# The Contribution of Southern African Amateur Observations to Professional Astronomical Studies

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**Abstract**: ASSA has a rich past of contributing astronomical observations in support of professional studies. In recent times this contribution has been dwindling to the extent that only a few dedicated individuals are making observations of scientific value. This paper summarises some of the past and current contributions and makes yet another plea for new observers to become involved. For simplicity I refer to South African observations in this paper, but within this terminology include the contributions of observers in Namibia and Zimbabwe.

## Introduction

The Astronomical Society of Southern Africa possesses a number of Observing Sections. These Sections exist to coordinate observations in specific fields and are run by a Director, who should be proficient and show a keen interest in the subject field. Those Sections dedicated to astronomical observation are shown in Table 1.

These Sections have participated both in the past and currently in Professional-Amateur (so-called Pro-Amat) campaigns. However, in recent years a certain degree of apathy has arisen among amateur observers, which threatens not only this long standing collaboration, but the very existence of these Sections. We need to reverse this trend and cultivate new observers prepared to make scientific observations.

| Section | Director |
|---|---|
| Comet and Meteor | Tim Cooper |
| Deep Sky | Auke Slotegraaf |
| Double Star | Chris Middleton |
| Occultation | Brian Fraser |
| Solar | Jacques van Delft |
| Variable Star | Brian Fraser |

**Table 1: List of Observing Sections**

In this paper I would like to review the historical contributions of ASSA members, summarise some current active programs and provide some guidelines and ideas on how to broaden and strengthen ties between our amateur astronomers and professional organisations, both locally and internationally.

## Variable Stars

Contribution of South African observations to Professional studies exists longest in the case of variable stars and this contribution is not insignificant. The AAVSO database consists of around 13 million observations, of which over 654 000 (5%) are attributable to South

African observers. To this we will soon have added another 70 000 from the AW Roberts project.

Janet Mattei (2002) discussed the contribution of South African amateurs to variable star research in broad terms in her Danie Overbeek Memorial Lecture at the 5th ASSA Symposium in 2002. Her talk included a number of slides on Pro-Amat collaboration, mainly on cataclysmic variables in outburst.

Henden (2006) has demonstrated the value of amateur variable star observations to professionals in his paper 'Pro-Am collaboration and the AAVSO'. He states 'There is a resource of which all professionals should be aware: the opportunity for professional-amateur collaboration'. He mentions some areas where amateurs can contribute to professional programs:

- Visual observations – historical long term monitoring of variable stars, extending back to the late 1800's, has been invaluable to the understanding of evolution in many variable stars, especially brighter long period variables. For this reason alone it is essential for amateurs to continue this long running sequence of observations
- Visual observations - determining the time of outburst of eruptive variables. More and more, professionals are studying variable stars in different wavelength regions using the services of large ground based telescopes and earth orbiting satellites. They rely on close monitoring by amateurs to provide prompt notification of changes in behaviour of target stars in order to trigger so-called 'Target of Opportunity' observations with these instruments
- Monitoring of variables which previously were outside the scope of amateurs, such as fainter variables or variables with small amplitudes, due to the increased use of advanced instrumental techniques by amateurs who are becoming technologically more proficient

Before considering South African contributions in these key areas of collaboration, it will be useful to summarise the broad types and number of variable stars.

## Types of Variable Star

In the broadest sense, variable stars may be one of two kinds, either intrinsic or extrinsic. Intrinsic variables are those in which variability is caused by physical changes in the star itself. Extrinsic variables are those in which variability is caused by eclipse of one star by another or by the effects of stellar rotation. These two kinds may be further defined by five classes of variable star following the definitions of Samus and Durlevich (2004); pulsating, eruptive, cataclysmic, eclipsing and rotating. Within this broad classification there exists a host of different sub-types, depending on the nature of the variability.

**Pulsating variables** are those which show a periodic expansion and contraction of their surface layers. The pulsation may be either radial, in which the shape remains spherical, or non radial, where the shape deviates from spherical periodically. Subdivision of types depends on period, mass and evolutionary status of the star.

**Eruptive variable** stars are those which vary in brightness due to violent processes or flaring taking place in the outer layers of the star. These variations are accompanied by changes in the stars outflow or solar wind and in shells surrounding the star.

**Cataclysmic variable** stars are those which undergo thermo-nuclear blasts in their surface layers (novae) or interiors (supernovae)

**Eclipsing Variables:** Binary stars whose orbital planes are inclined such that from the observers viewpoint one component passes in front of the other.

**Rotating Variables:** Stars with non-uniform surface brightness due to light or dark spots, or stars with ellipsoidal shape, such that variability exists due to rotation of the star.

The total number of known variable stars is around 38 000 at the present time. However the number of southern variable stars which are observed regularly, is probably less than 200!

## Historical South African observations

From a historical standpoint, South Africa has a rich heritage of variable star observation. Until recently the earliest South African observations in the AAVSO database were those of JF Skjellerup [1915] and Arthur Long [1917]. However, following the discovery of the original observations of AW Roberts, we have now extended this contribution back to 1891. Certain eras have been dominated by individual observers. Hers (1986) identified these as Skjellerup, Houghton, de Kock and Overbeek. Prior to these we should add Roberts and in the post Danie Overbeek era, Berto Monard has made a significant contribution, though much of his work is now non-visual. Table 2 shows the contribution of these observers to the visual database.

AW Roberts came to South Africa in 1882 (van Zyl 2003) to take up a teaching position at Lovedale College. He started to observe variable stars in 1891 and entered into correspondence with

| Observer | Period | Visual Observations |
|---|---|---|
| AW Roberts | 1891-1932 | 70 121 |
| JF Skjellerup | 1915-1948 | 6 733 |
| HE Houghton | 1926-1942 | 25 589 |
| RP de Kock | 1934-1973 | 160 777 |
| MD Overbeek | 1952-2001 | 287 150 |
| LAG Monard | 1992- | 40 000+ |

**Table 2: Significant South African contributors by period**

Gill, who acted largely as his mentor. Indeed Snedegar (2001) documented this professional-amateur relationship which already existed over a century ago. Roberts (1906) mentions having observed 105 different variable stars, though for a handful of these there were very few observations. Following the discovery of Roberts' original observations in three cupboards at Boyden Observatory, a team comprising Brian Fraser, Tim Cooper and the University of the Free State, have been capturing, digitizing and adding these observations to the AAVSO database. The project is still in the process of adding the already-digitized observations to the database, but has already yielded a number of findings.

The first is the clarification of reports that Roberts made over quarter of a million observations (Hers 1986, Henden 2006). This possibility was first mentioned by Gill (Houghton 1947) where he states 'Roberts has made in all about 250 000 independent estimations of stellar magnitude....I know of few instances of more successful devotion of small means and limited opportunity to the attainment of great scientific ends than the work of Dr Roberts'. In fact the processed number of observations is a little over 70 000 and it is probable that each variable star estimate was the averaging of 4 or 5 measures on each occasion. Secondly, that Roberts observed with an accuracy of 0.01 magnitudes. In fact this was just a result of making several observations of the star and averaging the observations, without rounding the result to one decimal place as is normal practice. But the fact is that Roberts did make a significant contribution, extending the sequence for many stars by over 20 years earlier. We have captured his observations for 99 separate stars, which have the distribution among the different types shown in Table 3.

It should be noted that Roberts' observations were made with very modest equipment by today's standards (Cooper et al 2004). He used three instruments; a 1-inch theodolite by Troughton and Simms, a 2-inch Cooke equatorial and later a 3¼-inch Ross telescope for the fainter observations, which enabled him to reach about magnitude 11.5. The latter instrument was fitted with a prism to allow the field to be rotated to investigate the affects of position angle. Roberts efforts with modest equipment can serve as motivation for today's amateurs to continue observation in the same vein.

| Type | Number of Stars |
|---|---|
| Long period | 55 |
| Cepheids | 20 |
| Semi regular | 10 |
| Eclipsing | 7 |
| Others | 7 |

**Table 3: Types of variable stars observed by AW Roberts**

The analysis of Roberts' observations is already yielding some important improvements to professional work (Ramoshebi 2006). She investigated those stars for which there is an overlap in the light curve between Roberts' and AAVSO observations. She found a smooth match in terms of times of maxima and minima, but some discrepancies in amplitudes due to anomalies outside the magnitude range 7-10. This may be due to the magnitudes of reference stars adopted by Roberts differing from accepted AAVSO comparisons at the time.

Ramoshebi also extended the trend curves for amplitude and period for the long period variable R Cen. She added around 1 000 observations made between 1891 and 1918 made by Roberts to around 13 000 observations made from 1918 to 2000 in the AAVSO database. Applying Fourier analysis to obtain a power spectrum and wavelet analysis to study the time dependence of period and amplitude, she was able to extend the decline in period and amplitude as found by Hawkins et al (2000) and to show that in addition there is a sharp increase in amplitude in the earlier observations made by Roberts.

The star Roberts observed most was RR Cen. Indeed he discovered the variability of this star himself and Overbeek (1976) quotes Roberts as having made over 10 000 observations of this star. We have found and logged 2 289 observations and again the higher number from previous references is due to a misunderstanding. Roberts (1903) himself explains that over 10 000 light determinations were obtained for RR Cen and that:

> 'In order to eliminate the troublesome effects of position angle, six pointings were made each observation, the field being rotated through 60° each setting. A single observation is held to be the mean result of all six pointings. Five comparison stars were used in estimating the brightness of the variable and thus for each observation, thirty six light determinations, or sequences, were made.'

The next of our major contributors, HE Houghton, made over 25 000 observations between 1926 and 1942. Hendon Egerton Houghton was born in England in 1892 and came to South Africa in 1920 to join the staff of the High Commission's Office (Cooper 2003). He joined the Cape Astronomical Society and was ASSA secretary from 1923 until 1930. In 1934 he succeeded Ensor as Director of the Variable Star section of ASSA, after Ensor's resignation and held this position until his passing in 1947. His obituary written by Forbes in *MNASSA* (1948) stated 'In continuing the work of variable star observing in South Africa, so ably pioneered by the late Dr AW Roberts, no one has done more for the advancement of the science than Mr Houghton'.

During Houghton's sojourn as Director, a new observer appeared in the form of Reginald Purdon de Kock, who was to become one of South Africa's most prolific amateur observers. He was born on 2 July 1902 in Colesburg and by the time of his passing in 1980, had contributed 160 777 variable star observations to the AAVSO between 1934 and 1978, at that time their all-time record (Glass 1986). His observations were made with a 3-inch alt-azimuth refractor from his home in Paarl, or the 6-inch Grubb refractor after he joined the Royal Observatory in 1941. The same year de Kock co-discovered a comet, C/1941 B2, with Paraskevopoulos. De Kock discovered the magnitude 5.8 comet accidentally on the morning of 15 January 1941 while observing the variable star R Lupi. It once again demonstrates the value of being alert to the unexpected whenever observing. De Kock served as Director of the Variable Star Section of ASSA from 1948 until 1975, when Danie Overbeek took over.

Finally in terms of the historical contributions we come to Michiel Daniel Overbeek, better known as Danie, who certainly still is the AAVSO's most prolific variable star observer. He was born in 1920 and in 1951 he completed building a 6-inch newtonian reflector and submitted the first of his variable star observations to the AAVSO. Two years later he completed construction of a 12.5-inch Dall-Kirkham reflector, which he used for the majority of his over quarter of a million observations. The instrument was housed in a modest observatory above his study. The instrument was a fine one, but Danie once told me, 'the only telescopes used for meaningful observation are those held together with rubber bands and sticky tape', in reference to the fancy engineered scopes of latter day amateur telescope makers which are used more as show pieces than for doing 'real science'.

The fact remains that Danie Overbeek's contribution to variable star astronomy, made over half a century and entirely as an amateur, is immense. Not only for the fact that he made over 270 000 observations, but that he served as a mentor for the variable star observers of today. We owe it to him to continue this legacy.

## Modern day observations

These historical amateurs naturally concentrated on variable stars with larger amplitudes and periods and variables generally brighter than about magnitude 14, due to limitations in equipment and aperture. Nevertheless, they have contributed largely to the understanding of certain types of variable stars. The modern amateur has no such restrictions. With the advent of CCD and other instrumentation, powerful home computing options and economical access to larger aperture telescopes, observations and results can be derived of a standard that was before limited to professional observatories. Nearly all types of variable stars can now be studied by amateurs, contributing these on request to professional studies. The following are some examples of the types of observations amateurs can contribute to professionals.

**Long period variables:** Since visual observation of Mira type stars has been going on for well over a century, there is a need to continue visual coverage in order to study long term trends in period and amplitude. This is due to the fact that CCD photometry cannot simply take over due to the differing spectral response of the human eye and CCD chips. The AAVSO lists those stars which are desperately in need of observation. Despite this call, most of these stars are still sadly neglected. Consider as example the light curves in Figure 1. Above is the light curve of a well known and well observed southern variable, R Car. Below is the light curve for V Scl for the same period, one of those stars for which observations are urgently required. Clearly this star, well observed in Roberts time, is neglected by modern amateurs.

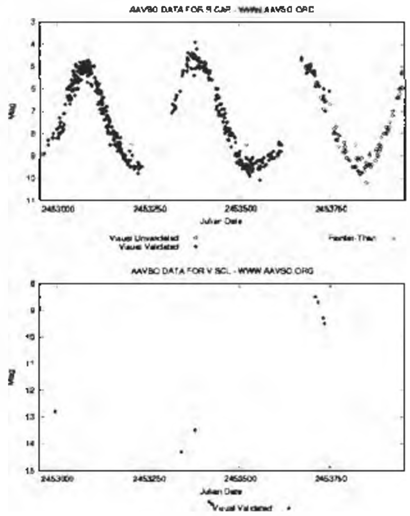

**Fig. 1 Light Curves for R Car (above) and V Scl (below). Courtesy AAVSO**

**Cataclysmic variables:** With the small number of active observatories and satellites, it is impossible for professionals to monitor all these stars on a continuous basis. Thus the amateur can play an important role by monitoring cataclysmic variables and providing professionals that study these stars with prompt notification of the commencement of an outburst. In addition amateurs are themselves able to study these stars. Berto Monard conducts time series photometry of a number of objects in conjunction with the Centre for Backyard Astrophysics. It is not necessary to have a CCD detector and large

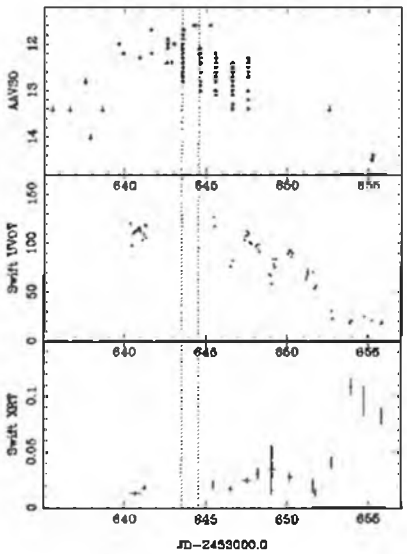

**Fig. 2 Light Curves for Z Cha (from Wheatley 2005). Reproduced with kind permission of Dr Peter Wheatley, University of Leicester, UK**

telescope to study cataclysmic variables. Figure 2 shows the results of observations of Z Cha in three wavelength regions (Wheatley 2005); UV flux and X-Ray emission from the Swift satellite compared to optical using the author's eye as detector! Using the eye it is also possible to observe the eclipses of the white dwarf and hot-spot by the secondary component, which have an amplitude around 1 magnitude (note vertical lines of observations within one nights observations).

**Eruptive variables – RCrB stars:** In the same way amateurs can provide constant coverage of R Corona Borealis type variables and notify professionals timeously of any fading behaviour. These stars are hydrogen deficient objects, burning helium to form carbon, which builds up in the atmosphere of the star, thereby decreasing the transparency of the atmosphere and blocking light from the star. Professionals are keen to understand the mechanisms of the fades, especially monitoring the dust in infrared during the early moments of the fades. Some of these stars, of which only perhaps two dozen are known, fade infrequently (e.g. Y Mus), while others seem to fade regularly (e.g. V854 Cen).

**Eclipsing variables:** Chris Middleton is studying the southern EB-type eclipsing binaries as part of a degree project in astronomy. Also called, W UMa stars, these are close binaries, which unlike most eclipsing stars show almost constant light variation. Chris studies these with a CCD camera on his 12-inch Schmidt Cassegrain.

With over 38 000 variable stars known, there is clearly much the amateur can do in conjunction with professional astronomers in observing and elucidating mechanism in the birth, life and death of stars.

## Comets, Asteroids and Meteors

Another field in which ASSA has contributed valuable observations is in the study of the debris of our own solar system; the comets, asteroids and meteors. We live in an era where significant discoveries are being made in these fields and many opportunities exist for amateurs to contribute to this process of discovery. The study of comets enables us to study the primordial solar nebula, including the composition, homogeneity and structure of the nebula. Our knowledge of cometary nuclei has grown with spacecraft flybys of 1P Halley, 21P Giacobini-Zinner, 26P Grigg-Skjellerup, 19P Borrelly and 81P Wild 2, while the Deep Impact mission monitored the impact with 9P Tempel. In 2014 a probe will attempt to land on 67P Churyumov-Gerasimenko. These missions are supplemented by results from amateur observations. Brightness and morphology studies with time and solar distance tell us more about different comets and their interaction with the Sun.

Since meteor showers are the dust residue left behind by comets as they round the Sun, their study tells us more about the parent comet, how dust is spread in the solar system and its interaction with the planets.

The boundary between comets and asteroids is becoming increasingly overlapped and many objects initially classified as asteroids are later re-classified as comets on the appearance of a coma. Clearly much work remains to understand the comet-asteroid relationship.

## Historical Contributions

The history of South African cometary astronomy can be traced back to 1652, with the first discovery of a comet from these shores by Jan van Riebeeck (Cooper 2003). Since then I find 57 comets which can be attributed to independent discovery or co-discovery from South Africa. The most prolific discoverers are William Reid and Michiel Bester with six discoveries each and Daniel du Toit with five. However, Reid was the only one of these to purposely hunt for comets, while Bester and du Toit found theirs on photographic plates used to study variable stars. If one considers this with the serendipitous discoveries of comet Houghton-Ensor (T Aps) and de Kock-Paraskevopoulos (R Lup) during variable star observations, the future discovery of a comet by a South African variable star observer cannot be discounted. However, the last discovery of a comet from South Africa was Haneda-Campos in 1978. Scientific study of comets has been less practiced and in recent times I have attempted to correct this situation.

Fraser (2006) summarised South African discoveries of asteroids. He finds the number of confirmed South African discoveries as 156, with Cyril Jackson (71), Hendrik van Gent (39) and E L Johnson (18) the most prolific. Apart from discovery and orbit determination, there was little scientific work done on asteroids until 1982 when Hers and Overbeek reported the first planetary occultation results in *MNASSA*. This program involves the timing of disappearance and reappearance of a star as the asteroid passes in front of it. With sufficient timings it is possible to determine the size and shape of the occulting object after plotting the reduced times and observers positions onto the fundamental plane. The number of successful results is shown in Table 4.

Despite the fact that meteors can be detected by various techniques, the historical observation of meteors involved mainly visual work. Notable contributions include Hoffmeister's (1948) list of 5 406 visual radiants compiled partly while he was in Namibia. Special watches were arranged during the 1950s under the then-director SC Venter, with contributions from JH Botham and A Morrisby. The latter also operated a meteor camera. In the last decades of the 20$^{th}$ century, Graham Poole detected meteors using the Grahamstown meteor radar, but this program has been discontinued.

| # | Date | Asteroid | Diameter | Observers* | Chords |
|---|---|---|---|---|---|
| 1 | 03/30/82 | 15 Eunomia | >309 | Overbeek | 1 |
| 2 | 05/05/83 | 65 Cybele | >150 | Hers | 1 |
| 3 | 08/08/84 | 87 Sylvia | >249 | Strobos, Hirsch | 1 |
| 4 | 04/21/85 | 12 Victoria | | V Ellinckhuyzen | 0.5 |
| 5 | 04/21/88 | 139 Juewa | 164±20 | Cooper, Wakefield | 2 |
| 6 | 07/09/88 | 250 Bettina | >97 | Coo, Wakefield, O/beek, Fraser | 3 |
| 7 | 06/15/90 | 3 Juno | | Overbeek | 1 |
| 8 | 06/15/91 | 356 Liguria | | Lund | 1 |
| 9 | 12/15/94 | 336 Lacadiera | >52 | Overbeek | 1 |
| 10 | 06/27/98 | 248 Lameia | 62x53 or | Coo, O/beek, Fraser, Smit, Lund | 5 |
| 11 | 10/14/99 | 48 Doris | 55x52 | Coo, O/beek, Fraser, de Jager | 4 |
| 12 | 06/11/00 | 345 Tercidina | 127x64 | Overbeek, Smit | 2 |
| 13 | 10/05/00 | 135 Hertha | | Turk | 1 |
| 14 | 05/22/00 | 5 Astraea | 162x96 | Streicher, Brakel | 2 |
| 15 | 01/07/02 | 712 Boliviana | | Streicher | 1 |
| 16 | 04/09/03 | 693 Zerbinetta | | Cooper | 1 |
| 17 | 08/05/05 | 246 Asporina | | Fraser, Smit | 2 |
| 18 | 04/09/05 | 42 Isis | | Streicher | 1 |
| 19 | 06/26/05 | 207 Hedda | | Fraser | 1 |

*Note: Coo = Cooper, O/beek = Overbeek

**Table 4: Successful asteroidal occultations**

The most active southern shower is the eta Aquarids, which are the outbound stream left behind by comet 1P Halley. They were observed by Tupman in 1870 (Roggemans 1989) and by ASSA during the 1950's and 60's, but were largely neglected in the past. Even during the apparition of the parent comet in 1986, there were few contributions from South Africa as part of the International Halley Watch. Since the late 1980s we have been concentrating more efforts on this shower, making some important contributions to its understanding (Cooper 1997, Dubietis 2003).

## Opportunities for modern amateurs - Comets

With the growing menace of light pollution in this country, along with many dedicated professional search programs, the opportunities for comet discovery have become limited. However, much useful work can still be done on brightness and morphology observation from the backyard, both visually and with imaging, in support of professional studies.

**Photometry:** The use of visual photometry is well established. At the 6th ASSA Symposium (Cooper and Begbie 2004) I presented a summary of brightness studies based on ASSA observations of several comets and concluded that this data to derive the true brightness performance, absolute magnitude and photometric constant of the comets compares well with global results. There is much scope for observers with CCD cameras to monitor comets at much fainter magnitudes while they are far south and out of view of the many observers in the northern hemisphere who do this work. The study of cometary nuclei is important to professionals to constrain models of solar system formation and evolution (Williams and Lowry 2006) and these are best studied at large distance while the nucleus is not surrounded by coma and hence at fainter magnitudes.

Ferrín (2005) has used visual photometric data to derive much more information on individual comets such as onset and offset of sublimation, time lag at perihelion, absolute magnitude, perihelion magnitude, nuclear magnitudes, secular amplitude and photometric description of the envelope of the comet. His work shows that amateur observations lead to a sharp edge to the lightcurve on the brighter edge and a more diffuse fainter edge. One way to reduce this error is to make brightness estimates with the smallest aperture possible to reliably show the comet. The secular light curve also depicts the nature of the envelope of the comet. Computing the mean magnitude may lead to systematic errors of 2-4 magnitudes. He has requested increased ASSA observations of comets at southern declinations to support his program.

Crovisier (2005) has shown the use of amateur visual data in deriving empirical production rates of gas from comets, particularly water vapour, which can be well correlated to professional methods of study.

**CCD Imaging:** Amateur astronomers can play a leading role in studying the behaviour of comets as they interact with the Sun. As the comet comes increasingly under the solar influence, constituents in the nucleus sublimate and gas and dust grains are released to form a coma. By imaging the comet on a nightly basis, or even several times per night, it is possible to measure differences in size and morphology, dust production rate, splitting and fragmentation of cometary nuclei and even spin rate of the nucleus. Spin rates can be determined by monitoring the rotation of features such as jets emanating from the nucleus and possibly from light curves for elongated bodies, such as for example the nucleus of comet 19P Borrelly. To date the spin rates of few comets have been derived.

A potential but as yet under-utilised technique to accurately determine nuclear size and shape of comets is that of occultations of stars, in the same way that the technique is used for determining this data for asteroids.

## Opportunities for modern amateurs - Asteroids

The first asteroid was discovered by Piazzi in 1801 [1 Ceres]. Today the number of bodies for which the orbits are known is over 200 000 (Marsden 2003) and more are discovered each year. The first Kuiper Belt Object was discovered in 1992 and today over 1 000 are known, 10 of which have diameters exceeding 1 000 km and one of which, Sedna, exceeds 3 000 km. Several objects are binary or possess satellites. Fitzimmons (2006) comments that many of the Near Earth Objects ($q<1.3$ AU) classified as asteroids may be inert comets. The amateur can play an important role in further understanding these bodies.

Discovery and orbit determination can be carried out using CCD imaging and by accurate positional measurements. Relationship with comets can be inferred from orbital grouping and by monitoring asteroids for the appearance of any coma. One example of an object previously classified as a main belt asteroid, but later as a comet is 133P Elst-Pizarro (Sky and Telescope 2006 August, p20).

Size and shapes can be studied by timing occultations of stars by small bodies. To be of real use requires a large number of observers contributing timings. ASSA simply needs many more observers than the handful currently active.

Rotation rates can be determined by measuring light curves over time. Light curves can be used to determine sidereal and synodic rotation periods, amplitudes and phase coefficients and pole orientation (Tedesco 1970). Since rotation rates are in the periods of hours many complete light curves can be constructed over one nights observations. Several asteroids have amplitudes that can be detected visually, while hundreds can be monitored by CCD photometry.

There is a growing list of binary asteroids and those with satellites. I summarised those suspected based on occultations or light curves (Cooper 1986) and today over one hundred objects have been confirmed to be binary or possess satellites. Again the amateur can embark on a program of discovery or to refine parameters of known objects.

### Meteors

The discovery that meteors are the debris left behind by comets was made in 1867 with the outbursts in the Leonids in that year coinciding with the return of comet 55P Tempel-Tuttle to perihelion. Today many annual showers are known and their association with parent comets has been confirmed due to similarity in their orbital characteristics. The amateur can make a considerable contribution to professional studies of meteors. Under Commission 22 of the IAU, Dr Peter Jenniskens chairs the working group on Pro-Amat studies of meteors, of which the author is a member. However, the contribution of ASSA observations to this group is sparse and needs to be improved. The following are areas where ASSA members can contribute.

**Visual observations:** Meteor science is one area where the amateur can make a significant contribution using only the naked eye. The particle density within a stream can be modeled in the form of an activity profile by counting meteors with time. The zenithal hourly rate is determined according to:

$$ZHR = \frac{N \times F \times r^{(6.5-LM)}}{T_{eff} \times \sin(h)} \qquad (1)$$

where:

- N = number of shower meteors observed
- F = factor correcting for obscuration by clouds, trees etc.
- r = population index, derived from magnitude distribution
- h = mean altitude of radiant above horizon
- LM = limiting magnitude
- $T_{eff}$ = observing time in hours corrected for breaks

The rate profile is then derived by plotting ZHR versus solar longitude. By monitoring the profile from year to year it is possible to monitor evolution of the stream. With sufficient observers and small time bins it is also possible to detect filamentary structure within the stream as the earth passes through bursts of particles caused by individual active events from the parent comet.

**Radio Monitoring:** In addition to known streams there exists a host of minor streams, transient streams or unexpected outbursts. Though some of these are detected visually (Jenniskens 1995) most are missed, but can be detected by radio reflection. Since meteors entering the atmosphere do so at high speed (typically 20-70 km/s) they leave a trail of ionised particles in their wake which reflect radio waves. Several stations have been set up around the globe, but attempts in South Africa have been fruitless to date and a gap exists in the southern hemisphere coverage.

**Photographic and video:** With the growing availability of still and video CCD cameras able to detect fainter objects, much scope exists to monitor meteors by camera. Meteor paths can be accurately determined by frame grabbing and plotting. From these plots the amateur can determine accurate orbital characteristics and radiant structure of meteor streams.

## Conclusion

The perception exists that amateurs need large telescopes and expensive equipment to contribute meaningful observations to professional studies. This notion is wrong and the examples in this paper show that amateurs can make excellent contributions visually and with modest equipment. There is a significant demand for South African observations and a call is made for more to become involved, in addition to the usual few dedicated observers currently active.

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