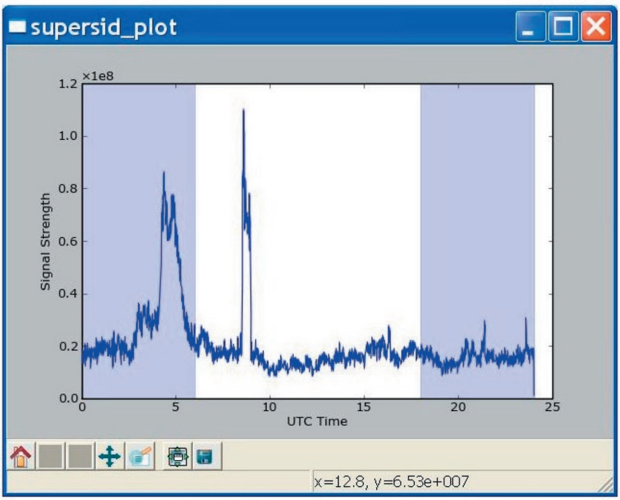
Solar flares are classified using the letters B, C, M and X with the B class being relatively mild and quite common during times of high solar activity. Conversely, the X class flares are the rarer and much more energetic variety. In order for a flare to be picked up by a small SID receiver it needs to be around class C5 or brighter. M class flares show up very nicely. NASA publishes a daily summary of all sorts of events happening on the sun and these can be seen at http://www.swpc.noaa.gov/ftpmenu/indices/events.html

As we approach solar maximum, predicted to occur in 2013 or 2014, the number and intensity of solar flares is increasing. During May 2013 there were a number of M class flares and even one X class flare associated with a very active sunspot group.

Gamma Ray Bursts

There had been a long running debate about whether SID stations would be able to detect Gamma Ray Bursts (GRB's) and this argument was settled in 2001 when Danie Overbeek and Dominic Toldo reported the detection of a gamma ray burst (GRB010222) on a receiving station that they were running in Edenvale. This was the first recording of a GRB by any amateurs anywhere in the world.



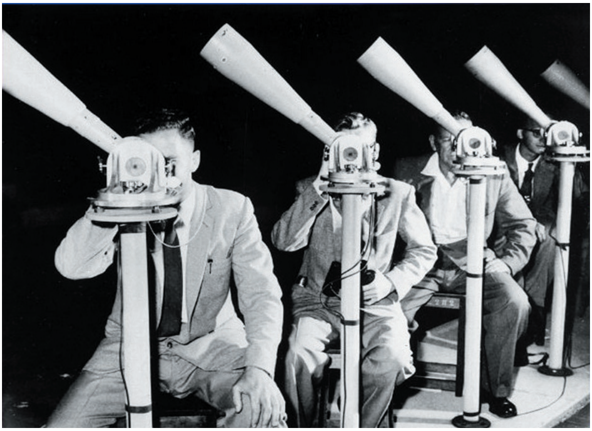


GRB 130427A as recorded at Station NAA (top) and NPM (bottom) on 27 April 2013.

On 27 May 2013 the most violent GRB ever detected, at 94 billion eV (94 GeV), was picked up and monitored by the GRB network. An amateur astronomer, Patrick Wiggins, photographed it from Utah, USA. It was keenly studied by many professional observatories. It was also picked up by a SID recording station in Henley on Klip, RSA, and shows up very strongly on graphs from two different radio stations. Because the transmitting stations are located in different geographic locations the signals patterns received look different. However they both show the event, albeit in different ways, around 9 UT. ☆

Moonwatch in South Africa: 1957-1958

Jan Hers



The Pretoria Moonwatch team manning Apogee telescopes, observing from the CSIR rooftop.

This posthumous publication of an article by Jan Hers (see obituary in *MNASSA* Vol. 69 nos 9 & 10) recounts South Africa's involvement in what can be called the beginning of the Space Age. The launch of Sputnik 1 on 4 October, 1957, during the International Geophysics Year (IGY) caught most of the world by surprise, primarily because the United States was planning to put about six satellites into orbit during IGY. Africa was the first land mass crossed after a rocket was launched from the US and this was the motivation for South Africa's involvement. Jan Hers' detailed memories of these times makes for interesting reading.

Around 1956 it became known that the United States of America, as part of its contribution to the International Geophysical Year, would attempt to put a number of artificial satellites (possibly a maximum of six) in orbit around the Earth. If these were to serve a useful scientific purpose, accurate tracking would be necessary, and in order to do this three methods were proposed:

1 by radio,
2 photographic,
3 visual.

Radio tracking would obviously depend on whether usable radio signals could be obtained from the satellites. As this would depend on many factors which were as yet unknown, much emphasis was placed on photographic and visual tracking. This would in any case be necessary in the case of satellites without radio transmitters, or with transmitters which had failed, rocket casings, etc. It was anticipated that visual observing methods would probably be the only ones flexible enough to observe the very early stages of a satellite's journey, and the only ones available to observe a dying satellite. They might be essential for determining the preliminary orbits and ephemeredes necessary for aiming

The author busy checking on the time service which he developed at the Union Observatory in Johannesburg.

the more accurate photographic Schmidt ("Baker-Nunn") telescopes (see *MNASSA* Vol. 71 Nos. 5 & 6 p. 103).

Amateur Observers

It was felt that this work could best be done by teams of amateur observers in various parts of the world, who would be asked to provide themselves with small, inexpensive, portable telescopes, just powerful enough to observe the kind of satellite initially contemplated, viz. a 20-inch diameter (0.5 m) sphere. The project which was given the code name *MOONWATCH*, was organized and coordinated by the Smithsonian Astrophysical Observatory in Cambridge, Mass., which was also responsible for the precision photographic tracking programme. Details on how to start observing teams, and how to build the small telescopes which were considered most suitable, were published in the *Bulletin for Visual Observers of Satellites*, which was issued as a supplement to *Sky and Telescope* from July 1956 onwards. Numerous teams were registered in the U.S.A. and efforts were made to recruit as many as possible in other countries.

First Observing Teams in South Africa

In South Africa it was realized that this country would be the first land mass to be crossed by a satellite launched from Florida in a south-easterly direction, and observations made in South Africa would therefore be particularly important. The project was disclosed at an early stage at the Union Observatory in Johannesburg with some of the observatory's amateur associates, all of whom were active and experienced observers. It was felt that Johannesburg and Pretoria would prove to be ideal observing sites because of:

1 the very good climate,
2 their large populations, from which a sufficient number of good observers might be drawn,
3 the close proximity to astronomical observatories, almost essential for organizational and scientific guidance and support.

Shortly afterwards Moonwatch teams were formed in both Johannesburg and Pretoria, under the respective leadership of Dr Charles N Williams and Mr Roy FN Smith, and these were registered with

Moonwatch Headquarters in February 1957. These two teams, together with one in Hawaii, were the first ones registered outside continental associates.

Meanwhile, in Cape Town, Dr David Evans had been investigating the possibility of organizing, through the Astronomical Society of Southern Africa, a suitable team of amateur astronomers, to be stationed at the Cape Observatory, but he had delayed further action until more was known regarding the availability of optical equipment.

Optical Instruments
In Johannesburg, however, Dr Williams and the Moonwatch Committee members were busy making investigations regarding supplies of optical components, and had drawn up a schedule of three alternative possibilities.

1 15 complete instruments, wide angle: £400 approx.
2 Components for 15 instruments, wide angle: £100
3 Components for 20 simpler instruments, narrow angle: £36

The following additional comment was made: "We have committed ourselves to the programme, and it is our intention to proceed with the plans in any event. Failing outside financial support, this will limit us to schedule (c)"

This memorandum was forwarded to Mr DG Kingwill at the CSIR on 11 March, for submission to the S.A. National Committee for the International Geophysical Year, IGY.

Dr Evans, who by now was taking an increasingly active part, was invited to attend a meeting of the Steering Committee of the SANC on 26 March 1957, where the matter was discussed further. Unfortunately details of the new space developments had only reached official circles at a late stage, when preparations for other activities in connection with the IGY had already been in progress for a considerable time, so that it was difficult to find additional funds. Nevertheless, a sum of £500 was made available to the three Moonwatch teams in Johannesburg, Pretoria and Cape Town, to buy components according to schedule (2). It was agreed that Dr Evans should be invited to serve as Coordinator for the Moonwatch programme with the assistance of Mr J Churms of the Union observatory as Assistant coordinator for the Transvaal. The Coordinator was to supply specifications of the optical components to the CSIR, who would take responsibility for ordering them from overseas.

Visit of Dr Karl Henize
Dr Karl Henize of the SAO visited South Africa at the beginning of April 1957 and a meeting was held at the Union Observatory on 2 April, to discuss the various Moonwatch aspects. Present were Dr WS Finsen, Dr SP Jackson, Dr Karl Henize, Dr DS Evans, Messrs J Churms, J Hers, DG Kingwill and RFN Smith.

In the memorandum drawn up after the meeting it was stated that the South African amateur astronomers, both individually and as members of the Astronomical Society of Southern Africa, were willing to assist in making visual observations on the lines of the MOONWATCH system proposed by the USA authorities. The Directors of the Observatories at Johannesburg, Pretoria and Cape Town were willing to grant site facilities and technical advice in general to assist the efforts of the South African amateur astronomers.

It was also stated that "all correspondence with the USA authorities will pass through Dr Evans to the U.S. Coordinator for Moonwatch, Dr Leon Campbell junior – a decision rapidly overtaken by later events.

Initially three Moonwatch teams were to be organized as shown in Table 1 below.

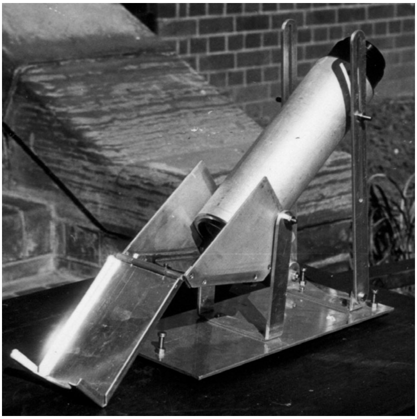
It was not considered desirable to try to encourage the formation of Moonwatch groups in other South African centres, as it seemed probable that the best results would be obtained by concentrating on three teams. Dr Henize reported that the U.S. Navy might supply optical equipment for two stations, having higher magnification and a smaller field (and hence requiring more observers). This would definitely not constitute a means of equipping an ordinary station, and must be regarded as a supplement. Decision was to accept such equipment if and when it should arrive, but not to vary the settled policy on that account.

On 20 May a further meeting of the Satellite Management Committee was held at Dr Finsen's house, where it was agreed that a Moonwatch team would

An example of an early Moonwatch telescope.

Table 1: The initial Moonwatch teams.

Johannesburg	Team leader:	Dr CN Williams
	Deputy:	Mr J Churms
	Location:	Grounds of the Union Observatory
Pretoria	Team leader:	Mr RF Smith
	Deputy:	Mr N van der Vlist
	Location:	Grounds of the Radcliffe Observatory
Cape Town	Team leader:	Dr DS Evans
	Deputy:	Mr WP Hirst
	Location:	Grounds of the Royal Observatory



An early Moonwatch telescope, made at the Union Observatory for about 15 shillings! (CSIR Archives)

be set up at Bloemfontein, under Dr J Stock, who was at that time at the Boyden observatory. Regrettably a request from Port Elizabeth had to be turned down as no funds for further equipment were available. Since the cost of eyepieces had gone up by 50%, the number would have to be reduced from 80 to 60, i.e. each team would be entitled to 15. In the meantime a simple Moonwatch type telescope had been built at the Union Observatory at a cost of about 15 shillings.

The Johannesburg team leader reported that by May 1957, 16 observers had been recruited, while on 12 June Cape Town had recruited 40, and Bloemfontein as many as 75.

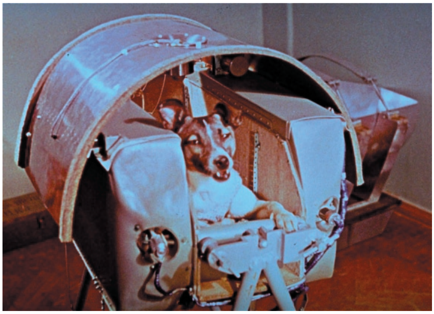
Two sets of telescope components which had been ordered to be sent by air freight were received on 21 May, and this made it possible for prototype telescopes to be built at both Johannesburg and Cape Town. Unfortunately the others which were to be shipped by air freight were very slow in coming, and it was not until September that it was learned that they had in fact been shipped. However, it was firmly believed that no satellite would go up before 1958. At a meeting of the Satellite Management Committee held on 24 September it was noted that components had not been received, and it was agreed that as soon as they were to hand a meeting of team leaders should be arranged in Bloemfontein – a meeting which never took place.

It was at this same committee meeting that Dr Finsen mentioned that he had received information that the Russians, too, were planning to launch a satellite. This was greeted with some incredulity by the other members present, but after the meeting one of the other persons present admitted privately that he had received similar information.

Sputnik I and II (1957 Alpha and Beta)

The first Russian satellite burst upon an unsuspecting world on 4 October 1957, upsetting most of the carefully made plans. None of the special tracking stations planned for South Africa were as yet in operation, and even the Moonwatch teams were unequipped. What they could do was to bring out every available pair of binoculars or small telescope, and to start observing the satel-

Sputnik 1, launched on 4 October 1957, was the first satellite placed in Earth orbit.



Sputnik 2 was launched on 2 November 1957 and carried the first living creature into space, a dog named Laika. In 2002 it was revealed that Laika died several hours after launch, from stress.

lites whenever and wherever they could be seen. The author was on his way to Cape Town at the time, and found himself at the Royal Observatory on the evening of 7 October. As there was no one else ready to help with this task, he was asked to man the telephone, to spend the next hour or so trying to answer and uninterrupted stream of reports and enquiries from all over the peninsula.

In Johannesburg a small model was constructed in great haste, to help explain the motion of a satellite to the press and the general public. Also as an aid in determining the motion of the satellite around the Earth, and for predicting where and when it might be visible. Some time later this idea was further developed by Dr Finsen into a larger Earth and satellite model which became in effect a kind of three-dimensional slide rule, of sufficient accuracy to provide predictions for visual observers.

Early Predictions

Accurate predictions became an urgent necessity almost immediately, because information from abroad was mainly in the form of Russian press handouts, vague and often unreliable. It proved impossible to obtain orbital elements and the Russian news would merely state that at such and such a time the satellite would be over, say, Delhi or Tokyo. Radio signals were received from the satellite, but it was soon realized that what was seen was not the satellite itself, but the much larger rocket casing. Predictions for the visual object would therefore have to be made from visual observations, and the initiative to do this was immediately taken by Dr Finsen. From 9 October onwards the prediction of satellite positions, from local observations and from any other data which might be available, became a full time activity. Daylight hours were spent computing (using an electro-mechanical calculator: this was long before the days of electronic calculators) and evenings – and later, early morning hours – were spent looking for satellites and, as accuracy increased, also finding them.

It was already becoming obvious that the observing procedure differed considerably from what had been visualized in the original "Moonwatch" programme, for which the instruments were in any case not yet available. In the first place, the objects now seen were much brighter than had been predicted for the very small American satellites, and could usually be spotted with the naked eye. The procedure became, therefore, to obtain a large number of timings of satellite positions in relation to whatever bright stars could be identified. These positions were then plotted, and after possible discrepancies had been removed, an accurate mean position obtained. Alternatively, the satellite was photographed, with a 9x12cm camera on Royal-X Pan sheet film, using a rudimentary hand-operated shutter to obtain timing marks on the trail.

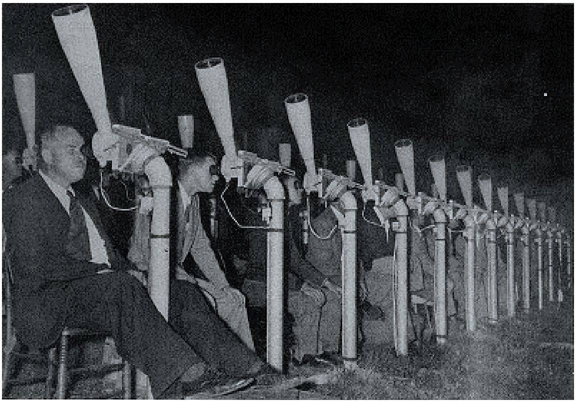
Reports of Sputnik Observations

When the initial excitement had begun to die down, a new question arose. It was all very well to observe Russian satellites, but what was to be done with observations? Were they really required by anyone? The Moonwatch project was started in the first place to observe American satellites, and to observe them mainly at the very beginning and near the end of their life. Observations made in Johannesburg and Pretoria of Russian satellites were being forwarded to Dr Evans in Cape Town, where they were combined with the Cape observations and then transmitted to Cambridge, U.S.A., but no useful predictions were received in return. It seemed clear that the day when each new observation would be fed into a computer, to produce a corrected orbit and a new prediction, was still very far off. Was there anyone who really needed the results?

"Spacetrack" Predictions

It soon became apparent that these observations were indeed urgently needed in some places. As from 13 December 1957, the Union Observatory started to receive copies of cabled predictions with the code name "Harvest Moon" (later changed to "Space Track") which had been prepared by the Air Force Cambridge Research Center, and which were being forwarded through the American Embassy in Pretoria. These proved to be the first predictions from elsewhere which agreed well with local observations. From this time onwards local observations were regularly telephoned to the American Embassy for onward transmission.

The Observatory was told that the visual observations and prediction data, as very kindly provided by Dr Finsen, had been forwarded by telephone, cable and airmail to the associates. These communication arrangements having been developed in advance of the regular IGY reporting system envisioned by reporting satellites to be launched in the associates. The observations furnished by the Union observatory had proved to be extremely valuable: many of them were made at times when no sightings from other parts of the world could be obtained. It was felt it would be desirable if the South African Moonwatch observations from other sources (viz. Pretoria, Bloemfontein and Cape Town) could also be forwarded.



The Cape Town Moonwatch team with Apogee telescopes. (Image: *Cape Times*)

This interest proved to be a very great source of encouragement to the amateur astronomers, and removed the last shreds of doubt which there might have been as to the value of the observations.

"Cosmos" Predictions

Very shortly afterwards, on 10 January 1958, a communication was received from the IGY coordinator, Vice-Admiral A Day, conveying an offer from the IGY Committee in the USSR, that ephemerides should be transmitted direct to the various Moonwatch centres. This was gratefully accepted and "Cosmos" cables started to arrive in due course. For various reasons it was felt to be undesirable that individual teams should communicate their observations direct to the Soviet World Data Centre, and as funds were in any case not available at the Union Observatory, the observations were communicated by telephone to Mr Hide's office at the CSIR from where they were cabled to Moscow.

Apogee Telescopes

Towards the end of 1957 Dr Evans was approached by Moonwatch Headquarters, asking whether he could use a number of the so-called "Apogee Telescopes" (the high power small field instruments originally mentioned by Karl Henize) at each of the four South African stations. The original proposal was for 20 instruments for each station, but this was later changed by the U.S. Naval Research Laboratory, which had organized the project, to a larger number of instruments for Cape Town and Bloemfontein only, since it was felt that Johannesburg and Pretoria were too far north to observe the American "Vanguard" satellites for which the instruments were intended. At Cape Town the instruments were installed at the Royal Observatory during January 1958, and a large number of observers were trained to use them, but at Bloemfontein some difficulty was experienced in finding enough observers.

The Explorer 1 Team, from L to R: William H Pickering, director of the Jet Propulsion Laboratory, which designed and built Explorer, James A van Allen, University of Iowa physicist who directed the design and creation of Explorer's instruments and Wernher von Braun, head of the U.S. Army Ballistic Missile Agency team that designed and built the Jupiter-C rocket.

1958 Alpha – Explorer 1

When the first American satellite was launched on 1 February 1958, very determined efforts were made to observe it, but these were wholly unsuccessful until 8 February when 1958 Alpha was seen by the Cape Town team using the newly installed Apogee Telescopes.

Meanwhile in Johannesburg, Dr Finsen had been making daily analyses and preparing predictions based on local Minitrack observations and the rather infrequent orbit data received from overseas. At the Observatory the regular Moonwatch telescopes were supplemented by conventional astronomical telescopes, up to 12 inches (30 cm) in aperture, but the Cape Town observations made it clear that the regular Moonwatch Telescopes were simply not capable of making such a faint object visible. It was, in Dr Finsen's words, like looking for a needle in the wrong haystack.

Pension of Operations in Johannesburg

Immediately after another unsuccessful observing session in the very early hours of 9 February, when it became clear that the satellite must have passed unobserved through the field of several telescopes, a meeting was held of the Johannesburg Moonwatch Committee, which passed the following resolution: "The Johannesburg Moonwatch Team has decided temporarily to suspend operations on the American satellite pending receipt of their Apogee telescopes."

It was decided, however, to continue with attempts to observe the satellite with conventional narrow field astronomical telescopes, as a purely observatory activity, with the help of some of the more enthusiastic voluntary assistants, Dr Finsen continued his daily computation of predictions, using the Cape observations to correct the orbital elements. His work was rewarded in February when MD Overbeek observed the satellite from his home using a 12-inch (30 cm) reflector. The mean of three observations made on 20 February at the Union Observatory differed from the locally computed value by 23.5 seconds in time and only 1 minute of arc in altitude, a quite astonishing achievement.

Apogee Telescopes for Johannesburg and Pretoria

Representations made through the National Committee of the IGY finally bore fruit. Around the middle of February approval was given for some of the Apogee Telescopes, which had been sent to Bloemfontein but not yet installed, to be transferred: five to Johannesburg and five to Pretoria.

The Johannesburg instruments were received on 1 March. The first successful observation was obtained by HC Lagerwey on 3 March, even before the instruments were suitably mounted. At Bloemfontein the first observation was made on 20 March.

The five Pretoria instruments were erected at a new observing site at the CSIR, which was likely to be more practical, and where the first observation was made by N van der Vlist on 22 March. From this time onward observations of 1958 were made on a fairly regular basis until the end of the year.

Dr Finsen's predictions proved to be invaluable for another purpose. Very great difficulty was being experienced at the new photographic tracking station at Olifantsfontein, where very precise orientation of the Baker-Nunn Telescope was needed if the satellite was to be photographed. Errors in the predictions from the U.S.A. often exceeded the maximum allowed. When the first successful photograph was obtained on 18 March – the first in the world – this was due entirely to the computations made at the Union Observatory.

The number of observations of 1958 of Alpha, reported to the Satellite Management Committee in the associates by 16 April 1958 was as follows:

United States	45
South Africa	33
Japan	5
Australia	2

Amalgamation of Johannesburg and Pretoria teams

The proximity of the Johannesburg and Pretoria teams, both with a rather small number of instruments, and the latter almost entirely dependent on the former for predictions, made it desirable that the two teams should amalgamate – at any rate for administrative purposes. On 23 February a combined meeting was held to give effect to this.

Dr CN Williams was to be the Team Leader, with Mr RF Smith Deputy Team Leader in Pretoria, and Mr JH Botham Deputy Team Leader in Johannesburg. As the Assistant Coordinator, Mr J Churms, had resigned from the Union Observatory at the end of 1957 and Mr J Hers was appointed in his place.

Stresses and Strains

It was now becoming clear that the procedures for visual observing had strayed a considerable distance from the Moonwatch scheme as originally conceived. Instead of observing a satellite for a few nights only, at the beginning and at the end of its life, the demand was now for almost continuous night by night observing, apparently not much diminished by the fact that the precision tracking stations were now fully operational. Observers were beginning to get tired, often discouraged, and were starting to withdraw. Tempers were wearing thin. This must have been particularly frustrating to the Moonwatch Coordinator in Cape Town who was trying to maintain some semblance of the original organization.

However, this was no easy matter, for Cape Town was rather out on a limb, and far removed from the centre of activities. Often the northern and southern teams did not seem to be speaking the same language. The Johannesburg team, having produced a far greater number of good observations that all the other stations combined, felt that it was hardly fair that it could only get, after a great deal of argument, one tenth of the instruments which had been freely allocated to Cape town and Bloemfontein. The Cape Town team was justly proud of its achievement of being the first to observe 1958 Alpha, against great odds, but Johannesburg replied that with similar instruments, and with Dr Finsen's predictions, they would have done as well, if not better.

Apogee telescopes in Cape Town. The Apogee telescope was a great asset to the Moonwatch programme for several reasons, one of which was that it had a horizontal eyepiece which enabled long periods of uninterrupted observation. Image: Peter Smits

Furthermore, many of the Johannesburg observations had not been made at the Observatory, but at the homes of enthusiastic amateurs, or wherever a suitable instrument was available. In the view of Dr Evans such observations, which had not been made at the central, registered, observing site, were more or less a waste of time. However, experience had shown that this was by no means the case. Very often such an observation had turned out to be the only one available from anywhere in the world. In such cases *any* observations became a key observation.

The tendency at Johannesburg was, in fact, to move away from the idea of a long "fence" of telescopes, with a large number of observers watching small sections of the meridian almost at random, but to rely on a small dedicated group of skilled observers and – very important – accurate predictions. Experience with Dr Finsen's predictions – produced the hard way, without the aid of electronic computers – had shown that this was entirely possible. Good predictions would lead to good observations, which in turn would lead to better predictions.

Last words to Mr Robert Cameron, Astronomer-in-Charge at the Olifantsfontein Satellite Tracking Station , in a letter to Dr CN Williams: "Recent correspondence from the Smithsonian Astrophysical Observatory indicates that in addition to being the first in the world to photograph 1958 Alpha, our telescope at Olifantsfontein was the first to get the Delta 2 after it had separated from Delta 1. Furthermore, we had more Delta 1 photographs than any other station by a considerable margin. In attaining these successes, we were locating the satellites almost entirely on predictions made by Dr Finsen using the Johannesburg-Pretoria Moonwatch observations. The amazing world record number of turnouts for Moonwatch sessions held by the Johannesburg team, combined with the large number and high reliability of the observations deserves the highest commendation as a very important contribution to the International Geophysical Year."

1958 Epsilon – Explorer IV

Launched on 26 July 1958, Explorer IV seemed to be temporarily lost. The Johannesburg and Pretoria teams combined all their telescopes to cover an arc of approximately 50° on 27 July, but nothing could be seen. Predictions from overseas for the next day differed by more that 10° in altitude. This was too much to cover by either of the two groups of apogee telescopes and difficult for both groups since the distance was also uncertain. A position was therefore computed on the basis of a rough Minitrack observation made the previous day (which gave time only). The possible range in altitude was divided between the two teams, Pretoria taking the northern and Johannesburg the southern half, in the expectation that one of the teams might be able to see the satellite. And so it happened that when the satellite passed very nearly through the centre of the northern half, Roy Smith, of the Pretoria team (which by then consisted of four observers) became the first in the world to see Explorer lV.

New ideas on Moonwatch

The methods which had been developed in Johannesburg were clearly stated in a memorandum by Dr Finsen, dated 2 July 1958, of which the following is an extract:

"Moonwatch may be regarded as in the melting pot. In its original conception as a technique for "acquiring" faint satellites out of the blue, it must be regarded as almost an out-and-out failure. The duration of a "watch" is too long and the large number of observers required compels one to rely on raw inexperienced amateurs, incapable of making reliable observations, or distinguishing between meteors and satellites. Their enthusiasm is short-lived and is not resistant to frequent call-outs,

especially at meal-times or in early mornings in winter. No long-term reliance can be placed on such assistance.

On the other hand, the importance of visual observations to keep day-to-day track of satellites has exceeded all expectations, especially when carried out in intimate association with the camera station. The emphasis is no longer on initial "acquisition" of satellites followed by long rustication till they "spiral to Earth" but on day to day monitoring with the highest possible precision. Predictions must therefore be as accurate as possible, but on the other hand only a few observers will be required, as a complete "fence" is no longer necessary. In short, it will be a professional, as distinct from an amateur activity.

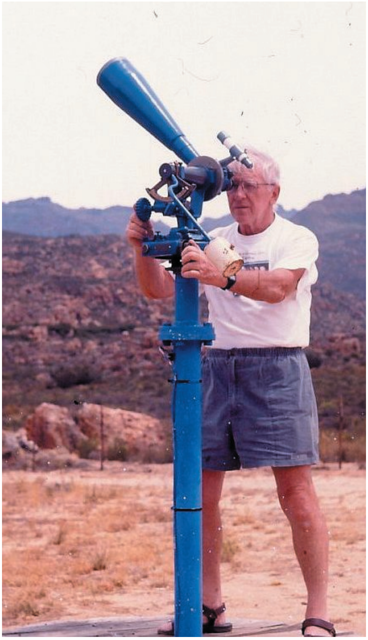
In this connection it is significant that in a recent Smithsonian compilation of satellite observations, the work of established observatories tends to overshadow that of amateur Moonwatch teams. The notable success of South African Moonwatch teams is only apparently an exception, our teams have been built round a solid professional core.

The conclusion seems inescapable that "Moonwatch", as originally visualized, is moribund. The team should be dropped. Visual observation, rendered more efficient by improved prediction and methods, will be largely a professional activity centred at the satellite institution or camera station. This does not mean that amateur assistance will be discouraged – practically every observatory can count on the help of seasoned, experienced helpers who are professionals in all but the name.

The very clear implication, therefore, was that in future the visual observation of satellites should be a recognized professional activity, which should not be left to a group of amateurs or to the nearest astronomical observatory. However, in many circles this point was not well understood. Dr J Allen Hynek, the Associate Director of Optical Tracking, during his visit to South Africa and to the Union observatory at the beginning of September 1958, expressed shocked surprise when told that the Johannesburg Moonwatch team intended to disband at the end of the year, and that the Observatory intended to go back to some astronomy. "The world's foremost Moonwatch team quitting? Never!"

On the other hand, at the meeting of the South African Satellite Management Committee on 30 October 1958, there seemed to be a strong feeling that optical observations were of relatively little use, and that in future whatever funds were available should be used for radio tracking only. In spite of the fact that cables costing some £1800 per month were still being sent to the Union Observatory, no further funds would be available for outgoing cables reporting observations, and the South African National Committee could not be responsible for any further charges relating to the Moonwatch programme.

It was recognized, however, that professional and amateur astronomers who were interested might, in special circumstances, be willing to make certain observations on request. For this reason it would be desirable to leave some equipment at each centre.



Honourary ASSA member Cliff Turk at the Cederberg Observatory with the Apogee telescope used by Dr W Hirst.

End of IGY

On 13 January 1959 the leader of the Johannesburg Moonwatch team informed the Secretary of the S.A. National Committee that the team terminated its activities as from 31 December 1958, and was now completely disbanded. All members of the team had been sounded and the decision was unanimous.

At the Union Observatory the policy became that normal astronomical functions would once again enjoy priority. Satellite observations would still be made in all cases of genuine emergency, not as a "Moonwatch" team, but with the help of half a dozen or so experienced amateurs permanently associated with the observatory. However, when a request was received for the return of the Apogee telescopes, this activity of necessity had to cease.

The Bloemfontein team was disbanded but at Pretoria and Cape Town small teams continued to function on a limited basis, in a manner which has proved to be a striking vindication of the prediction that future observing would be done by very small, closely integrated, teams of professional or semi-professional observers. ☆

Table 2: Total number of Visual Satellite Observations made in South Africa as reported to Moonwatch Headquarters during 1957-1958

	Russian Satellites	American Satellites	Total
Johannesburg	393	74	467
Pretoria	139	56	195
Cape Town	49	42	91
Bloemfontein	14	38	52

IGY Reminiscences

WS Finsen

Dr William Stephen Finsen was Chief Assistant of the then Union Observatory in Johannesburg. In 1956 he became Union Astronomer and eventually the one and only Republic Astronomer when South Africa became a Republic in 1961. These reminiscences are interesting for the background detail he gives, see article in this issue on "Moonwatch in South Africa". His remark that he ". . . was not prepared to see the Observatory turned into a satellite station . . ." came after the International Geophysical Year (IGY) was over. His feelings were almost prescient, echoing those of many of the astronomical community today, who don't see astronomy being a "space science"! ***Editor***

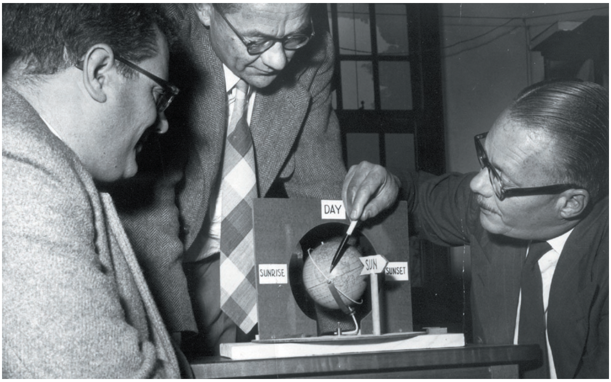
The IGY logo shows a satellite orbiting Earth - very few people recognized the significance of this.

Although the symbol or badge of the International Geophysical Year (on letterheads, etc.) was a satellite orbiting the Earth (Fig. 1), the South African IGY Committee had apparently not taken this very seriously and had perhaps regarded the successful launching of satellites as a flight of fancy. At any rate, no funds had been set aside for possible participation by South Africa. As far as I know, I was the first to draw attention to the serious preparations that were being made for this project overseas. This was at a small meeting convened by Dr TEW Schumann (Director of the Weather Bureau), and there was visible surprise on the part of those present at my urging that "sputnikery" was to be taken seriously. Dr Schumann even suggested that as I appeared to know so much about the subject I should give a lecture on it! I replied by saying that I had already exhausted my knowledge of the subject. Dr Schumann: "You are very honest!"

At a later meeting I warned of the imminent launching of Russian satellites. It was Major Cockbain, of Defence Intelligence, who told me afterwards that they had also got wind of it.

Sputnik 1 launched

As I remember, it was on a Saturday morning that the news broke of the launching of Sputnik 1. The office was bedlam – phone ringing continuously (almost), reporters etc. No time at all



The author explaining the behaviour of orbiting satellites to J Churms (left) and JA Bruwer using the model or three-dimensional slide-rule which he constructed. (CSIR Archives)

to sit down and sort things out. No hard information from overseas – only the TASS predictions that at such and such times the Sputnik would be "over" such and such cities (none of which were in South Africa). And of course the whole of South Africa wanted to know when it would be visible here. Over the weekend I locked myself in my workshop and made a small and rough model of Earth and satellite orbit. With the help of this and the TASS predictions I was soon able to see the general nature of the orbit (period inclination, etc.) and with a rough guess at the rate of precession of the node, I was able to forecast fairly accurately when the Sputnik would first be visible from South Africa. I accordingly wrote a short statement, and I think it was on the next day that Prof SP Jackson came to the office to see if we could tell him anything definite. I showed him my statement and he asked if he could take it away, which he did. On that night Dr Naude did a national broadcast on the Sputnik in the course of which he read my statement – without acknowledging its source!

I shall not easily forget the relief I felt when we first saw Sputnik 1 shooting across the sky in good agreement with my prediction. For some days thereafter SAPA phoned the TASS predictions through to me, which was a great help.

Quest for accurate predictions

For the three-dimensional slide-rule I bought the largest terrestrial globe obtainable locally, and converted it in my workshop. It was calibrated with care so that one could set it with conventional astronomical orbital parameters, and there was even provision for determining the time of entry into the Earth's shadow. This model gave times, altitudes and directions with sufficient accuracy for naked eye Sputniks, correct to a minute or so in time, and about 5° or so in altitude when fairly high in the sky, and better when near the horizon. I remember occasions when we observed (and photographed) a Sputnik over Tristan da Cunha and Madagascar. The model was also helpful for correcting the orbital elements using the observations of the night before.

The public demand for information was so insatiable and the resulting phone calls from press and public for predictions so continuous and disrupting that the only remedy was to phone predictions for the next day (or days, when weekends followed) to SAPA before 10 am. I therefore had to be in the office as early as 5 or 6 am every day to reduce the observations of the night before, correct the orbit, and prepare predictions for the major centres. This after two or even three observing sessions during the night: I often had to set my alarm twice during the night. I think I am right in saying that I took part in every observing session – except of course when I went to Moscow for the IGY and IAU meetings.

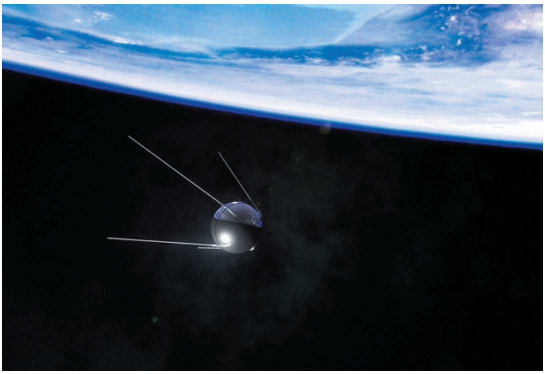
I think the observing methods and the vetting of observations must have been rather sound, for in Moscow I was interviewed by a member of the Russian organization who wanted to know exactly how we made such accurate observations.

Incidentally, the Russians at the IGY meeting were very cagey about releasing the conventional orbital elements of their Sputniks. They claimed that their computers were not capable of doing this, and that all they could supply were predictions. This led to rather heated protests from foreigners present, including myself. I asked why they did not let us have the conventional parameters that they must be using – we could turn them into regular orbital elements ourselves. No, they couldn't do it.

Sputnik fatality!

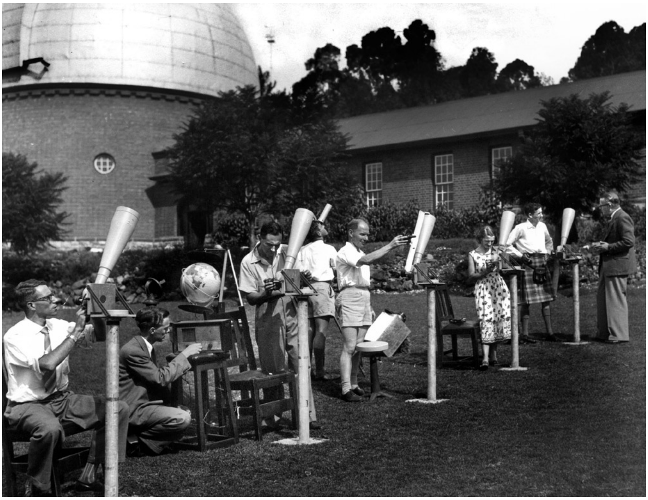
It may not be remembered that the Sputniks resulted in at least one fatality in South Africa. This happened because newspapers sometimes did a little predicting on their own – they noticed that often there were two passes in the evening separated by 100 minutes or so. What they did no realize was that their predicted second pass was invisible as the satellite was then in the Earth's shadow. On one such occasion a man on the roof or balcony of a block of flats leaned over too far in his attempt to see the invisible spectacle, and fell to his death.

I found then that the easier and most successful way of observing a Sputnik was to mount a pair of binoculars on a tripod



Artists impression of Sputnik-1 in orbit.

with three axes, one of which permitted tracking along the plane of the orbit. The Sputnik was then followed till it passed between two suitable stars. The binoculars were then left in position and the stars identified at leisure.



The Johannesburg Moonwatch team set up their Apogee telescopes on the grounds of the Union Observatory next to the Innes dome. Note the model or three-dimensional slide-rule in the background. (CSIR Archives)

Fainter American satellites

The three-dimensional slide-rule was adequate for naked eye Sputniks, but was not sufficiently accurate for faint American satellites, although even in these cases it was useful for showing the general situation, and for rough checking. For the American satellites it was necessary to use quite sophisticated computational methods for reducing observations, correcting the orbits, and computing the predictions. Though they were based on well-known dynamical procedures (certainly well-known to a double star specialist!) it was necessary to invent and improvise, and look for all possible shortcuts. It was very heavy work, at the crack of dawn, day-in and day-out. The accuracy of the predictions was quite pleasing: the error in time was a matter of seconds rather than minutes, and in altitude of minutes of arc rather than degrees.

South African Witchdoctor

It was at the braaivleis to celebrate the opening of the Baker-Nunn station that a set of predictions for SAO clattered out of the telex, ending with the greatly appreciated compliments: "but rely heavily on Finsen's predictions". Also appreciated was Cameron's generous acknowledgement of the value of my predictions. On at least one occasion, so he told me, he ended a telexed report to SAO of successful observations with the words "Predictions by South African Witchdoctor" and he even presented me with a plaque with the legend "South African Witchdoctor".

I always felt that the difficulties under which Cameron had to work were not understood: beginning a whole new project involving sophisticated but untried techniques in unfamiliar surroundings in a foreign country. My personal relations with him were always of the most pleasant nature.

For the record and as a testimonial to his ability, I would like to mention his notable contributions to conventional astronomy since severing his connection with artificial satellite work, e.g. his meticulous editing of the published proceedings of the symposium on Magnetic and Related Stars (1965) and his chapter on Stellar Evolution in *Introduction to Space Science* (Ed. Wilmot N. Hess), one of the most lucid surveys at the present time (1959 -1960).

The Baker-Nunn station

Shortly before the beginning of the IGY, great pressure was brought on me to agree to the Union Observatory undertaking the management of the Baker-Nunn station. The inducement was even held out of the Observatory acquiring the camera at the end of the IGY and using it for purely astronomical purposes, (as I once remarked at a meeting of the Satellite Committee, the belief seemed to be prevalent that all artificial satellites would obediently tumble to Earth on 31 December1958 – failure to realize that we were witnessing the birth of a new era.) I insisted that the proposal would be acceptable only on condition that the camera station had its own Officer-in-Charge as a branch of the Observatory, recruited its own staff, and in the event of unfillable vacancies, would not be allowed to call on the observatory's astronomical specialists. Outside commitments always tend to take priority over domestic activities, and I was not prepared to see the Observatory turned into a satellite station. My views were not sympathetically received, but subsequent events have only reinforced my attitude and I have never regretted the stand I took up.

Returning to Astronomy

We entered into whole-hearted cooperation with the IGY activities with the understanding that it was limited to the period 1957-1958 and that thereafter we would revert to our normal astronomical activities. This attitude also met with some criticism. At one of the last meetings of the Satellite Committee I expressed the view that after the IGY satellite work should be the responsibility of specialists and proposed that a small satellite bureau should be created to retain the services of one or two people who had shown special aptitude. This proposal was received almost with horror.

When Dr Hynek expressed his surprise at the decision to disband "the world's foremost Moonwatch team" I countered by telling him that the suggestion that we should carry on indefinitely, was like shouting to a hundred yard sprinter as he breasted the tape "now carry on for a mile!" We had exerted ourselves to the utmost and given of our best as loyal members of an international team, but we had had enough. ☆

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: Occultation of the T Tauri Star RW Aurigae A by its Tidally Disrupted Disk
Speaker: Joseph Rodriguez, Vanderbilt
Venue: SAAO Auditorium
Date: 9 May 2013
Time: 16:00
Abstract: RW Aur A is a classical T Tauri star, believed to have undergone a reconfiguration of its circumstellar environment as a consequence of a recent fly-by of its stellar companion, RW Aur B. This interaction stripped away part of its circumstellar disk, leaving a tidally disrupted "arm" feature and a short truncated disk. We present photometric observations of the RW Aur system from the Kilodegree Extremely Little Telescope (KELT-North) showing a long and deep eclipse that occurred from September of 2010 until March of 2011. The eclipse has a depth of ~2 magnitudes and a duration of ~180 days. The eclipse was confirmed by archival observations from American Association of Variable Star Observers (AAVSO). We suggest that this eclipse is the result of a portion of the tidally disrupted disk occulting RW Aur A. The calculated transverse linear velocity of the occulter is in excellent agreement with the measured relative velocity of the tidally disrupted arm. Using simple kinematic and geometric arguments, we show that the occulter cannot be a feature of the RW Aur A circumstellar disk, and we also discount other hypotheses. We also place constraints on the (projected) thickness and semi-major axis of the portion of the arm that occulted the star.

Title: Improving Stacking Techniques with Bayesian Statistics
Speaker: Michelle Knights, AIMS
Venue: SAAO Auditorium

Date: 25 May 2013
Time: 16:00
Abstract: Stacking is a technique used in almost every field in astronomy whereby multiple noisy datasets (for example spectra or images) are co-added to improve the total signal-to-noise and allow average signals to be pulled out of the data. However, traditional stacking techniques can be inflexible (often requiring precise position data, for example) and lose information that could potentially be extracted. In this talk, I will introduce a new approach to stacking using Bayesian statistics, explaining in detail how one can potentially use hierarchical modelling to obtain information about the underlying distribution from which the data are drawn. I will illustrate the idea with some simple examples and explain the Multiple Block Metropolis Hastings algorithm I have implemented to solve the computational challenges that arise with this method.

Title: Distance measurements with Tip of the Red Giant Branch
Speaker: Marek Gorski, Astronomical Observatory of the University of Warsaw (Poland)
Venue: RW James lecture hall C
Date: 13 June 2013
Time: 15:00
Abstract: Infrared TRGB brightness measurement enables accurate and independent measurement of the distance to the Local Group galaxies. I'll explain why and how we are using it to measure distance and what is the current status of this technique. I'll present some issues, questions and results of TRGB distance determination, based on Araucaria Project measurements

Title: Precise distance measurements within local Universe
Speaker: Piotr Konorski, Astronomical Observatory of the University of Warsaw (Poland)
Venue: RW James lecture hall C
Date: 13 June 2013
Time: 15:30
Abstract: Although very commonly used in many different areas of modern astrophysics, the great potential of binary stars as distance indicators still remains underexploited. In the course of Araucaria Project we are using this tool to calibrate distances in our Galaxy and beyond. During my talk I will present details of the technique and try to prove that it serves as most precise method for determining distances within the local Universe.

Title: The IAU Office of Astronomy for Development
Speaker: JC Maudit
Date: 20 June 2013
Venue: SAAO Auditorium
Time: 16:00
Abstract: The International Astronomical Union (IAU) is the largest body of professional astronomers in the world and has set up the Office of Astronomy for Development (OAD) in partnership with the South African

National Research Foundation (NRF). The OAD is located at the South African Astronomical Observatory (SAAO) in Cape Town. Its mission is to realise the IAU's Strategic Plan, which aims to use astronomy as a tool for development. In 2012 the first open Call for Proposals was launched, focusing on three main areas: "Universities and Research", "Children and Schools" and "Public Outreach". Eighteen projects worldwide have been approved for 2013 and are currently under way. The OAD is also setting up regional nodes and language expertise centres around the world. This presentation will describe the ongoing activities of the OAD and plans for the future.

ACGC

Title: The Dyer-Roeder Approximation and the Influence of the inhomogeneities in the Cosmological Tests
Speaker: Dr Vinicius Busti
Venue: M111, Maths Building, UCT
Date: 7 May 2013
Time: 13:00

Abstract: The existence of inhomogeneities in the observed Universe modifies the distance-redshift relations thereby affecting the results of cosmological tests in comparison to the ones derived assuming spatially uniform models. In this talk, I will discuss the Dyer-Roeder (DR) approximation, phenomenologically characterized by the smoothness parameter, from an observational viewpoint. A discussion of how to compare the DR with the traditional weak lensing approach will also be addressed, based on the effects in some cosmological consistency tests.

NASSP

Title: Gravitationally Lensed Galaxies Discovered by the Herschel Space Observatory
Speaker: Prof Lerothodi Leeuw
Venue: RW James Lecture Hall C
Date: 2 May 2013
Time: 13:00
Abstract: I will give context to the importance of the discovery and nature of dust- and gas-rich lensed galaxies observed by the Herschel Space Observatory and a range of follow-up observations by the Southern African Large Telescope and other telescopes around the world. The work that will be described is conducted in conjunction with the Herschel-ATLAS team.

Title: Exploding Stars and Their Aftermath in Radio
Speaker: Dr Michael Bietenholz, HartRAO
Venue: RW James Lecture Hall C
Date: 8 May 2013
Time: 13:00
Abstract: Supernovae are very important in wide range of astronomical contexts. In particular, both supernovae and supernova remnants are often bright in the radio. Although no supernova has been directly observed in our

own Galaxy since the year 1604, the Galaxy does contains many supernova remnants, and we see many supernovae occurring in external galaxies. I will give an overview of radio observations of supernovae and their remnants, discussing interferometric observations of Galactic supernova remnants with telescopes such as the VLA (and, in future, MeeKAT) and also discussing Very Long Baseline observations of extra-galactic supernovae. I will show VLBI movies of supernovae 1986J and 1993J showing there evolution. I will also discuss the connection between supernovae and gamma-ray bursts, and what constraints radio observations can provide on gamma-ray burst mechanisms.

Title: A Brief History of the Coming Revolutions: Who moved my galaxy?
Speaker: Dr Bruce Bassett, AIMS
Venue: RW James Lecture Hall C
Date: 15 May 2013
Time: 13:00
Abstract: Astronomy, academia and Universities in general are facing a tumultuous period which will see them revolutionised. In 10 or 20 years they may be almost unrecognisable with the lenses of today. Being successful researchers and academics in such rapidly changing waters will require new sets of skills. We will discuss the coming changes - deep unsupervised machine learning, crowdsourcing, MOOCs and more - and the strategies for adapting to this brave new world.

UWC

Title: The Circumgalactic Medium: New Frontiers in Understanding Galaxy Evolution
Speaker: Professor Romeel Dave
Venue: Room 1.35 of the Physics Department, UWC
Date: 27 March 2013
Time: 13:00

SKA

Title: KAT-7 Science Verification: Hi Observations of NGC 3109 - Understanding its Kinematics and Mass Distribution
Speaker: Claude Carignan
Venue: Auditorium on the 2nd floor of the SKA South Africa office
Date: 2 May 2013
Time: 13:00
Abstract: HI observations of the Magellanic-type spiral NGC 3109, obtained with the seven dish Karoo Array Telescope (KAT-7), are used to analyse its mass distribution. Our results are compared to what is obtained using VLA data. KAT-7 is the precursor of the SKA pathfinder MeerKAT, which is under construction. The short baselines and low system temperature of the telescope make it sensitive to large scale low surface brightness emission. The new observations with KAT-7 allow the measurement of the rotation curve of NGC 3109 out to 32, doubling the angular extent of existing measurements. A total HI

mass of 4.6 ×108 M is derived, 40% more than what was detected by VLA observations. The observationally motivated pseudo-isothermal dark matter (DM) halo model can reproduce very well the observed rotation curve while the cosmologically motivated NFW DM model gives a much poorer fit to the data. While having a more accurate gas distribution has reduced the discrepancy between the observed RC and the MOdified Newtonian Dynamics (MOND) models, this is done at the expense of having to use unrealistic mass-to-light ratios and/or very large values for the universal constant a0. Different distances or HI content cannot reconcile MOND with the observed kinematics, in view of the small errors on those two quantities. This result for NGC 3109 continues to pose a serious challenge to the MOND theory.

AIMS

Title: New Views of Mercury from MESSENGER

Speaker: Prof Catherine Johnson, Participating Scientist on the MESSENGER

Venue: African Institute for Mathematical Sciences, 6 Melrose Road, Muizenberg

Date: 14 May 2013

Time: 19:00

Abstract: In March 2011, MESSENGER became the first spacecraft ever to orbit Mercury, the innermost planet in our solar system. Over the past two years the spacecraft has collected, and relayed to Earth, a wealth of new data about this planet including images of the surface, and measurements of topography, gravity, magnetic field and composition. I will summarize some of our findings about this enigmatic planet and some of the challenges of getting to, and operating at, Mercury. ☆

... continued from p. 90

Roy's daughter Moira had this to say:

Besides my Dad's astronomical hobby and his metrological career, there is not too much of interest as he led a very simple and humble life. His brilliant mind and extensive general knowledge is going to be sorely missed by us all.

He lived for his heaven and stars so it formed an integral part of our upbringing too! My sister and I have many memories of being dragged out to the telescope to observe something.

Jack Bennett was my godfather, although he passed away when I was still young so I don't remember too much besides the excitement of looking at Comet Bennett.

We will be very happy for him to be remembered and know that, as much as he hated attention and drama, he would be immensely proud to be remembered in the astronomical world which was his love and passion. ☆

Celestial Home of Stars

Magda Streicher
magdalena@mweb.co.za

Image source: Stellarium.org

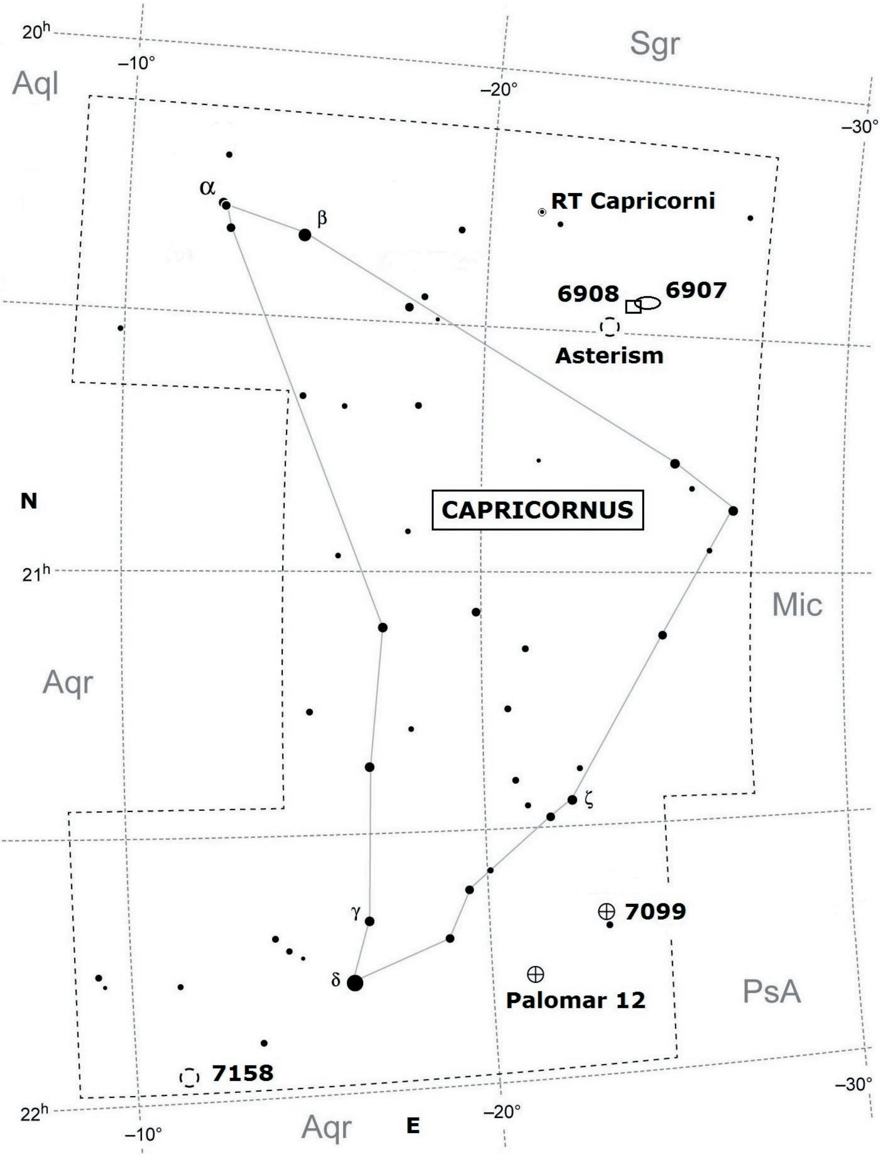
In antiquity the Capricornus constellation was seen as a monster with the head and forelegs of a goat and the posterior of a fish. The creature could almost be compared to the so-called Mermaid but could also sometimes, in the case of Capricornus, refer to the Fishman.

The name 'Tropic of Capricornus' originates from the fact that when first observed towards the east it indicates the point of the winter solstice, this solstice at present being 33° to the west in the figure of Sagittarius.

Monument marking the tropic of Capricorn outside Polokwane, Limpopo province.

The constellation is special to the author for two good reasons. Not only does she live right inside the old Tropic of Capricorn Circle, but the image also reflects a particular shape: it looks very much like a huge lopsided triangle, and special in the star composition. Heaven alone knows how anyone could see a sea goat with horns in that particular star pattern, but be that as it may ... We will carefully unravel the constellation, which holds a large number of bright stars to pleasure the eye.

The constellation occupies 414 square degrees of sky and is situated just east of Sagittarius, but sadly it is not rich in deep-sky objects. Still, it is an easily recognisable compilation, with several



look-alike double stars and is, famously, a close neighbour to the centre of the Milky Way.

The lovely double star, alpha Capricorni, also the star closest to the Sagittarius boundary, is a wide, naked-eye

NGC 6907 Its misty glow represents a miniature Large Magellanic Cloud. Dale Liebenberg

double star. In fact, four companions are listed. Double star director Dave Blane indicate that Alpha Capricorni is an optical double star with components αlpha^1 Cap and αlpha^2 Cap having magnitudes 4.3 and 3.6 respectively. They have a separation of 381" at a position angle of 292^0. αlpha^1 is a G type super-giant and αlpha^2 is a giant star of the same spectral class. Each component is in turn a multiple star, with αlpha^1 having a magnitude 9.6 companion with separation of 46.9" at a position angle of 222^0, which is unrelated, while αlpha^2 has a magnitude 10.5 companion with separation 153" at a PA of 160^0.

Another star, quite extraordinary in its own right, about halfway along the western boundary of the constellation, is **RT Capricorni**. It is a carbon star which glows with a lovely reddish colour that varies irregularly between magnitude 7 and 11.

Further towards the south-western corner of the constellation the galaxy **NGC 6907** displays a misty glow with an elongated shape in a north-east to south-west direction and strongly resembles a miniature Large Magellanic Cloud. The centre area shows a small star-like nucleus. Higher magnification reveals knotted texture on the surface with a small, barely visible arc-like patch embedded in the north-east listed as **NGC 6908** (see picture).

Just 15’ east of **NGC 6907** is a lovely **Asterism** contains six colourful stars in a prominent north-south arrow shape, with the brightest star (HD 194412) at magnitude 8. It is quite prominent against a sparse star field.

An object that is questionable is **NGC 7158**, which forms a triangle towards the north-east from the stars magnitude 5 mu and magnitude 5.5 lambda Capricorni. This is one of those objects which is nowhere to be found, but which, on closer investigation, appears as a very faint string of three close stars between magnitude 9 and 11. Steve Coe, using a 13” f/5.6, notes: “Is given as a triple star in NGC 2000 catalogue. Sure enough, there is a triple with two members about 9th magnitude and one 11th at this location. They are separated by about 30 arc seconds in a straight line at 100X. This multiple star system must have been included in the NGC because of its appearance at low power this group is nebulous. It is marked as a galaxy on Uranometria 2000.”

The rare globular cluster **Palomar 12** (named after the Palomar Observatory), situated relatively close to the Pisces Austrinus border, is around 60 000 light years distant. This globular cluster is estimated to be much younger than most of the globular clusters in our Milky Way. Tom Polakis’ motion studies suggest that Palomar 12 may have originated in the Sagittarius Dwarf Galaxy, but was probably later captured by the Milky Way.

Capricornus is home to the distinctive globular cluster **NGC 7099**, or Messier 30, also known as Bennett 128, which is situated about 3 degrees east of the magnitude 3.7 zeta Capriconi. Messier 30 were discovered by Charles Messier (1730–1817) on 3 August 1764 near the star 41 Capricorni. He devoted much of his life to searching the skies for comets and his notes indicate the object to be round, containing no stars and seen with difficulty in a good Gregorian 3 ½-foot telescope.

With low power it might well resemble a comet, in line with the comment of the Reverend Thomas William Webb, a British astronomer, born 14 December 1807 and died 19 May 1885, though some sources give his year of birth as 1806. He was the only son of a clergyman, and was raised and educated by his father, his mother’s having died while he was still a little child. However, the globular cluster grows gradually brighter towards a tiny, very dense and bright core. Careful observation reveals an image resembling an elongated north-south honeycomb covered with bees (see picture). With higher magnification faint stars mingle asterism-like at random, with two prominent strings extending north and north-west, one

M 30 Globular Cluster, or NGC 7099, is a comet-like cluster, that moves the opposite direction to the rotation of the galaxy, probably as the result of an intergalactic gravitational encounter. Dale Liebenberg

slightly longer, giving the impression of a pair of firefly antennae. The south-eastern part of the globular is broken down in starlight and in a way cut off by a short string of four stars. Also to be seen is a double star towards the southern part. Messier 30 is a large globular cluster that can be easily spotted with binoculars and measures nearly 90 light years in diameter. It is a very special object – one to remember long after observed it.

In Philosophical Transaction 1814, William Herschel described it as a brilliant cluster, the stars of which become gradually more compressed in the middle. John Herschel, son of William, observing with the 18-inch f/3 speculum at the Cape of Good Hope, records the object as "a globular cluster, bright, 4' long by 3' broad; all resolved into stars, gradually more compressed in the middle. In this accumulation of stars, plainly see the exertion of a central clustering power, which may reside in a central mass."

Admiral William Henry Smyth, an English amateur, was moved to wild speculation about the object. "What an immensity of space is indicated. Such an arrangement is intended as a bungling sputter for a mere appendage to the speck of a world on which we dwell, to soften the darkness of its petty midnight."

Closer to home, a very realistic observation of Messier 30 by Auke Slotegraaf indicates the position as lying in south-eastern Capricorn, outside of the large delta-wing shape of the Sea Goat, in the direction of the star Fomalhaut. He further indicates M30's integrated magnitude as V=6.9, and it is plainly visible through binoculars as a bright round cometary glow, with a tight nucleus, accompanied by the pale yellow magnitude 5 star 41 Cap. Just 4' west-south-west of the nucleus of the cluster lies a magnitude 8 star. A small telescope shows it as a 3'-diameter glow, growing slowly brighter towards the centre, where it becomes suddenly much brighter, forming a definite, strongly condensed, nucleus. The brightest stars in M30 - its red giants - are between magnitude 12 and 13, so a small telescope will show a few individual stars. Larger telescopes bring the cluster up to about 5' diameter, showing several more cluster members scattered across the background haze of unresolved stars. Two short rows of magnitude 12 stars, leading away from the compact nucleus, catch the eye: one pointing north, the other to the north-west.

M30 is almost 13 gigayears (Gyr) old and has a mass of about 80 000 suns. It lies 26 000 light years away from our Sun and moves in an orbit around our galaxy, which is opposite in direction to the rotation of the galaxy itself. This suggests that M30 was not formed as part of our Milky Way, but was, instead, accreted (gravitationally captured) when its own parent galaxy had a close encounter with our galaxy.

Allow me the opportunity to thank Dale Liebenberg for the excellent pictures he so gratefully contributes to the articles that are constantly share with the readers.

Don't avoid the fish-goat. Grab it by the horns and use them to penetrate the objects within its realm. ☆

Object	Type	RA (J2000.0)	Dec	Mag	Size
RT Capricorni	Carbon Star	20^h17^m2	-21°20	7 - 11	*
NGC 6908	Nebulosity	20 25 1	-24 48	14	0.5'x0.3'
NGC 6907	Galaxy	20 25 6	-24 49	11	3.2'x2.3'
Asterism	Star Group	20 26 7	-24 57	8	10'
NGC 7099, M 30	Globular Cluster	21 40 4	-23 11	6.9	9'
Palomar 12	Globular Cluster	21 46 6	-21 15	11.7	2.9'
NGC 7158	Unknown	21 57 4	-11 36	9.5	'x6'

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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