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News Note: ASSA Scholarships

Dr Claire Flanagan wrote (22 April 2019): The ASSA Scholarships Committee comprises five ASSA members, who allocate all scholarships administered by ASSA. ASSA currently administers two scholarships (the ASSA and the Cooke Scholarships). During 2018, we also allocated three HartRAO-ASSA scholarships. Students are invited to send just one application and will be considered for any of the scholarships available.

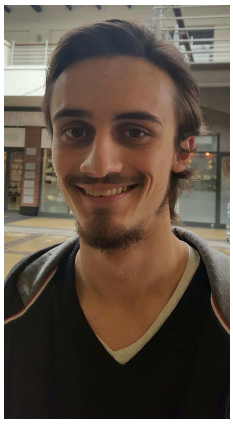
2018

Valid applications were received from seven students. All five scholarships were awarded.

The Cooke Scholarship was allocated to **Kelly Macdevette**, (left) then a third-year BSc student at UCT studying Astrophysics and Applied Mathematics. Kelly obtained good final results (including one distinction), and was awarded her BSc degree at the end of the year. During 2019 she intends studying towards a BSc (Hons) degree in the Department of Applied Maths at UCT, hoping to work on a cosmology-related project. Her long-term goal is a research career in Cosmology.

2019

Eight valid applications for two scholarships were received, and both scholarships were awarded.



The Cooke Scholarship was awarded to **Clinton Stevens**, currently in his final year of a BSc degree in Physics and Applied Mathematics at NWU (Potchefstroom). Clinton intends doing post-graduate studies at NWU, with the aim of pursuing a research / academic career in Astrophysics and Space Science. He has been doing programming work for the Centre for Space Research at NWU. His 2018 results include a number of distinctions in Mathematics and Physics.

News Note: SAAO 1.0m Telescope pivotal in the discovery of a 'Forbidden' Planet in the 'Neptunian Desert'

Matthew Burleigh and Daniel Cunnama

The South African Astronomical Observatory's 1.0m telescope provided crucial follow-up observations in new research published today by members of the Astronomy and Astrophysics Group at the University of Warwick, UK, detailing the discovery of an exoplanet in the so-called "Neptunian Desert".

The planet NGTS-4b, also nicknamed 'The Forbidden Planet' by researchers, is about 20 times the mass of the Earth and about 3 times the size. The planet orbits its host star in just 1.3 days with temperatures exceeding 1000 degrees Celsius. It was first noticed using the state-of-the-art Next-Generation Transit Survey (NGTS) observing facility, designed to search for transiting planets on bright stars. NGTS is situated at the European Southern Observatory's Paranal Observatory

The discovery relied heavily on follow-up observations made by Dr Matt Burleigh (University of Leicester) using the Sutherland High-speed Optical Cameras (SHOC) on the SAAO 1.0m Telescope in November 2017. This triggered an international effort to obtain further observations and a few weeks later it was confirmed that the transit was indeed a sub-Neptune exoplanet.

When looking for new planets astronomers look for a dip in the light of a star – this is the planet orbiting it and blocking the light. Usually, only dips of greater than 1% are picked up by ground-based searches, but the NGTS telescopes can pick up a dip of just 0.1%. With a dip almost that small, this exoplanet is, by a long way, the shallowest transiting planet ever discovered by a ground-based survey (the transit is less than 0.2%).

Dr Burleigh explained "Since this transit is so shallow, NGTS-4b wasn't initially one of our top priority targets. But thanks to the excellent telescopes at SAAO in Sutherland, we were able to detect and confirm the transit, convincing ourselves the planet is real. We then set in motion many more observations to measure its mass and size." It is the first exoplanet of its kind to have been found in the "Neptunian Desert", which is the region close to stars where, up until now, no Neptune-sized planets have been found. This area receives strong irradiation from the star, meaning the planets do not retain their gaseous atmosphere as they evaporate, leaving just a rocky core. However, NGTS-4b still has its atmosphere of gas leading researchers to believe the planet may have moved into the Neptunian Desert recently, in the last one million years, or that it was originally very big and its atmosphere is still evaporating.

The Great Red Spot in 2019 and its unusual interaction with retrograding vortices

Clyde Foster (1) clyde@icon.co.za, John Rogers (2), Shinji Mizumoto (3), Andy Casely (4), and Marco Vedovato (5)

(1) Astronomical Society of Southern Africa; (2) British Astronomical Association, London, UK; (3) ALPO-Japan; (4) Independent scholar, Australia; (5) JUPOS team, Italy.

Abstract: Early in the 2019 Jovian apparition, ring-like structures on the southern edge of the South Equatorial Belt (SEBs) were recorded by various amateur planetary imagers. Due to the retrograding jet at this latitude, the rings were progressively drawn towards, and into, the Great Red Spot Hollow (GRSH). This resulted in deformation and ultimate dispersal of the rings, with interaction taking place with the Great Red Spot (GRS) as well as the South Equatorial Belt (SEB) immediately following the GRS. These interactions were apparently responsible for the repeated detachment of red 'blades' from the GRS. Concurrently, an elaborate structure developed on the SEBs following the GRS, with dark material being drawn from this structure around the GRS, This paper presents the development of the SEBs rings and their subsequent interaction with the GRS and surrounding region, based largely on observations by the first author.

1 Introduction

Since 2014, the GRS has been smaller than at any time in the last two centuries, and has had a dark red colour that was hardly ever seen except when the SEB was whitened. For several years it has also been largely undisturbed by retrograding rings (vortices) travelling westward along the SEBs; these have been generally sparse in the last few years.

The first author has monitored the planet Jupiter from his location in Centurion, Gauteng, South Africa for the last 5 years. Primary equipment has consisted of a Celestron 14" Edge HD Schmidt-Cassegrain telescope combined with various planetary imaging cameras. Monochrome imaging using various filters has been the primary technique employed.

The state of the GRS and SEB over this period has been documented by J.H.R. in BAA Jupiter Section reports (https://www.britastro.org/node/17157), and by S.M. in compilations of maps on ALPO-Japan: (http://alpo-j.asahikawa-med.ac.jp/Latest/j_Cylindrical_Maps/j_Cylindrical_Maps.htm). After solar conjunction in 2018, good-quality ground-based imaging began in 2019 Jan. Meanwhile, the Juno spacecraft camera obtained views of the GRS at perijoves 17 (Dec.21), 18 (Feb.12) and 19 (April 6), especially at PJ18 when Juno flew very close to the GRS.

2 SEBs retrograding rings and their interaction with the GRS in 2019

Early in the 2019 apparition, amateur ground-based images started to capture an interesting structure along the SEBs edge. Oval or ring-like structures had formed and these were being carried in a retrograding direction due to the jet stream at this latitude. This renewal of the typical SEBs jet activity occurred across large sectors of longitude. It was maintained at least from February to May and appeared to be generated by the turbulent region following the GRS. Due to this retrograde motion, some of the rings were carried into the GRS Hollow, resulting in deformation of the rings, and interaction with both the GRS itself as well as the SEB immediately following the GRS.

During this period, various amateur imagers were able to capture red streaks or "blades" apparently sweeping off the west end of the GRS. They were also seen in JunoCam images at PJ17, 18 and 19 (see Figure). In view of their red colour and their brightness in methane-band images, they appeared to be material detaching from the GRS.

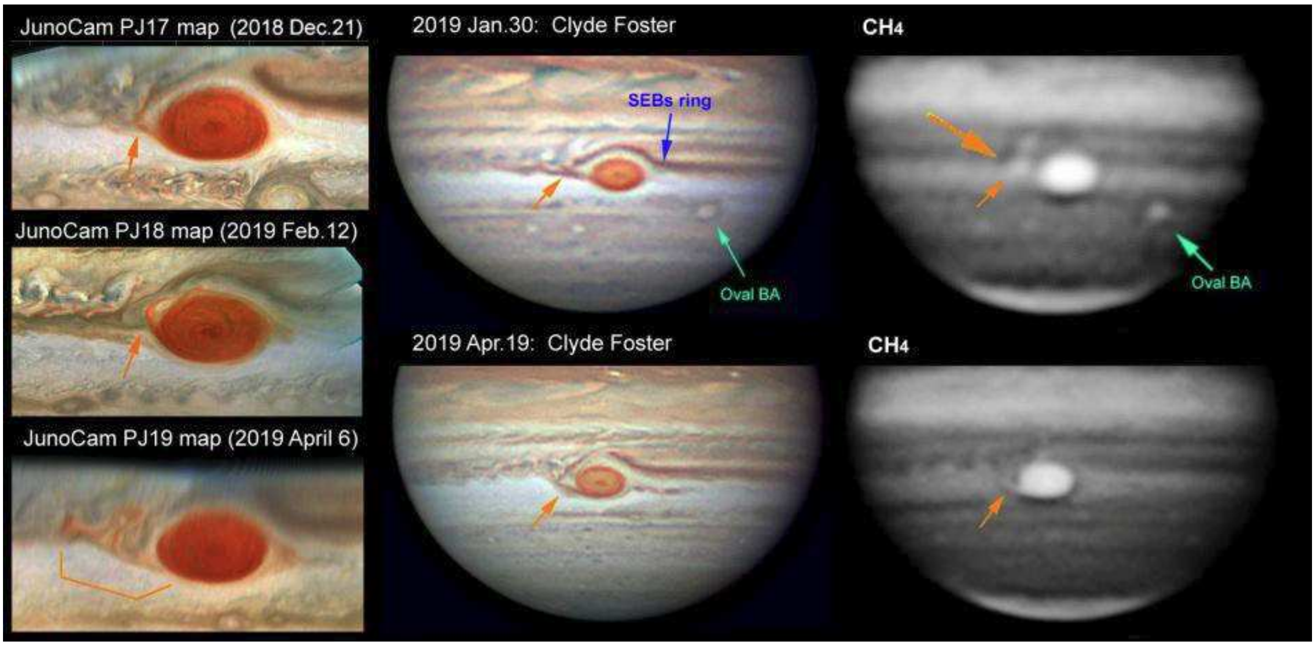


Fig 1: Left: Cylindrical maps from JunoCam images of the GRS. (Credit: NASA/SwRI/MSSS/ Gerald Eichstädt / John Rogers.)
Right: Examples of images by C.F. All show red 'blades' (orange arrows).

Maps of amateur images showed that each of three successive 'blades' was formed within a few days after a retrograding ring entered the GRSH, suggesting that these vortices were disrupting the periphery of the GRS. The red fragments last for more than a week, extending westward within the SEB(S). Their reddish colour is often difficult to distinguish from the brown of the belt but they can be identified as methane-bright.

In early April, another pair of retrograding rings was observed approaching the GRSH. Amateur images and map animations were able to monitor the distortion of the rings as well as their movement along the edge of the hollow, whilst interaction with the GRS itself was also observed. Indeed they triggered the emergence of a pair of red blades from the GRS (April 17-20). However, the interaction became more complex. A dark hook-like structure developed on the southern edge of the SEB immediately following the GRS. (This was reminiscent of the South Tropical Disturbance (STrD) that was passing the GRS in early 2018, although it did not have the circulation pattern of a true STrD.)

Some of the dark material in the hook-like structure was captured by the prograde jet that flows past the south edge of the GRS, forming a very dark grey ring around the GRS, and was distributed into the South Tropical zone preceding the GRS. This was a dynamic stream with multiple concentrations and extensions. Further observations of this stream, and comparison with the 2018 STrD, will be reported.

3 Discussion

Similar red 'blades' have occasionally been reported in the past, and may have been under-reported because they are only detectable with high resolution. Nevertheless, it is possible that this behaviour has only recently become common. In the Voyager 1 movie in 1979, SEBs retrograding rings were swinging round the GRS with vigorous interactions but not usually causing obvious disruption of the GRS itself as at present. In publicly posted maps from the Hubble Space Telescope, no such feature was recorded in 2014, 2015 or 2016; but the paired maps of 2017 Feb.2 showed a similar red 'blade', and showed its dynamics over 10 hours. The GRS periphery has also appeared 'ragged' in subsequent Hubble and JunoCam images, although the recent 'blades' appear more substantial. We suggest that the small size of the GRS has made it susceptible to disruption by incoming vortices in a way that did not commonly occur previously.

4 Acknowledgements

We are grateful to the other amateur observers whose images enabled continuous coverage of these events. We also acknowledge the NASA JunoCam team for the JunoCam imagery.

News Note: SKA Consortium completes design of Science Data Processor

The role of the SDP consortium was to design the computing hardware platforms, software, and algorithms needed to process science data into science data products (astronomical images). The SKA SDP will be composed of two supercomputers, one located in Cape Town, South Africa to process data from SKA-Mid, and one in Perth, Western Australia, to process data from SKA-Low. South African Radio Astronomy Observatory (SARAO) scientists, as well as SARAO-funded industry, have been members of the SDP Consortium since the approval of the concept design review in 2012.

An international consortium of computing specialists, led by the University of Cambridge in the United Kingdom, has completed the engineering design work of the Science Data Processor (SDP) for the Square Kilometre Array (SKA) Radio Telescope, to the level required for a Critical Design Review (CDR).

The role of the SDP consortium was to design the computing hardware platforms, software, and algorithms needed to process science data into science data products (astronomical images). The SKA SDP will be composed of two supercomputers, one located in Cape Town, South Africa to process data from SKA-Mid, and one in Perth, Western Australia, to process data from SKA-Low.

The South African Radio Astronomy Observatory (SARAO) scientists, as well as SARAO-funded industry, have been members of the SDP Consortium since the approval of the concept design review in 2012. SARAO's Technical Lead for Scientific Computing, Simon Ratcliffe, was selected as the SDP Consortium System Engineer in 2012, and SARAO System Engineer, Shagita Gounden, was appointed to the SDP Consortium on a full-time basis to work on the control and monitoring component of the SDP – the system that allows sub-elements within the SDP to communicate with each other, as well as with external elements such as the Telescope Manager and the Central Signal Processor. In addition to SARAO's contribution, South Africa's Space Advisory Company (SAC) and Eclipse Holdings, who were awarded funding from SARAO's Financial Assistance Programme (FAP), seconded four engineers to the SDP consortium. As part of this effort, SAC's Data Processing System Engineer, Ferdl Graser, was appointed as the SDP Consortium System Engineer in 2014, and has distinguished himself in this role, culminating in the recently passed Critical Design Review.

The CSIR Centre for High Performance Computing (CHPC) and the University of Cape Town (UCT) are other South African members of the SDP Consortium. The CHPC provides compute platform testing and innovation services, by leveraging the significant compute resources it has available, while UCT provides the lead of the SDP delivery work-package through Professor Rob Simmonds, from the Department of Computer Science, as well as supporting the Inter-University Institute for Data Intensive Astronomy.

SARAO Managing Director, Dr Rob Adam, congratulated the SKA SDP Consortium on passing the Critical Design Review and said he was proud of the world-class design work completed by SARAO system engineers, which will contribute to the SKA's ability to monitor the sky in unprecedented detail. "The unique requirements for the SDP have also driven our specialists to be creative and design unique technologies that allows SARAO to contribute to economic development and commercialisation in South Africa."

SARAO will continue to play an important role in the SKA bridging phase, during the lead up to construction of the SKA SDP. Through an extension of the FAP programme, five industry-based engineers, as well as three SARAO employed engineers, will work with international computing specialists to develop and construct the SDP.

News Note: First light for CAMS@SA

Tim Cooper, Bredell Observatory

On the night of 13/14 June 2019, sixteen cameras peered skywards and measured the orbits of 49 meteors as they entered earth's atmosphere at an altitude of around 95km. This was the result of the first-light runs of CAMS@SA, now operating as part of the global Cameras for All-Sky Meteor Surveillance (CAMS) project, run under the guidance of NASA's SETI Institute.

CAMS@SA is a collaboration between Hartebeesthoek Radio Astronomy Observatory (HartRAO), with Philip Mey as coordinator, and Tim Cooper (Coordination CAMS South Africa). The current setup comprises two sites each with eight low light CCTV cameras situated at Hartebeesthoek and Bredell Observatories. Pieter Stronkhorst and Jacques Grobler provided engineering support for the camera mounts and enclosures, and the mounts were machined by Richard Moralo based on the design and drawings prepared by Pieter Stronkhorst.

CAMS has the mission statement - **an automated video surveillance of the night sky to validate the IAU Working List of Meteor Showers**. With that in mind CAMS has been running in the northern hemisphere since 2007 and by 2013 had determined over 100 000 meteor orbits. In 2014 the network was expanded to the southern hemisphere, with two stations with sixteen cameras each in New Zealand. Following discussions between Tim Cooper and Dr Peter Jenniskens we decided to set up CAMS stations in South Africa, and the first light runs are the final realisation of that goal. The details of the CAMS@SA program are described in the following article.

For more details on the CAMS program visit : http://cams.seti.org/

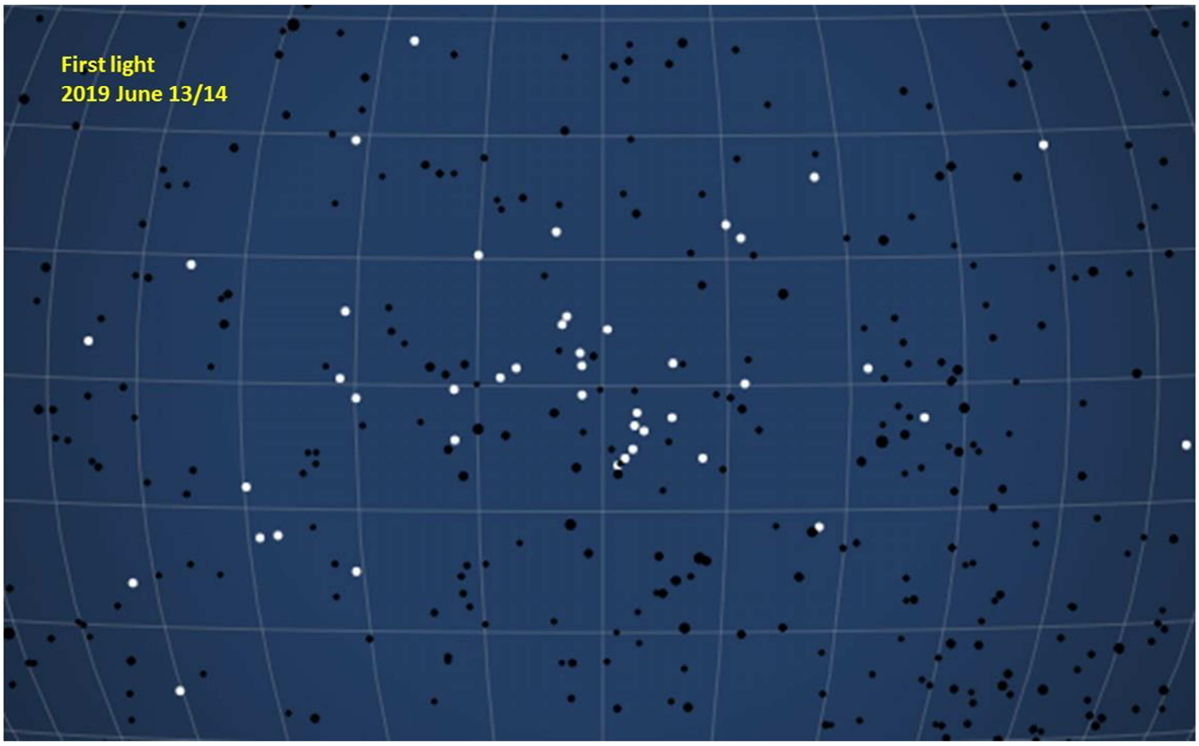


Fig 1: for first light for CAMS@SA, apparent radiants for 49 meteors on the night of 2019 June 13/14. Black dots are stars, white dots are derived meteor radiant positions. Note the concentration around the constellations of Scorpius and Sagittarius, from where most of the Anthelion meteors radiate at this time of year.

Detection of Meteor Streams and first light for CAMS@SA

Tim Cooper, Bredell Observatory

Abstract

Meteors are the debris left behind during the passage of comets around the Sun. After release from their parent comet, these meteors continue to orbit the Sun in a similar orbit to the parent comet and, when the orbits of the Earth and meteor stream coincide, the result is a meteor shower. While many showers exist for which the parent is unknown, these showers are the smoking guns of comets that have

previously intersected with Earth's orbit, and may do so again in future. The use of low light video to detect meteor streams and its use in the identification of potentially hazardous comets, which have yet to be discovered, is described. The participation in the Cameras for All-sky Meteor Surveillance (CAMS) network in conjunction with the SETI Institute, and the consequent setup and first light of the CAMS@SA network, which is a joint development between the author and Hartebeesthoek Radio Astronomy Observatory (HartRAO), is outlined.

Meteor Streams and their relation to comets

Around the time Halley was doing pioneering work on cometary orbits, meteors had been thought to be due to terrestrial phenomena within Earth's atmosphere, such as for example the ignition of sulphurous vapours (Beech 1994a). The first triangulation of a meteor event was attempted by Halley (1719), when he collected numerous sightings of the very bright bolide of 19 March that year (Julian calendar). From a number of eye-witness accounts Halley derived its probable path and published his results in the Philosophical Transactions of the Royal Society, concluding "they abundantly evince the height thereof to have exceeded sixty English miles." Actually the value he arrived at was around 64 miles, or 103 km above the town of Prestaigne. Greg (1860) records the same fireball in his catalogue of 1860, citing:

N.N.E to S.S.W.? brilliant; oval; loud detonation over S. of England. March 19. Seen 65 miles over Hereford; burst? 70 miles high; v.=350 miles per minute; d.=1½ miles; seen all over Northern Europe. Halley calculated it at 150 miles high when first seen; 8000 feet d.; v.=5½ miles in a second. Another account gave 297 miles high.

While we now know that the meteors do not begin their visible passage at such high altitudes, the value determined by Halley around 103 km is in good agreement with modern understanding of the height at which meteors ablate, and his results can be considered the start of a process of triangulating meteors that today forms the basis of detecting new meteor streams.

Given the energetic nature of the 1719 event, it may well have been a small fragment of an asteroid rather than of cometary origin, but in any case Halley could not have made the association as the first asteroid, Ceres, was only discovered by Piazzi on New Year's Day 1801 (Pilcher 1979). Also at that time, the relationship between meteors and comets had not yet been realised. It was not until 1798 that Chladni suggested that meteors could not be 'explained from the accumulations in the upper regions of the atmosphere' (Beech 1994b) and therefore they could not be terrestrial in origin. About that time Brandes and Benzenberg conducted double station observations of meteors in order to determine their paths, and concluded that meteors must have an extra-terrestrial origin (Roggemans 1989). Only after the

Leonid storms of 1799, 1833 and 1866, and the discovery of comet 55P/Tempel-Tuttle in 1865 was it realised that the orbits of the Leonid meteors bore a striking resemblance to that of the comet, and that the outbursts coincided with the return of the comet to perihelion in its 33 year orbit. Other associations followed, including the realisation in 1866 that the Perseids are the debris of comet 109P/Swift-Tuttle, and in 1867 that comet C/1861 Thatcher is the parent of the April Lyrids (Jenniskens 2006a).

Historical perspective of meteor imaging

The first person to photograph a meteor was Ladislaus Weinek (Hughes 2013). He set up two stations at Prague and Jena with the intention of photographing meteors from comet 3D Biela to determine their height. The comet was discovered by Wilhelm von Biela in 1826 and returned as predicted in 1832, but on its return in 1846 it was seen to have split into two pieces.   The two pieces were last seen in 1852, after which the comet was lost. At its predicted return in 1872 it was not seen, but instead a spectacular meteor shower was observed. The Andromedids are the remnants of comet 3D Biela, and weak activity can still be observed in present times. Weinek was not successful in capturing double-station images, but he did manage to capture a single meteor on one plate taken from Prague on 27 November 1885, the first recorded image of a meteor.

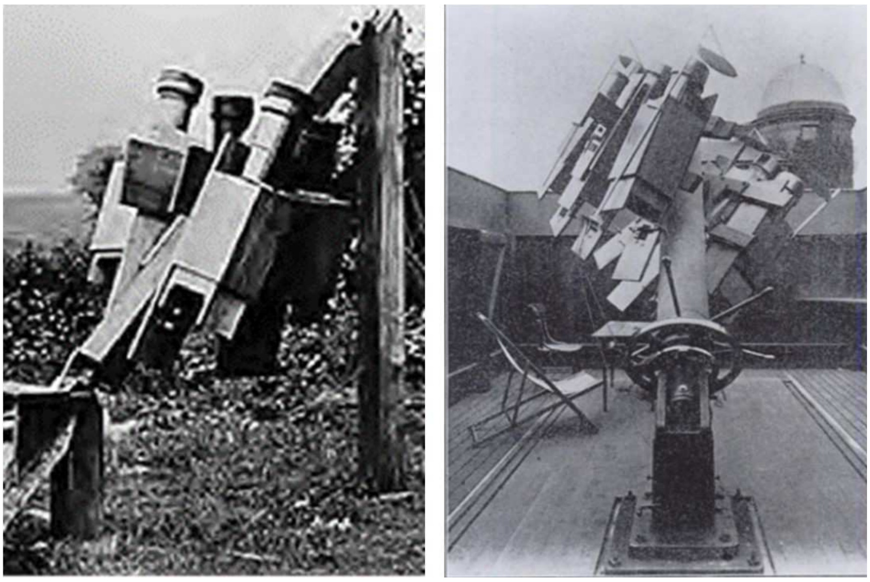


Fig 1. Two camera arrays used by Elkin to record the altitude and velocity of meteors. Pictures from Hughes 2013.

The second image of a meteor was on a Harvard College Observatory plate exposed on 12 September 1887 (Hughes 2013). In 1889 W Lewis Elkin pioneered double-station meteor photography using rotating shutters in order to derive both the altitude and velocity of the meteors (Figure 1). Elkin had previously spent several years in the Cape at the invitation of Sir David Gill, where they collaborated to measure the stellar parallaxes of several bright stars (Schlesinger 1936). In the subsequent period between 1894 and 1910 he managed to image around 130 meteor trails and derive their velocities (Hoffleit 1975, Williams 2004). Later the technique found success with the work of Willard J Fisher, Peter Millman, Dorrit Hoffleit and

Fred Whipple. Fisher and Olmsted (1931) published a catalogue of meteor trails captured on HCO plates up to 1930, and Hoffleit followed this with a second catalogue in 1937, including meteors captured at the Boyden station (Figure 2). So it is evident that South Africa already played a role in the early history of meteor imaging.

Fig 2. Image of meteor recorded in the Catalog of the Harvard Observatory Meteor Photographs (Millman, P. M., Hoffleit, D., & Shapley, H. 1937).

Meteor Streams from Short and Long Period Comets

On the assumption then that comets are the parent bodies of meteor showers and that showers can be used to identify potentially hazardous comets, it is useful to briefly consider the formation of a meteor stream from a comet. Comets originate from two known sources; the Oort Cloud, and the Kuiper Belt, or scattered disk, outside the orbit of Neptune. Both sources lead to differing orbital characteristics which delineate the comet families. The Oort Cloud is thought to be a roughly spherical reservoir of cometary material, with a tendency to high orbital inclinations, peaking at i = 145°, largely due to the contribution of the Kreutz family of comets. New comets approaching for the first time travel on nearly parabolic orbits with original semi-major axes a_0 >10 000 AU (Dones et al, 2004). These comets approach without warning, and do not concern us in this paper. On the other hand there are a number of returning Oort Cloud comets which have made at least one previous passage through the inner solar system, and they can be discerned from their original semi-major axis a_0 <10 000 AU. These long period comets may still have periods of several thousand years, so they too approach without warning since their previous perihelion passage was before recorded history. If their orbits intersect Earth's orbit, the potential exists for a collision if the comet and earth are in the vicinity at a future nodal crossing, and hence these comets are considered potentially hazardous. Since they have made at least one passage through the inner solar system and laid down a stream of debris, their presence can be inferred by detection of the meteor stream from the parent comet.

The Trans-Neptunian Objects are a belt of small bodies probably ejected beyond the orbit of Neptune during formation of the early solar system, and include both the scattered disk and classical Kuiper Belt Objects, with semi-major axes $30<a<50$ AU (Morbidelli and Brown 2004). Interactions with Neptune perturb their orbits so that they approach the sun, and it may be that the classical Kuiper Belt is the primary source of the short period comets (Kuchner, Brown and Holman, 2002). While some KBO's may have high orbital inclinations, greater than 60°, the majority have inclinations ≤ 15°, and thus orbit close to the ecliptic plane. This introduces the possibility of interactions with the other major planets, particularly Jupiter, resulting in further changes to the comet's orbit. There are currently 363 known short period comets listed by the MPC (2017). In addition there are 347 short period comets which have not been numbered, either because they have not yet made a second return to perihelion since discovery, or because the comet was not re-observed and was lost after the discovery apparition, and 263 asteroids in comet like orbits (Yoshida 2017) which may be comets but so far have not displayed signs of a coma. In all of these cases the orbits are sufficiently well known so that any relationship with established meteor showers is known. There remain however many minor showers for which the parent body remains to be identified.

Irrespective of the source, comets comprise the materials left over from the primordial solar nebula, including both volatile gases, and more complex organic molecules and inorganics in the form of dust particles. The three most prevalent volatiles are invariably water vapour, carbon monoxide and carbon dioxide, though the relative amounts vary from one comet to another. At the distance of the Oort Cloud and Kuiper Belt the temperature of the nucleus remains below the sublimation point of cometary volatiles, and consequently the nucleus remains in a frozen state and the body is asteroidal in appearance. As the nucleus approaches the sun it comes under the ever-increasing warming effect of solar radiation, and at some stage the temperature rises sufficiently to cause the sublimation of carbon monoxide, and the nucleus transitions to form a gaseous coma. At the same time dust particles are released from the now-active nucleus. Ferrin (2009) has determined the distance from the sun at which the nucleus switches on for several comets and finds R_{ON} in the range –1-17 AU. Similarly as the comet recedes into the outer solar system after perihelion, the point at which the comet ceases to be active, R_{OFF}, is in the range +1-34 AU. Clearly activity ceases at a much larger distance from the sun on the outward passage due to the nucleus having been warmed for a prolonged period prior to and during perihelion passage. What is clear is that in some cases the nucleus can remain active for a large arc of the comet's orbit, during which time it is able to release dust grains into its path. Even in the case of a short period comet such as 1P Halley, P~75 years, which is the parent of two meteor showers, the nucleus had already become active during its last apparition at a distance of 6.15 AU, while C/1995 O1 Hale-Bopp, a long period comet which pre-perihelion had P~3400 years, had already switched on at R=17.3 AU. If the orbit of the laid down stream intersects the orbit of the Earth, then a meteor shower results if there are particles in the vicinity at the time the earth moves past the node in its orbit. The mere fact that a meteor shower exists at a given solar longitude is an indication that at least a 1-revolution stream exists, laid down by the parent comet in a historical passage around the Sun, and that the parent comet may return and cross earth's orbit again in the future. Meteor showers with no known parent then are the smoking gun revealing the existence of an Earth-crossing comet yet to be discovered.

The incidence of meteor showers and their parent bodies

The current IAU Working List of meteor showers (Jopek and Kanuchova 2014, Rudawska et al 2017) documents 790 entries, of which only 119 are confirmed as being active. There remain therefore a large number of showers which require confirmation and further investigation to determine the parent body. All of these streams, if their existence is confirmed, are indicators of potentially hazardous comets that could in future be on a collision course with Earth. The number of showers for which a parent body has been confirmed (Jenniskens 2006b) numbers only 35 (Table 1).

Table 1 Meteor showers with confirmed parent body (after Jenniskens 2006b)

Name	**IAU No/Code**		**Parent**	**i**	**q**	**Period**
Jan Comae Berenicids	90	JCO	C/1913 I Lowe	188		123
Quadrantids	10	QUA	2014 TB18	18.7	1.83	2.84
β Tucanids	108	BTU	C/1976 D1 Bradfield	46.8	0.85	~1600
δ Pavonids	120	DPA	C/1907 G1 Grigg-Mellish	110.0	0.92	162
Daytime q Pegasids	129	QPE	2005 EM169	10.9	0.75	4.83
Lyrids	6	LYR	C/1861 G1 Thatcher	79.8	0.92	415.5
π Puppids	137	PPU	26P Grigg-Skjellerup	22.4	1.09	5.24
η Aquariids	31	ETA	1P Halley	162.3	0.59	75.3
η Lyrids	145	ELY	C/1983 H1 Iras-	73.3	0.99	959

π Cetids *	158	CET	Araki-Alcock C/1874 G1 Winnecke ?	148.3	0.89	
τ Herculids	61	TAH	73P Schwassmann-Wachmann 3	11.2	0.97	5.44
June Boötids	170	JBO	7P Pons-Winnecke	22.3	1.24	6.32
Daytime Arietids	171	ARI	Marsden Group	ẋ=26	ẋ=0.05	
Daytime β Taurids	173	BTA	2004 TG10	4.2	0.31	3.34
α Capricornids	1	CAP	169P NEAT = 2002 EX12	11.3	0.61	4.20
South δ Aquariids	5	SDA	Marsden Group	ẋ=26	ẋ=0.05	
ψ Casseiopeids	197	PCA	1973 NA	68.0	0.89	3.80
Perseids	7	PER	109P Swift-Tuttle	113.5	0.96	133.3
β Indids	195	BIN	C/1991 L3 Levy	19.2	0.98	51.3
ζ Draconids	73	ZDR	6P d’Arrest	19.5	1.36	6.56
Aug δ Capricornids	199	ADC	45P Honda-Mrkos-Pajdusakova	4.2	0.53	5.26
α Aurigids	206	AUR	C/1911 N1 Kiess	148.4	0.68	2497
κ Leonids	212	KLE	C/1917 F1 Mellish	32.7	0.19	145.0
Daytime Sextantids	221	DSX	2005 UD	28.7	0.16	1.44
Orionids	8	ORI	1P Halley	162.3	0.59	75.3
Leo Minorids	22	LMI	C/1739 K1 Zanotti	124.3	0.67	
October Capricornids	233	OCC	D/1978 R1 Haneda-Campos	5.9	1.10	5.97
October Draconids	9	DRA	21P Giacobini-Zinner	31.9	1.03	6.59
Leonids	13	LEO	55P Tempel-Tuttle	162.5	0.98	33.2
Northern Taurids	17	NTA	2004 TG10	4.2	0.31	3.34
Southern Taurids	2	STA	2P Encke	11.8	0.36	3.30

Andromedids	18	AND	3D Biela	13.2	0.88	6.65
Dec Monocerotids	19	MON	C/1917 F1 Mellish	32.7	0.19	145.0
Ursa Minorids	15	URS	8P Tuttle	55.0	1.03	13.61
Phoenicids	254	PHO	289P Blanpain = 2003 WY25	5.9	0.96	5.32
Geminids	4	GEM	3200 Phaethon	22.3	0.14	1.43

* Parent body for the pi Cetids is not confirmed, and is given here for local interest sake only, shower noted by J C Bennett, observing from Kruger National Park on 1977 June 28.
# C/1917 F1 has also been linked to the April ρ Cygnids (Neslusan et al, 2016)

Most have a cometary parent, totalling 28 of the known parent bodies, but there are also those, such as the Geminids, which apparently have an asteroidal parent, in this case asteroid 3200 Phaethon. But the orbit of this asteroid is more like that of a short period comet, and it is probably a cometary nucleus from which the volatile matter has been stripped following a long epoch of perihelia to become a dead comet. Indeed it is probable that cometary activity decays over time, and comets approaching to within 1 AU of the Sun probably survive around 1 000 perihelion passages before their volatiles are depleted (Marsden 1971) so that the remnant cometary nucleus has the appearance of an asteroid, but in a comet-like orbit.

There is a growing list of meteor shower detections (Jenniskens et al 1997) for which there is no immediately apparent parent comet. These far-comet type outbursts occur without warning and are generally of short duration, implying that they are the result of the 1-revolution debris streams from long period comets which have collected into a narrow filament and have not had sufficient time to disperse away from the original orbit. The short duration in activity also implies there is a narrow window of longitudes on earth from which the outburst is likely to be observed, and many such outbursts in the past have probably been missed.

One of the earliest far-comet type outbursts recorded by low light video detection was that of the 1995 alpha Monocerotids (Jenniskens et al 1997). Following outbursts in 1925, 1935 and 1985, Jenniskens (1995) predicted a further outburst of this stream due to interactions with both Jupiter and Saturn which were in similar positions in their orbits to the previous outburst years. The 1995 outburst occurred as predicted, with a very narrow maximum on November 22.06, with duration about half an hour and zenithal hourly rate (ZHR) reaching about 500/hr at its peak. Seven shower meteors were captured simultaneously by video which enabled triangulation and determination of the orbital elements, and yielded an orbital period for the parent comet of >140 years. The parent comet remains unidentified, but the details of this potentially hazardous comet are now known due to triangulation of particles in the debris stream that betray its existence, enabling focused searches for the comet prior to any impending return to the solar neighbourhood.

Confirmation of meteor streams, detection of new meteor streams and overview of CAMS network

This first success, which confirmed the existence of a dust stream from a potentially hazardous comet, is a forerunner of the Cameras for All-Sky Meteor Surveillance network that exists today. The original network was conceived in 2007 (Jenniskens et al 2011), and three stations were set up and commissioned in November 2010. The goal was to use a number of low light level security cameras to determine the orbits of double station recorded meteors, in order to validate the unconfirmed showers and detect new, previously undocumented showers. Today the CAMS objective remains 'An automated video surveillance of the night sky to validate minor showers in the IAU Working List of Meteor Showers'.

The principle of CAMS is the use of narrow field cameras to improve measurement accuracy. Image acquisition is by means of an array of Watec 902H cameras fitted with Pentax 12mm f1.2 lenses giving a FOV of 30° x 25° for each camera. The cameras are arranged so that their fields of view overlap, enabling coverage of a wide expanse of sky. The arrays at the two stations are then oriented in such a way as to ensure they view the same part of the atmosphere at an altitude of around 95km. In this way any meteors appearing at this altitude in the atmosphere are captured from both sites and can be triangulated to determine their orbital characteristics. The Watec cameras are fitted with a ½ inch interline transfer CCD chips with 811 x 508 pixels. The pixel size is 8.4 x 9.8µ giving a resolution of 2.6' per pixel, and the sensitivity is 100 microlux, which is sensitive enough to detect magnitude 5 stars with typical exposure times employed. This sensitivity coupled with the narrow field of view enables accurate frame calibration and measurement of the start and end coordinates of meteors captured. During exposure, any meteors are captured by means of a Sensoray Model 812 frame-grabber card, and are stored for astrometry after the nights run.

Frames in which meteors are captured are processed using CAMS 2.0 software. The protocols are beyond the scope of this paper but are described fully in Jenniskens et al 2011. Astrometry for meteors detected simultaneously from two sites are measured to determine orbital elements, which are then used to produce radiant maps for each observing session, and any radiants active above the sporadic background are identified. The stream to background ratio S/B is calculated for potential radiants, with S/B ≤2 indicating a tentative radiant, and S/B>3 a strong indication of an active shower radiant. The mean orbital elements derived from the detected radiants can be used to infer the orbital elements of the original parent body of the captured meteors.

The CAMS network was initially limited to the United States, with 60 cameras located around latitude +37°N and expanded with the BeNeLux network around latitude +52°N (Jenniskens et al 2016). By 2013 over 100 000 meteor orbits had been determined which enabled a good understanding of the distribution of meteor radiants north of declination -20°, including 60 newly-identified showers from CAMS data. Despite this success however a gap remained south of declination -20°, due to no CAMS networks operating in the southern hemisphere. Attention now switched to changing this state of affairs, resulting in the first two southern hemisphere CAMS stations in New Zealand which began operation in September 2014. These stations have already been very successful in closing the gap in coverage of the southern sky below declination -20°S. In 2017 alone, the cameras at Geraldine and West Melton had detected almost forty new showers which have been added to the IAU Working List (Jenniskens 2017). Another notable confirmation emanating from this network was that of the delta Mensids (Jenniskens et al 2016). Originally detected visually and in radar surveys nearly fifty years ago, the existence of the shower was finally confirmed in data from 17-22 March 2016, which also enabled determination of the streams orbital elements.

Setting up CAMS@SA. First results and future development

The author and Peter Jenniskens at NASA's SETI Institute had been discussing the possibility of setting up a South African CAMS station for some time. The two stations in New Zealand had already filled a gap in southern hemisphere coverage, but due to the short duration of meteor outbursts many are probably missed if they occur during the daylight hours in New Zealand. Therefore there was a need to expand the southern hemisphere coverage to longitudes coinciding with Southern Africa and South America to ensure continuous dark sky coverage around the clock. This fact was reinforced with the potential for a meteor shower from the recent apparition of comet C/2015 D4 Borisov (Jenniskens and Lyytinen 2017). If any meteors would be observable from the dust stream left behind by this comet, they would only be detected for a short period of 1-2 hours around nodal crossing which occurred during the early morning local time for southern African longitudes. As a result Cooper and Toumilovich (2017) set up a double station array with four cameras each at Bredell and Victory Park. The intention was to use the comet Borisov event as a pilot and to convert this to a permanent network later with additional cameras being added to increase sky coverage. First light trial runs were made during the night of 2017 July 22/23 and resulted in orbital elements for 87 meteors observed simultaneously that night. Thereafter, both stations ran throughout the night of 2017 July 28/29, starting the capture process immediately after darkness fell, and continuing until 04h00 UT, with any activity from comet Borisov predicted to occur centred on 02h00 UT. The full nights run resulted in 167 meteors captured simultaneously from the two stations at Bredell and Victory Park. Most of these could be traced back to the radiant of the Southern delta Aquariids. Unfortunately we could not confirm the existence of a dust stream from comet Borisov, but this negative result was important nonetheless, as it indicates the comet was not active at that point in its orbit, and yielded valuable experience for the future CAMS@SA network.

Following the success of the comet Borisov runs using two arrays of four cameras, the author procured a further eight cameras to expand the sky coverage of CAMS@SA. Some time was spent considering suitable alternative sites for a permanent second station, and after an initial approach to Dr Marion West an agreement was reached to site the two stations at the author's Bredell Observatory and Hartebeesthoek Radio Astronomy Observatory (HartRAO). CAMS@SA is now a collaborative effort between Tim Cooper (Coordination CAMS South Africa), HartRAO with Philip Mey as coordinator and the NASA SETI Institute with Dr Peter Jenniskens as project leader.

Construction of new mounts and enclosures started in late 2018, with machining taking place in the workshops at HartRAO. Richard Moralo machined the mounts for the cameras based on a design by Pieter Stronkhorst and they are shown with the cameras mounted on the bench in Figure 3 (left). The cameras are angled so that their fields of view overlap to give a combined field of view of nearly 100° x 60° on the sky. The enclosures are epoxy-coated mild steel, which were modified to accept a glass window, and sealed to prevent moisture ingress.

Fig 3. Watec 902H cameras mounted on aluminium mounts designed by Pieter Stronkhorst, and machined by Richard Moralo.

The camera mounts were placed inside the enclosures, which also contain the signal and power cables to the cameras and a heater cable that prevents dew from building up on the surface of the glass window. Fig. 4 shows the cameras in the enclosure at

Bredell just prior to connecting the cables, and Fig. 5 shows the finished array at HartRAO, ready for data acquisition.

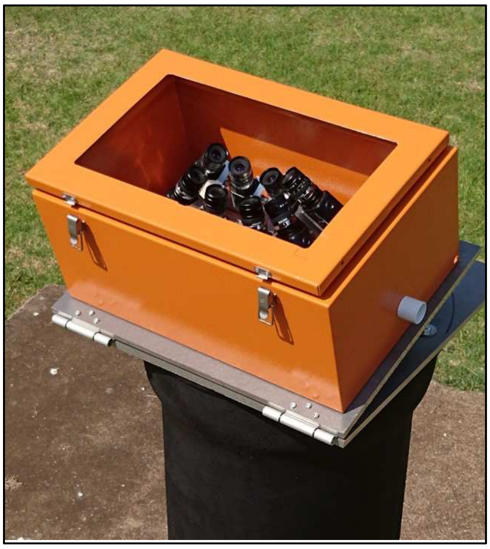


Fig 4 (left). Mounted cameras installed in the enclosure atop the new pier at Bredell Observatory, just prior to fitting the front window and connecting cables.

Fig 5 (right). Finished array at HartRAO. With both arrays at Bredell and HartRAO completed, CAMS@SA saw first light on the night of June 13/14.

The two arrays are mounted in such a way that their fields of view are coincident on the sky at an altitude of about 95 km, about the height where most meteors are visible as they plunge into the atmosphere. The two sites are separated by a distance of 67.1 km, and the arrays are oriented such that they point to each other at an elevation of 74°. The Bredell cameras are oriented in azimuth 289°, and the HartRAO cameras in azimuth 109°, which results in an effective coincidence of the fields of view as shown in Fig. 6.

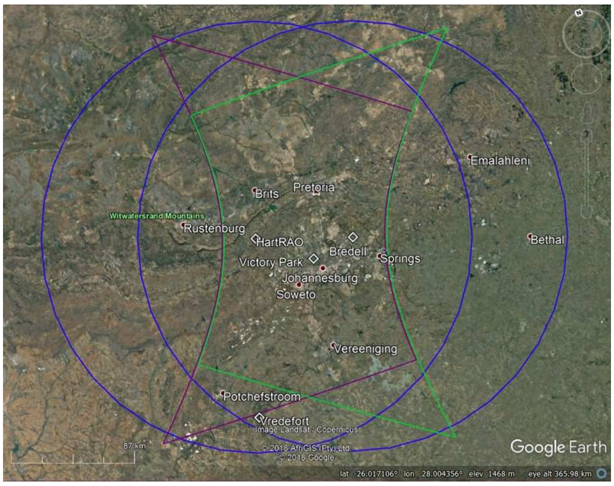


Fig 6. Overlap of fields of view of the Bredell (purple outline) and HartRAO (green outline) cameras.

Data capture starts immediately after dark and continues until dawn, when the power to the cameras is switched off. Thereafter the software processes the night's captures, looking for objects that move, which in addition to meteors includes birds, insects, aircraft, artificial satellites and clouds. The typical appearance of a meteor in the field of one of the Bredell cameras is shown in Fig. 7. Frames are inspected for meteors imaged simultaneously at both sites, and astrometry is conducted to determine orbital elements, which are then used to produce a radiant map for all meteors detected for each observing session. The radiant map for 'first-light' night of 13/14 June is shown in Fig. 8.

Fig 7 (right). Typical appearance of meteor in frame of one of the Bredell cameras.

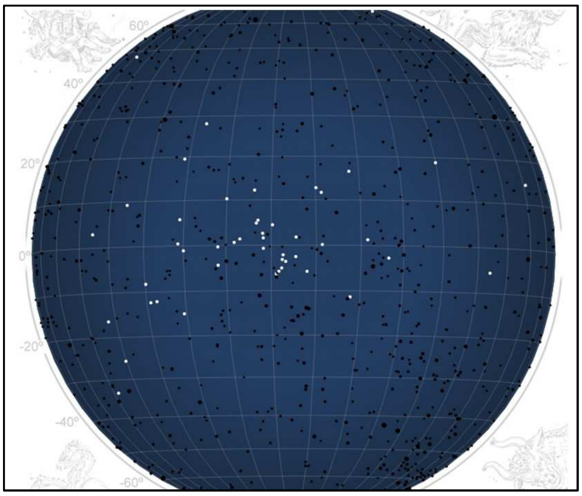


Fig 8 (left). Radiant map for night of first light, 2019 June 13/14, for CAMS@SA captures. Black dots are stars, whites dots are positions of meteor radiants. Note the concentration around Scorpius and Sagittarius, mainly meteors from the Anthelion sources active at this time of year.

With CAMS@SA now contributing nightly data on southern hemisphere radiants, we will gradually introduce improvements to increase the yield of successfully determined meteor orbits. This may involve increasing the number of cameras in the future to cover a greater expanse of sky.

Conclusion

With the growing number of cameras in the global CAMS program and the rapid increase in confirmation of previously reported streams and discovery of new streams, these are exciting times for meteor astronomy. After seeing first light during the night of June 13/14, and due to our unique position on the globe, we are confident that CAMS@SA will make a significant contribution to the study of southern hemisphere meteor radiants and their relation to potentially hazardous comets.

Acknowledgements

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References

Beech, M. (1994a). The makings of meteor astronomy: Part VI. WGN, *Journal of the IMO*, 22:2, 52-54.

Beech, M. (1994b). The makings of meteor astronomy: Part VIII. WGN, *Journal of the IMO*, 22:6, 214-217.

Cooper, T.P. and Toumilovich, O. (2017). The meteor stream associated with Comet C/2015 D4 (Borisov). *MNASSA,* Vol.76, Nos 9 & 10, pp240-248.

Dones, L., Weissman, P.R., Levison, H.F. and Duncan, M.J. (2004). Oort Cloud Formation and Dynamics, in *Comets II*, edited by Festou, M.C., Keller, H.U. and Weaver H.A. University of Arizona Press, p156.

Duncan, M., Quinn, T., and Tremaine, S. (1988). *Astrophysical Journal*, Part 2 - Letters, vol. 328, p. L69-L73.

Ferrin, I. (2009). Atlas of Secular Light Curves of Comets. *Planetary and Space Science*, 58, 3.

Fisher and Olmsted (1931). Catalog of the Harvard Observatory Meteor Photographs, *Annals of the Harvard College Observatory*, 87, Part 3.

Greg, R.P. (1860). *A Catalogue of Meteorites and Fireballs, from A.D. 2 to A.D. 1860*, Report of the Thirtieth Meeting of the British Association for the Advancement of Science; held at Oxford in June and July 1860. Published by John Murray, Albemarle Street, London. 1861.

Halley, E. (1719). An Account of the Extraordinary Meteor seen all over England, on the 19th of March 1718/9 (sic). With a Demonstration of the uncommon height thereof. *Phil. Trans.* 1719 30, 978-990, published 1 January 1719.

Hoffleit, D. (1975). Yale University Observatory at the turn of the Century. I*rish Astronomical Journal*, **12,** 104.

Hughes, S. (2013). *Catchers of the Light: The Forgotten Lives of the Men and Women Who First Photographed the Heavens*. ArtDeCiel Publishing. ISBN-13: 978-1467579940.

Jenniskens, P.M. (1995). Good prospects for α–Monocerotid outburst in 1995, *WGN, Journal of the International Meteor Organisation,* 23:3, p84.

Jenniskens, P.M., Betlem, H., deLignie, M., and Langbroek, M. (1997). The Detection of a Dust Trail in the Orbit of an Earth threatening Long Period Comet*, Astrophysical Journa*l, **479**, 441-447.

Jenniskens, P.M. (2006a). Meteoroid streams as debris from comets, in *Meteor Showers and their parent comets,* p11. Cambridge University Press.

Jenniskens, P.M. (2006b). Parent bodies listed in Table 7, Working List of Cometary Showers, in Meteor Showers and their parent comets, *ibid*, pp691-746.

Jenniskens, P.M., Gural, P.S., Dynneson, L., Grigsby, B.J., Newman, K.E., Borden, M., and Koop, M. (2011). CAMS: Cameras for Allsky Meteor Surveillance to establish minor meteor showers, *Icarus* Vol. 216, pp40-61.

Jenniskens, P., Nenon, Q., Gural, P.S., Albers, J., Haberman, B., Johnson, B., Morales, R., Grigsby, B.J., Samuels, D. and Johannink, C. (2016). CAMS newly detected meteor showers and the sporadic background. *Icarus*, Vol. 266, pp384-409.

Jenniskens, P., Baggaley, J., Crumpton, I. and Aldous, P. (2016). Confirmation of the delta Mensids (IAU#30, DME). *WGN, the Journal of the IMO,* 44:6, pp187-189.

Jenniskens, P.M. (2017). Private communication, CAMS network status 2017/12, email dated 23 December 2017.

Jenniskens P. and Lyytinen E., (2017) Potential New Meteor Shower from Comet C/2015 D4 (Borisov), *Central Bureau Electronic Telegrams*, No. 4403, 2 (2017). Edited by Green, D. W. E.

Jopek, T.J.; Kanuchova, Z.; (2014), in "The Meteoroids 2013", *Proceedings of the Astronomical Conference held at A.M. University, Poznan, Poland, Aug. 26-30, 2013*, Eds.: T.J. Jopek, F.J.M. Rietmeijer, J. Watanabe, I.P. Williams, A.M. University Press, 2014, p. 353-364.

Kuchner, M.J., Brown, M.E., and Holman, M (2002). Long-Term Dynamics and the Orbital Inclinations of the Classical Kuiper Belt Objects, *Astronomical Journal*, 124: pp1221–1230.

Marsden, B.G. (1971) Evolution of Comets into Asteroids. *Physical Studies of Minor Planets, Proceedings of IAU Colloq. 12, held in Tucson, AZ, March 1971*. Edited by T. Gehrels. National Aeronautics and Space Administration SP 267, 1971, p.413

Millman, P. M., Hoffleit, D., & Shapley, H. 1937. A study of meteor photographs taken through a rotating shutter, Plate 1, in *Annals of the Astronomical Observatory of Harvard College,* 105, no. 31, Cambridge, Mass. : The Observatory, 1937., p. 601-621

Morbidelli and Brown (2004). The Kuiper Belt and the Primordial Evolution of the Solar System, in Comets II *ibid*, p175.

MPC (2017). https://minorplanetcenter.net/iau/lists/PeriodicCodes.html, downloaded on 21 December 2017.

Neslusan, L., Vaubaillon, J. and Hajdukova, M. (2016). A study to improve the past orbit of comet C/1917 F1 (Mellish) on the basis of its observed meteor showers. *Astronomy and Astrophysics*, Vol. 589, A100.

Pilcher F. (1979). Circumstances of Minor Planet Discovery, in *Asteroids*, p1132, edited by Gehrels T., University of Arizona Press.

Roggemans, P. (1989). Ed. In *Handbook for Visual Meteor Observations*, Sky Publishing Corporation.

Rudawska R, Kanuchova Z and Jopek, T.J. (2017). List of all meteor showers, Meteor Data Centre, https://www.ta3.sk/IAUC22DB/MDC2007/, updated 2017, September 14.

Schlesinger, F. (1936). *Biographical memoir of William Lewis Elkin*, 1855-1933. National Academy of Sciences at www.nasonline.org/publications/.

Williams, I.P. (2004). The velocity of meteoroids: a historical review. *Atmos. Chem. Phys*. 4 (2), pp471-475.

Yoshida (2017). http://www.aerith.net/comet/catalog/index-periodic.html, downloaded on 21 December 2017.

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Recent Southern African Fireball Observations, #315-325

Tim Cooper, Comet, Asteroid and Meteor Specialist, Shallow Sky Section

This article continues the sequential numbering of reported fireball sightings from southern Africa. By definition, a fireball is any meteor event with brightness equal to or greater than visual magnitude (m_v) –4. The following events were reported to the author and details are reproduced as given by the observer [any comments by the author are given in brackets]. All times were converted to UT unless stated, and all coordinates are for epoch J2000.0.

Event 315 – 16 January 2019 – Secunda, Mpumalanga

Observed by Deon de Klerk from Secunda at 17h40, driving in a northerly direction, bright light with a tail behind seen directly in front of him. From a sketch he provided I determine the start point in azimuth/altitude 350°, 30°, descending at an angle of about 30° to the east, from a point just south of Aries, and crossing the constellation of Perseus. The 75% illuminated moon was 20° to the upper right of the start point, and the bright star Capella (magnitude 0) was just to the right of where the fireball was last seen. Duration 3-4 seconds, and pieces were seen to break away from the tail as it moved. No sounds heard. Deon said ‘I wish I had a dash cam or any source of video footage of the incident’.

Event 316 – 16 January 2019 – various, Western Cape

A bright bolide was widely seen over the Western Cape at 18h14m53s. It exploded at an altitude of around 46km, was followed by audible noise and vibrations and left a persistent train visible for several minutes. Video footage was secured from a camera located at Malmesbury, and four still images were obtained of the persistent train. Screen grabs from the video showing the appearance of the bolide are shown in Figure 1. A rough triangulation from the more reliable eye-witness accounts, and more importantly from images of the smoke train enabled an approximate determination of the trajectory. The meteor approached from the south descending at a steep angle, moving slightly towards the east, and disintegrated with two explosions just south of the coast between Hermanus and Pearly Beach, probably in the vicinity of Gansbaai. A full report was published in MNASSA Vol. 78, Nos. 1 and 2, pp 4-10.

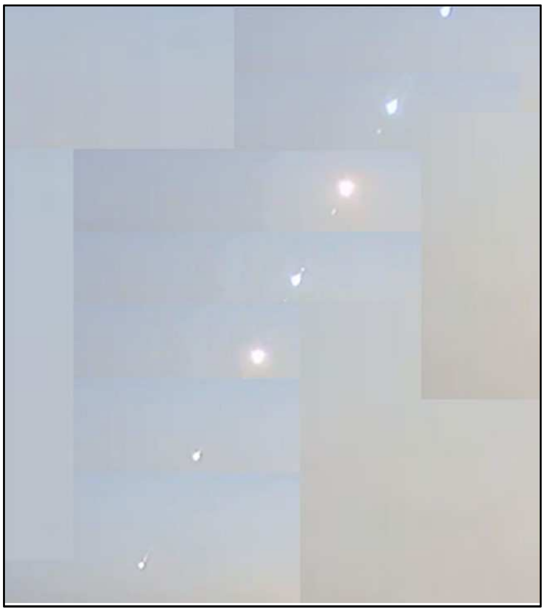

Fig 1. Montage of seven frames showing the appearance of the Western Cape bolide of 16 January 2019, including two disruptions

Event 317 – 7 February 2019 – Fourways, Gauteng

Observed by Bridget Salt from Douglasdale, Fourways at 22h10, facing west on her patio, was just seeing guests off after dinner when she witnessed a bright yellow/red fireball. One guest saw it reflected in a window. From a description provided by Bridget, the fireball started in azimuth/altitude 330°, 65°, that is near the head of Hydra, and descended at an angle of roughly 30° to her left in direction south-west. Duration was 2-3 seconds, and the fireball fragmented and a piece was seen to break off shortly before she lost sight of it behind a neighbour's house in about azimuth 193°. Bridget said 'it was a profound sighting, like nothing I have ever seen – it was quite scary'.

Event 318 – 16 February 2019 – Northern Drakensberg

Observed by Tomas Ridl at about 17h30. He was overnighting at Xeni Cave in the Drakensberg, and provided a photograph of the scene and excellent description of the path relative to discernible peaks on the distant Cathedral Peak range and a nearby ridge. From the azimuth and altitude of these features I determined the start point as 310°, 18° descending at a shallow angle and ending at 350°, 15°. The path was from just below Aries, ending between Mirphak and Capella. Duration 4-5 seconds, orange/red colour, m_v about -4. At the end of its flight it disintegrated into three distinctly red fragments which quickly dissipated. No sounds were heard.

Event 319 – 16 February 2019 – Honeydew, Gauteng

Observed by Shiralee Taylor-Bravi at about 17h50, driving on Taylor Road Honeydew in direction of azimuth 157°, while stationary at traffic lights saw a very bright fireball travelling from west to east, descending at a shallow angle from about azimuth 160° and disappeared behind buildings on the left at azimuth 130°. Intense red glow at the front followed by a strong [sic] white tail, duration 2-3 seconds, flared with a bright white light and disintegrated into smaller pieces before disappearing below buildings. She said it appeared larger than a normal shooting star.

Observed by Dave Brookstein, between 17h50-18h00 [he said closer to 18h00], driving along M1 South in direction of azimuth 200°, saw a bright meteor moving west to east, duration 1-2 seconds, bright white/yellow. Start point about 60° in azimuth 200°, descending at a shallow angle of maybe a few degrees [not much steeper than the horizon] and finishing in azimuth about 140°. Dave said he had to lean forward to see it properly through the windscreen. No disintegration but the meteor appeared to sparkle.

The possibility exists that Events 318 and 319 were the same object. The time of appearance is between 17h30 and 18h00, but all three reporters gave the actual time as uncertain, particularly that for Event 318. Projecting the azimuths of the three observers gives a path moving north east across the Free State with a close convergence of the end points just north of the town of Villiers.

Event 320 – 15 March 2019 – Vaal Dam, Free State

Observed by Francois Strydom about 23h00 while fishing at Vaal Dam, 'angled trajectory towards the horizon at SSW [azimuth about 202°], round object with a blue-green tail and as it approached the horizon it changed to a deep orange almost red tail. It thereafter disappeared beyond the horizon. The whole event was about 5-6 seconds long.'

Event 321 – 31 March 2019 – near Molteno, Eastern Cape

Observed by Teresa Opperman and two others at 02h45, while camping in the Bamboes Mountains between Hofmeyr and Molteno, Eastern Cape. Facing south east, massive bright blue ball to the immediate lower left of Venus, azimuth/altitude approximately 95°, 13°, which lit up the whole sky, duration 2-3 seconds, then exploded and continued as a shower of blue lights falling down for another 3 seconds. They had the impression that the meteor was coming straight towards them as the visible path was quite short. Afterwards a red/orange glow remained where the explosion occurred which grew smaller and eventually disappeared. Brighter than the 23% moon, which was then in about the same azimuth, altitude 36°, and magnitude -9.6.

Event 322 – 1 April 2019 – Paradise Beach, Eastern Cape

Observed by Driessen Struwig at 19h02, bright green fireball, from azimuth/altitude 5°, 45°, plunged almost directly downwards [plotting the path backwards Driessen felt it must have passed directly overhead], and disappeared on the horizon 20° to the right of Cocks Comb peak in the distance (azimuth 350°), so in azimuth 10°. Given these coordinates I determine the fireball passed from the head of Leo down to the immediate left of beta Ursa Majoris. No sounds heard.

Event 323 – 2 May 2019 – various Gauteng and Limpopo

Several reports were received of a bright fireball, ending in a very bright flash. Clinton Kruger was driving on the N1 North freeway in Pretoria, just short of the intersection with the N4, when he caught the bolide on his dashcam (see Figure 2). The vehicle was then headed in direction 343° and the meteor suddenly appears in azimuth 335°, altitude about 25°, and descends from right to left at an angle of 40° to vertical. It ends in a bright flash just above the horizon at azimuth 310°. Duration of visible passage was 4 seconds, and the bright flash occurs at 18h21m48s (UT) according to the dashcam time stamp. Danie de Beer from Moreletapark was facing north-west and saw the fireball moving almost directly downwards from altitude 30° to the horizon at azimuth 330°. There was a bright flash on the horizon, which Danie thought was due to its impact.

Two reports from Limpopo were closer to the event. Regart Venter saw the fireball from a farm in northern Limpopo, and said 'shooting star, like a fireball, lit up the sky in a bright white colour.' Duration 4-5 seconds, not bright to start with but suddenly about half way it became very bright and lit up the surroundings. He was facing north and saw it descending right to left at an angle of 45-55°. He could not see if it reached the horizon as there was a building obscuring the view. Henk and Tjaart Kruger were at Tweerivier Game Farm near Lephalale, sitting around the camp fire when they saw the fireball moving almost overhead and slightly to their right looking north, and headed in direction of azimuth 338 when it was lost behind a large tree. They reported 'It all happened in seconds and started off as a bright white trail which changed to orange towards the end. The area around us was lit up almost like [taking a] photograph with a flash. The orange light trail faded before it reached the horizon. We heard what sounded like two bangs a while after the trail disappeared.'

Several other useful reports were received. Dries Retief was driving with his son on the R511 just north of Brits en-route to Limpopo when they saw the bolide ahead of them, at 18h20 according to the vehicle's clock, 'speeding from east to west at about 45˚ above the horizon. It started off as a bright white streak which then changed to green and eventually yellow/orange before it 'exploded' into an orange ball before disappearing completely. The streak was initially narrow but widened when it changed to green with the bright flash at the end being widest.' Their final destination was Tweerivier Game Farm, and when they arrived there around 11pm local time they were able to chat with those who had seen the fireball nearly overhead. Robyn Staley was at home in Benoni and said 'I saw an extremely bright fireball, very bright yellow-orange with an almost green glow', duration about 3 seconds, and no noise heard. She provided a sketch of the view from her garden, showing the path downwards from right to left at an angle of 55° and ending just above the tree line in azimuth 322°. Deon Pinetown was at the corner of William Nicol and Republic Road, Sandton, headed in direction 55°, when he observed 'a bright object falling from the sky. It looked like a shooting star/meteor, but way bigger and much brighter. It was bright green in colour with flames at the tail end'. He provided a sketch showing the fireball descending from right to left at an angle of 50° to the vertical. Lauren Bird observed from South Downs Centurion and reported 'brighter than the full moon would be, duration 5-6 seconds, bright blue and green, there was a bright flash after it supposedly made impact with the ground that lit up the night sky in the area'. No persistent train or disintegration was noted. Gaby Warren saw it from Garsfontein, Pretoria East, 'gold fireball with tail', low on horizon at about azimuth 334°, moving right to left.

Figure 2 The bright bolide of 2 May ,2019 seen from Gauteng and Limpopo. Montage of four screen grabs from dashcam footage courtesy of Clinton Kruger, driving north on the N1 east of Pretoria. Resolution as off camera, and extraneous street lights have been removed to better show the passage of the bolide.

Unfortunately, despite requests, no further footage could be obtained and with only the dashcam footage and the limited detailed eye-witness accounts, the path could not be ascertained with certainty. However, the general descriptions of the end points are consistent with termination over Central Province, Botswana.

Event 324 – 5 May 2019 – Bredell, Gauteng

Observed by Tim Cooper at 03h33, bright eta Aquariid during a two-hour watch on that shower, $m_v = -5$, white, fast, and left a persistent train visible for ~10 seconds.

Event 325 – 28 May 2019 – near Gansbaai, Western Cape

Observed by Du Toit Fourie at just after 04h00, driving south on the R43 from Stanford in direction of 191° towards Gansbaai, he said 'saw a shooting star but unlike any other I have seen before, moved over the sky for longer period of time than any I have seen before'. From a sketch provided I determine the fireball first appeared about azimuth/altitude 230°, 20°, nearby the star gamma Lupi and lost sight of it at 200°, 10° as it passed behind low clouds on the horizon around the centre of Crux. For the first two thirds it appeared as a normal bright meteor, but then suddenly increased to very bright greenish-white. No sounds were reported, but Du Toit was driving at the time.

Acknowledgements

Thanks to Dr Daniel Cunnama (SAAO) and Kos Coronaios (ASSA Observing Director) for forwarding various reports from the public.

News Note: Sky & Telescope acquired by American Astronomical Society

The AAS has agreed to acquire *Sky & Telescope* (S&T) magazine and its related business assets, including the skyandtelescope.com website*, SkyWatch* annual, digital editions, astronomy-themed tours, and S&T-branded books, sky atlases, globes, apps, and other stargazing products.

S&T's current owner, the magazine- and book-publishing company F+W Media, sought Chapter 11 bankruptcy protection in March 2019 after what court filings described as six years of poor strategy and management at the corporate level. The AAS, the major organization of professional astronomers in North America and a 501(c)(3) non-profit corporation, was the winning bidder for S&T in a bankruptcy auction process that concluded on Monday, 17 June, pending approval by all parties to the transaction, final documentation, filing of final sales agreements and schedules with the bankruptcy court, and a successful closing process.

The AAS anticipates that S&T's staff of editors, designers, illustrators, and advertising sales representatives will become AAS employees but will continue to work out of the magazine's offices in Cambridge, Massachusetts. The AAS is headquartered in Washington, DC, but already has about a dozen remote staff members scattered from coast to coast. As it accomplishes the operational transitions needed to publish S&T, the Society anticipates making few if any changes to the editorial content or the way the magazine operates, and subscribers should see no interruption in its monthly delivery schedule. Enhancements and new products and services are likely in the future; these will be developed in partnership with the magazine's editors and readers and with the Society's members and others.

“The synergies between our two organizations are many and strong,” says Peter Tyson, Editor in Chief of Sky & Telescope. “Many AAS members grew up on S&T, and we regularly report on the discoveries made by AAS members.”

Sky & Telescope was founded in 1941 through the merger of two earlier magazines: *The Sky*, produced at New York’s Hayden Planetarium, and *The Telescope*, published first at Ohio’s Perkins Observatory then later at Harvard College Observatory. The business was employee-owned until 2006, when the staff sold it to the craft-and-hobby publisher New Track Media, which in turn sold it to F+W in 2014.

Before he became AAS Press Officer in 2009, astronomer Rick Fienberg worked at S&T for 22 years, serving from 2001 to 2008 as Editor in Chief. Upon learning of F+W’s financial difficulties, he suggested that the magazine could be a good fit for the AAS, which publishes two of the leading peer-reviewed journals in the field — the Astronomical Journal (AJ) and the Astrophysical Journal (ApJ) and which recently created an Amateur Affiliate category of membership for backyard astronomers , many of whom collaborate on scientific research with their professional counterparts. AAS Executive Officer Kevin Marvel agreed and wrote a detailed proposal to the Board of Trustees, who unanimously endorsed the idea of trying to acquire S&T’s business assets, not only because of S&T’s close strategic alignment with the Society’s own goals, but also because it would enhance the AAS’s ability to connect with amateur astronomers and the general public.

“The AAS Board was totally onboard with the acquisition of *Sky & Telescope*,” quips AAS President Megan Donahue (Michigan State University). “Many of us are current and loyal subscribers, and more than a few started reading S&T when they were young and noted that the wonderful articles and beautiful graphics helped inspire them to choose a career in the astronomical sciences. The AAS and S&T together will be greater than the sum of the parts.”

“I decided to become an astronomer while voraciously reading back issues of *Sky & Telescope* during study hall in 10th grade,” recalls Marvel. “I’m thrilled with the Society’s acquisition of S&T and look forward to integrating the business fully into our operations, which will allow us to expand our efforts to fulfill our mission to enhance and share humanity’s scientific understanding of the universe.”

“We couldn’t be happier that we’ll now be producing *Sky & Telescope* and our other products under the auspices of the American Astronomical Society,” Tyson says. “We look forward to working with the AAS on our shared goals: supporting astronomers of all stripes, getting the word out about astronomical discoveries, enhancing pro-am collaborations, and mentoring the next generation of astronomers. It feels like S&T is finally landing where it belongs.” *(AAS Press release)*

Colloquia and Seminars

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

Also included in this section are the colloquia/seminars at the SAAO, UWC, the Astrophysics, Cosmology and Gravity Centre at UCT, ACGC and the NASSP lectures, aimed the at the students and interested astronomers. In addition there 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.

SAAO

Title: Standardisation of operations – Looking at information differently (I)
Speaker: Rupert Spann (South African Radio Astronomy Observatory)
Date: 9 May
Time: 11h00 – 12h00
Venue: SAAO Auditorium

Abstract: Getting the picture: a biological point of view:
The talk provides the framework for structuring information based on the way the biological brains function. It introduces the brain growth and development and how that is a benefit to the way it operates in its environment. How the brain takes in information from the environment assimilates it and processes information to make a decision and act. It demonstrates the function of the subconscious and how the subconscious can be used to assist is solving problems.

Title: Standardisation of operations – Looking at information differently (II)
Speaker: Rupert Spann (South African Radio Astronomy Observatory)
Date: 16 May
Time: 11h00 – 12h00
Venue: SAAO Auditorium
Abstract: Information as operations:
The application of the structure and functioning of the brain in creating value with, and the handling of, information in operations. Demonstrations of issues and solutions dealing with information and systems interfacing to information. In addition how this methodology of structuring information allows the brain to maximise its

potential – and at the same time provides a framework for AI systems and Industry 4.0. (This talk is directed towards individuals dealing with operational issues but applicable to dealing with information in general).

Title: Sprites research in South Africa
Speaker: Prof M. J. Kosch (South African National Space Agency)
Date: 23 May
Time: 11h00 – 12h00
Venue: SAAO Auditorium

Abstract: Transient Luminous Events (TLEs, also called sprites) are a gas discharge phenomenon in the middle atmosphere initiated by the electric field generated by positive lightning strikes during large convective thunderstorms. The optical emissions start at ~90 km altitude, descend downwards and are very bright but also very brief. As a result, they are rarely reported by naked eye observation. TLEs may come in different forms, e.g. halos, column or carrot sprites. South Africa is a world lightning hot-spot during summer (December-February) with large convective thunderstorms on a semi-regular basis. SANSA made the first sprite observations in 2016 from Sutherland and have since recorded over 500 events up to 900 km away. Some observations and results will be shown. In addition, a brief overview of some instrumentation in polar regions will be shown

UWC

Title: Cosmological implications of scalar-tensor theories of modified gravity
Speaker: Matteo Braglia (University of Bologna
Date: 17 May
Time: 11h30 – 12h30
Venue: Rm 1.35 New Physics Building, UWC

Abstract: I discuss the cosmological imprints of a non-minimally coupled scalar field. In the original Jordan frame, where matter particles follow geodesics of the metric, the coupling with gravity regulates both the late time acceleration of the Universe and the time variation of the effective Newton constant. Without resorting to any effective description, I describe the background and perturbed evolution of the Universe for different choices of the scalar field potential and coupling. I describe the initial conditions for the evolution of linear perturbations used to obtain the CMB observables, focusing in particular on a new scalar field isocurvature mode. I then show the current cosmological constraints and forecasts on the model and Post-Newtonian parameters. I end up discussing how to generate the aforementioned initial conditions from inflationary models with non-minimally coupled scalar fields, focusing on the open problem of the (in)equivalence of Jordan and Einstein frame

Title: An overview of upgraded GMRT - a view of head-tail radio galaxy using it
Speaker: Dharam Vir Lal (NCRA)
Date: 31 May
Time: 11h30 – 12h30
Venue: Rm 1.35 New Physics Building, UWC

Abstract: The Giant Metrewave Radio Telescope (GMRT) is located near Pune, India. Today it is a major international facility for research in radio astronomy and astrophysics in the 150-1500 MHz frequency range and is a SKA pathfinder. The talk will present a discussion of the major upgrade recently accomplished and present the nature of NGC4869, a head-tail radio galaxy in the Coma cluster, as viewed using (upgraded) GMRT.

AIMS

Title: Will Julia or Swift take Pythons Machine Learning Crown?
Speaker: Not given
Date: 29 May
Time: 11h00
Venue: KAT-7 boardroom, Floor 3 SKA building

Abstract: Python has become by far the most popular language amongst machine learning practitioners. Yet it suffers from a number of major limitations, such as slow execution speed. This usually requires developers to use a separate language (C/C++) for performance-critical codepaths, reducing productivity. Julia is a new language that attempts to give users the same performance as C/C++ via just-in-time compilation, whilst being as easy to use as Python. This talk will introduce Julia, and walk through some of its advantages over Python. In addition, we will look at why many people, such as Yann LeCun, believe that future deep learning frameworks will require moving away from Python, and why Julia and Swift are currently the leading contenders for such new languages

Errata

There were two errors in the last edition of MNASSA; Vol 78 Nos. 3 & 4.
1. Obituary of Prof. Michael Feast. This was written by Prof Patricia Whitelock, and the image should be credited to M. Soltynski
2. Mr M Soltynski’s name was omitted from the Editorial Board on the inside front cover.

Both errors are regretted.
Editor.

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

Publications: The Society publishes its electronic journal, the *Monthly Notes of the Astronomical Society of Southern Africa (MNASSA)* bi-monthly as well as the annual *Sky Guide Africa South.*

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

Local Centres: Local Centres of the Society exist at Bloemfontein, Cape Town, Durban, Hermanus, Johannesburg, Natal Midlands, 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 membership is required). Please contact the Membership Secretary for details.

Internet contact details: email: assa@saao.ac.za Home Page: http://assa.saao.ac.za

Council Members 2018		
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Vice-President	Dr Pierre de Villiers	pierredev@hermanusco.za
Vice-President	Chris Stewart	mwgringa@mweb.co.za
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I – Citizen Science	Allen Versfeld	Allan.versfeld@gmail.com

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