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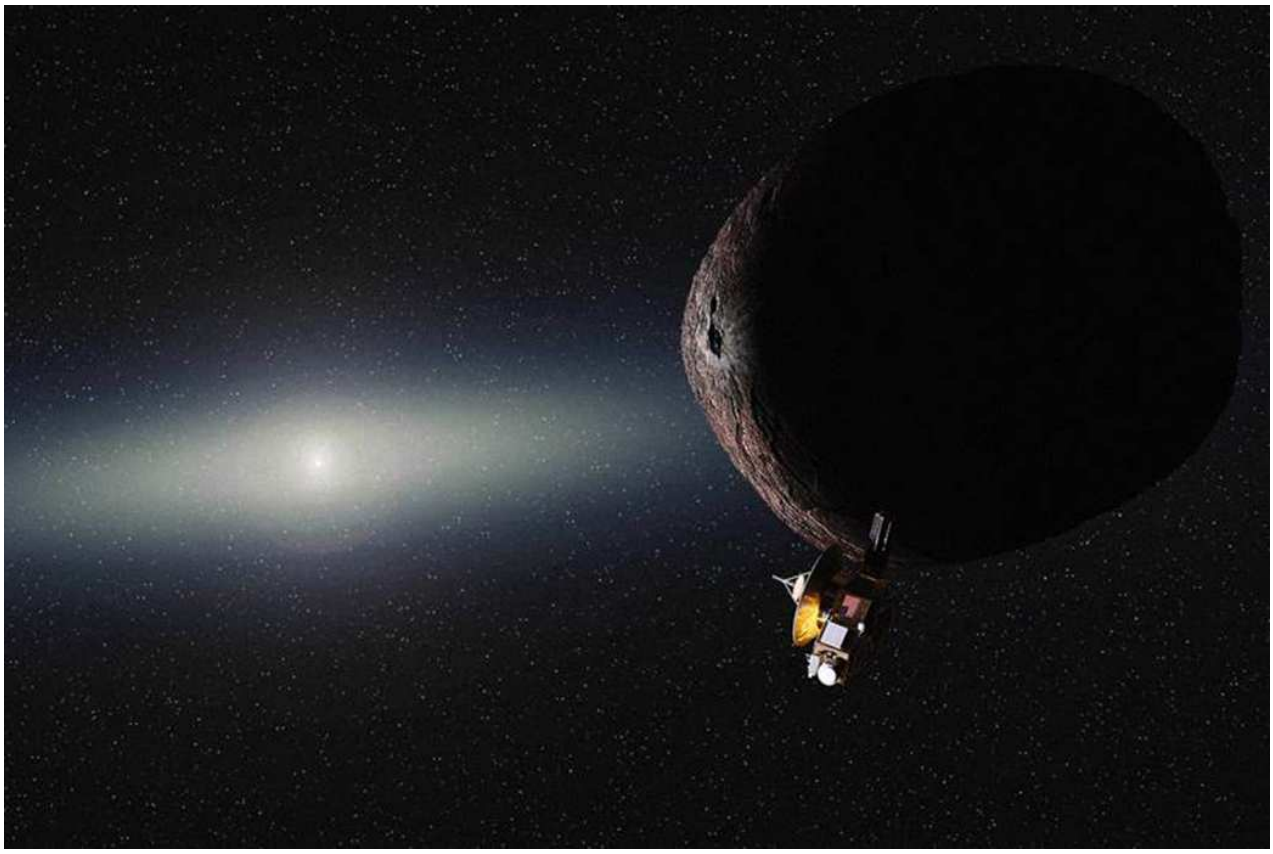

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Cover: Schematic of the New Horizons spacecraft journey through the Solar System. Credit: NASA.

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Astronomical Society of Southern Africa
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Editorial

The remarkable achievements of the New Horizons mission, to the dwarf planet Pluto, are not yet over. Its next target is the asteroid 2014MU69, a 40 km asteroid in the Kuiper Belt, which it will reach on 1 January, 2019. It occulted a star; meaning that the starlight from that star would be momentarily "blacked out" on 3 June, 2017.

Calculations showed that the shadow path would cross South Africa and Argentina and astronomers would set-up portable telescopes, with appropriate equipment to monitor the eclipse. In addition, observatories, like the SAAO in the right location, Sutherland and the Cedarberg, were used. Bloemfontein Observatory kindly hosted ASSA member Clyde Foster.

At the time of publishing, the analysis of the collected data is not finalized and hopefully MNASSA will be able to report on the results in the next edition; it was a unique event in which SA astronomers, both professional and amateur, took part.

News Note: Opening of IZIKO Digital Planetarium

The new Iziko Planetarium and Digital Dome that opened on 27 May 2017 is offering a new and unique experience.

Investments totaling R28.5 million have been secured for this project. Partners include: the Department of Arts and Culture (DAC); the Department of Science and Technology (DST); the National Research

Foundation (NRF); the National Lotteries Commission (NLC); and key academic institutions in the Western Cape; University of Cape Town (UCT), University of the Western Cape (UWC) and Cape Peninsula University of Technology (CPUT).

In the late 1950's the Museum set up a fledgling planetarium, and by the mid-80's, a newly built dome with a dedicated star machine followed, providing edutainment to over 2 million visitors to date. The new Iziko Planetarium and Digital Dome now stands on the threshold of an exciting new era. Fulldome digital technology has become the norm for planetaria worldwide, offering high resolution, multi-media image projection. Immersive and multi-sensory experiences create a hub of creativity and learning that is no longer only focussed on astronomy, but on an unlimited array of subjects and genre, with content for audiences of all ages and interests.

The Iziko Planetarium and Digital Dome brings the most advanced digital visualisation technology to Cape Town, creating a world-class digital fulldome theatre, with multiple functionality. This new fulldome theatre will provide unequalled edu-tainment, making virtual travel to explore the universe, the depths of the oceans, the inner working of the human body, the intricacies of atomic and chemical structures possible, or just providing animation and 360° cinema for sheer entertainment. Moreover, learners and educators from primary to tertiary levels will benefit from computer generated imagery that makes interactive teaching and visual learning possible, providing an unparalleled and accelerated learning experience.

Significantly, the upgraded Iziko Planetarium and Digital Dome will assist to optimise South Africa's eResearch and data visualisation capacity, placing us at the cutting edge of this technology, both on the continent and globally. In addition, this new facility will assist South African scientists to develop the skills base and infrastructure required for projects such as Square Kilometre Array (SKA), Southern African Large Telescope (SALT) and MeerKAT radio telescope.

Dr Ian-Malcolm Rijsdijk, senior lecturer at UCT's Centre for Film and Media Studies, said that the value of this digital dome for arts and the humanities was clear.

The most obvious capacity for the dome is in the area of digital media, animation and even fine art, but what he would really like to see is how artists develop innovative ways of using the space in the most immersive way possible.

He also stressed the potential of this space to bring the arts and sciences together for productive collaboration, especially around science communication.

There is a desire among scientists across the disciplines to better communicate their science and research to the public, to better tell the story of their research. This space offers real potential to build meaningful collaborations between the arts and sciences that will hopefully benefit the public at large.

The new Iziko Planetarium and Digital Dome, located in the revamped, state-of-the-art Iziko South African Museum will create a new and unique African "Centre of Excellence".

News Note: South African astronomy continues to receive favourable treatment

On 16 May 2017 Naledi Pandor, Minister for Science and Technology introduced the Budget for her Department.

The following extract contains her remarks on astronomical matters, including some proposed changes:
"The [Department's] 2017/18 budget is R7.5 billion, just slightly more than the R 7.4 billion of 2016/17."

“Honourable members know that South Africa has strategically invested in the enhanced development of astronomy sciences and infrastructure. We have several radio astronomy projects - the Hartebeesthook Radio Astronomy Observatory, the Meerkat, the Square Kilometre Array and the African Very Long Baseline Interferometry Network or AVN. I recently declared a new national facility bringing all these under one hub, the South African Radio Astronomy Observatory or SARAO. This hub will position South Africa as a key hub of radio astronomy.

I regard this hub as an important first step toward our long-term ambition to create in the medium to long term a national astronomy institute to house all aspects of astronomy. I have directed my department to explore the possibility of creating a South African Astronomy Observatory as a consolidated single national astronomy institute. I hope we can conclude this phase of our plans prior to the completion of SKA phase 1 in 2022.

Astronomy has also provided intrigue and challenge to curious and bright young people. On this note I'm pleased to welcome in the gallery, Mpho Mthombeni from Lentheng Middle School in the North West the winner of an NRF competition to name SAAOs new 1 metre telescope. Now called 'Lesedi', this new telescope is the first remotely operated South African owned telescope since the establishment of observing locations in Sutherland in 1974.

With respect to the SKA, R2 billion will be transferred to the NRF over the MTEF period for the completion of the Meerkat project and for the acquisition of additional land for the SKA project. This financial year R693 million has been allocated for the SKA project. On Africa day 25 May we will mark five years since South Africa was named as co-host of the SKA.

I'm pleased to report that we now have 45 antennas and 57 pedestals installed as part of Meerkat and we are on track to build the full complement of 64 by 31 March 2018. Meerkat has reached another

milestone with the integration of the 32 antennas into a polarisation correlator or array. The next array release, AR2, is set for later this year.

Furthermore, 75% of MeerKAT components have been sourced locally. To date MeerKAT has spent R134 million on local construction suppliers, and 351 people have been trained by major SKA contractors such as Stratcom. The SKA project has created 7 284 employment opportunities through the construction of the KAT-7, MeerKAT and related projects.

In its 11th year, the SKA bursary initiative has funded 919 students, 133 of whom are from other African countries. The Department continues to provide extensive support to schools in Carnarvon. Nine learners from Carnarvon High School have received full-cost undergraduate bursaries.
We look forward to the beginning of SKA phase 1 construction between 2018- 2022.

We congratulate Dr Rob Adam and the entire SKA team."

News Note: MeerKAT first images released

At the time of Minister Naledi's Budget presentation on 16 May 2017, the SA Chief Scientist of the SKA Dr Fernando Camilo and the SKA SA Head of Science Commissioning Dr Sharmila Goedhart showed her recent SKA imaging results, achieved by using various configurations of the 32 antennas currently operational in the Karoo. This milestone of the integration of 32 antennas with a single polarization correlator was achieved on schedule by the end of March 2017. The 32 antennas are part of the eventual 64 instruments that are being built at the Losberg site in the Northern Cape.

Dr Camilo and Dr Goedhart presented to the Minister:

- A view of the hydrogen gas in M83, a famous galaxy discovered in Cape Town in 1752, generated by MeerKAT. The image was made

with the MeerKAT configuration using seven 50-minute exposures – achieving this detail and sensitivity much faster than any previous observations.

- A linear feature – a radio galaxy – that is 4 million light years across, identifying it as a Giant Radio Galaxy, the first such extreme object identified by MeerKAT.
- A star-forming region in the Milky Way. The previous best image of this star-forming region was obtained with the Australia Telescope Compact Array (ATCA). The MeerKAT image is sharper and more sensitive; and shows fainter features with additional detail.
- The increased observation power of MeerKAT through demonstrating the images taken with KAT-7 in 2012, MeerKAT-4 in 2016, MeerKAT-16 in 2016 and MeerKAT-16 in 2017. The same black hole was observed with the increasingly improved arrays of antennas.
- The first radio image of a distant spiral galaxy, showing both the visible light and the radio waves that left this galaxy 230 million years ago.

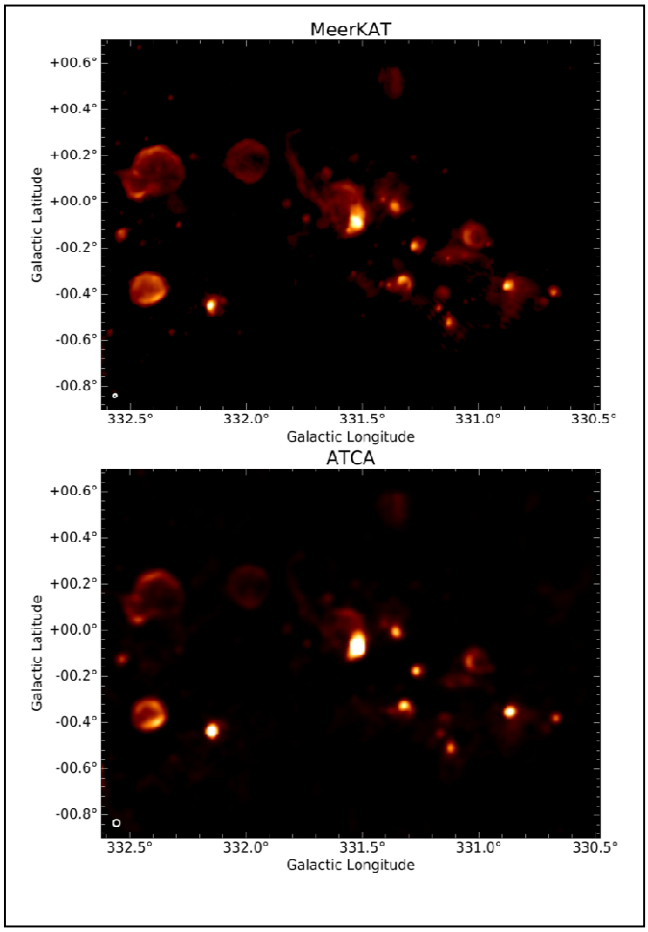

Fig 1. Large scale bubbles and arcs seen with MeerKAT show stellar nurseries (where stars are born) in the Milky Way. For comparison, the previous best image of this star-forming region is shown at the bottom, obtained with the Australia Telescope Compact Array (ATCA). Credit: SKA, SA.

Note: The SA SKA website www.ska.ac.za has been greatly improved and is worth looking at by interested readers.

MeerKAT is one of the precursor telescopes to the SKA and will eventually be integrated into SKA1-mid after being a world-class instrument in its own right for several years.

News Note: GAIA Conference Nice, France, 24-28 April 2017.

This conference, formally called “Astronomy and Astrophysics in the Gaia Sky” (IAU Symposium 330) was about the first results from the Gaia satellite, one of the most exciting space missions of recent years. The aim of this 5-year project is to find the positions and motions of stars in all three dimensions to distances as far from us as possible, as well as to obtain their spectra.

Because we are embedded deep within our own galaxy, it is extremely difficult for us to form a proper picture of it as an imaginary observer from outside the Milky Way would be able to do. However, by combining the Gaia results from myriads of individual stars we can at least hope to map the galactic neighbourhood around us.

Gaia is the successor of Hipparcos (operated 1989-1993), the first satellite designed to provide distances to stars, their proper motions, their radial velocities and their magnitudes. Because it was outside the unsteady atmosphere of the Earth, Hipparcos was able to provide positional accuracies about 100 times better than was possible from ground-based telescopes, for over 100 000 stars. Gaia will eventually yield a further improvement of 50-100 in position and observe about 10 000 times more stars.

It this way it will enable us to form a stereoscopic picture of a good part of our own galaxy.

The distances to stars are obtained fundamentally by trigonometry, observing their parallaxes against the most distant backgrounds as the Earth revolves around the Sun.

The Earth's orbit forms the baseline of a triangle and the angular apparent movement of a nearby star gives the included angle, so that its distance can be calculated. Unfortunately this simple-sounding method is complicated by other factors. Particularly it has to take account of the fact that the stars are also moving relative to each other in the gravitational field of the galaxy - in other words each one has a proper motion ("proper" here is used in an old sense of the word meaning "own particular"). These movements have to be determined before the parallaxes can be deduced. This means that they have to be observed for at least two revolutions of the Earth (and of course Gaia) around the Sun, and preferably more, to disentangle the two effects.

Gaia has not yet been working for long enough to separate the parallaxes and the proper motions from its own observations but by combining the positions included in the first year's "data release" with older ones from Hipparcos the proper motions can be found much more precisely than was heretofore possible. The parallaxes and hence the distances of the stars can already be obtained more accurately through this combination of old and new data. Of course, this only works for stars bright enough to have been in the Tycho subset of the Hipparcos Catalogue and we will have to wait longer to get the results for the fainter stars that Gaia is capable of measuring.

In the early days of distance determinations it was possible to assume that the more distant stars did not move significantly compared to the nearby ones. Now, with much more accurate data available for almost all the bright stars, it is necessary to understand what the background stars are doing. Already the fundamental catalogues of star positions derived from ground-based observations are obsolete. Stars beyond the Milky Way galaxy are generally too faint to measure so that quasars and other point-like objects have now become the reference against which stellar motions are measured. The best positions of these sources have hitherto come from radio astronomy.

By combining Gaia results with spectroscopy our understanding of many types of stars can be improved. It is also possible to calibrate the variable star period-luminosity relations more accurately, important for the series of stepping stones used to measure the distances to other galaxies.

Through a study of the motions of individual stars they can be separated into those belonging to the disc, halo, the Bulge and other components of our own galaxy. Gaia is even able to yield new data about asteroids in our solar system.

The Gaia satellite is a European success story. The two astrometric satellites Hipparcos and Gaia have been the products of European consortia, working through the European Space Agency (ESA). One way or another, thousands of people have contributed to the present project but special recognition was accorded at the conference to François Mignard of the Observatoire de la Côte d'Azur in Nice who was one of the main drivers of the project.

"Defragging" under the stars: Karoo Star Party 2017

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On Saturday April 22nd - after weeks of planning and organising, our annual "date" with the Karoo dark skies became at last a tangible reality. Arriving on different days at the Kambro padstal, next to the N12, about 20 kms north of Britstown, the ranks of partygoers kept on swelling until the arrival of a few latecomers on Wednesday. Though the official dates were April the 24th to 28th, early arrivals and late leavers extended that from Saturday the 22nd to Saturday the 29th. Pretoria ASSA members made up the bulk of the attendees, complimented by a few guests. Weather predictions were favourable, with only Wednesday night being less than perfect, resulting in ample hours under crisp, dark skies, making the 800km plus trip more than worthwhile.

The unique Karoo landscape is complimented by gorgeous sunsets and sunrises, with the early morning Moon and Venus adding to the splendour. As a bonus, passing plane's contrails added to the visual appeal, making for some interesting photographs. Even in a sleep-deprived state, following a dusk to dawn night of satisfying observing and astrophotography, all this made it just that little bit more difficult to embark on a "forced" shuteye exercise.

Everyone was on a different mission, whether going visual, or attempting to capture ancient photons onto camera sensors, the Karoo skies cater lavishly to everybody's fancy. As the years have gone by, the instrumentation used by the star party has changed rather dramatically. Whereas in 2011 there were about 2 go-to commercial telescopes, with the rest all handmade, this year there were mainly commercial go-to telescopes, with only two handmade versions.

Visually and photographically many new targets, as well as "old friends" were visited and re-visited, exploring the finer details and colours obscured from our city dweller's light polluted skies. Most of those present fulfilled their "bucket lists", getting a number of targets under the belt, including for some the ASSA 100 list.

A few of those present still adopted the "traditional" approach "drove" their telescopes "by the seat of their pants" - as Bosman Olivier put it. This included Fred Oosthuizen with his string telescope, Louis Lombaard with his original 6 inch Dobsonian, and Johan Smit brought along a revamped refractor, consisting of a century old camera lens used for aerial photography. As usual Johan designed and built a new instrument – a binocular mirror mount, with first-surface mirrors reflecting starlight and other targets into a pair of jumbo binoculars – making for very effective and comfortable viewing.

Percy Jacobs did bring along his handmade 10 inch Dobsonian, but sadly this scope did not see starlight! That was left to his refractor on a go-to

mount, with which he, apart from capturing quite a few targets photographically, also delved into his usual spectroscopic research.

Fig.1 Fred Oosthuisen and Percy Jacobs

Dawie Venter and the author immersed themselves in the usual quest for digital imaging with varying levels of success; this was an extremely satisfying and rewarding endeavour. The telescopes used in these photographic sessions included a wide range of designs, ranging from Schmidt-Cassegrains to Newtonian reflectors and refractors, as well as camera lenses of different shapes and sizes, literally from 8 to 2 845 mm. Bosman Olivier, having joined the ranks of the computer driven observers. Hunting down several ASSA 100 targets.

Fig 2. The Christmas Tree and Cone nebulae.

It is not always necessary to view through the night sky through a telescope; Andy Overbeek one night just sat and enjoying the vistas and the company, occasionally binoculars. Waldo Koen brought his monster 12 inch Dobsonian along, entertaining himself, and other members, with views of the crystal clear sky

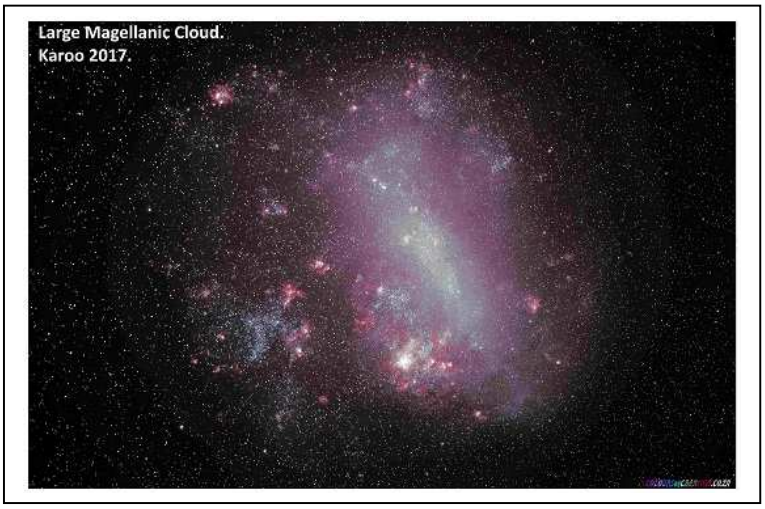

Fig 3. LMC

Every year visitors form an integral part of the Karoo experience and on the Thursday night those attending were introduced to the wonders of the Karoo skies, and starting out cloudy, the early evening gave opportunity for a talk to be presented. One attendee of Johan Smit's informative talk on light pollution was a young lady with a severe visual impairment. She suffers from narrow angle glaucoma, leaving her blind in one eye and with very limited "tunnel vision" in the other. Nonetheless, she was able to follow the talk – sitting very close to the screen. Once the skies had cleared, he embarked on showing her something through the eyepiece, and several hours and numerous attempts later, what surely must be the highlight of the star party, was when she shouted: "I can see the rings"! (Saturn).

With great courage and perseverance from her side, Johan was able to guide her to other deep sky targets, including the nebulosity in the Eta Carina nebula, bright stars in clusters and star colours. He had to admit that this experience left him "a little bit emotional"- rather an understatement!!

Fig. 4. Waldo and Louis, left; Robyn and Bosman, right.

Apart from the lure of the skies, the Karoo experience also offers among other things,

gastronomical delight! As usual the local cuisine (dinners) offered at the Kambro padstal, exceptionally prepared by Wilma and her staff, left many going for more. Coupled with good wine and at times some engaging conversations, these made for precious memories.

In the end the interactions, conversations, camaraderie, jokes and quips shared between the party goers are what really elevates this event; preparations for 2018 are already underway with four chalets have already been booked. Whilst taxing on the body, the Karoo star party does however bring rich rewards, restoring both spirit and soul. As Danie Barnardo reflected; the opportunity to experience the shadows cast by the Milky Way, to see objects you only read about on the Internet, to enjoy the hospitality and excellent facilities at the Kambro padstal was indeed a huge privilege.

Definitions of terms in meteor astronomy and recent Southern African Fireball Observations

Tim Cooper, Bredell Observatory

This article summarizes the definitions agreed by Commission F1 of the IAU during its recent vote pertaining to meteors, and continues the sequential numbering of reported fireball sightings from southern Africa.

Definition of terms in meteor astronomy

In order to clarify the terminology relating to meteor astronomy, and seeing that the 'basic definitions in meteoric astronomy' adopted at the IAU General Assembly in 1961 no longer correspond to the current state of knowledge, Commission F1 of the IAU recently voted (including this author) and on 30 April 2017 approved a number of definitions, including inter-alia the following related specifically to meteors (the full text of the definitions can be found on the Commission F1 webpage):

Meteor - is the light and associated physical phenomena (heat, shock, ionization), which result from the high speed entry of a solid object from space into a gaseous atmosphere.

Meteoroid - is a solid natural object of a size roughly between 30 μm and 1m moving in, or coming from, interplanetary space.

Meteorite - is any natural solid object that survived the meteor phase in a gaseous atmosphere without being completely vaporized.

Meteor train - is light or ionization left along the trajectory of the meteor after the meteor has passed.

Meteoroid stream - is a group of meteoroids which have similar orbits and a common origin.

Meteor shower - is a group of meteors produced by meteoroids of the same meteoroid stream.

In the remarks to the term 'meteor':

A meteor brighter than absolute (distance of 100 km) visual magnitude –4 is termed a **bolide or a fireball**.
A meteor brighter than absolute visual magnitude –17 is also called a **superbolide**.
Note no distinction is made in the definition between a bolide or fireball. The major change relevant to this catalogue of Southern African sightings is the definition of a fireball as being brighter than absolute magnitude –4, whereas previously brighter than magnitude –3 was used. For purposes of continuity with the previous definition of a fireball, the following reports include sightings reported as $m_v = -3$ as they all occur before the new definition was approved. Any catalog entries subsequent to 30 April 2017 will concur with the latest IAU definition of a fireball.

Catalogue of Recent Sightings

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 in brackets]. All times were converted to UT unless stated, and all coordinates are for epoch J2000.0.

see previous discussion, as of 30 April 2017. Prior to that date meteors of m_v –3 are included.

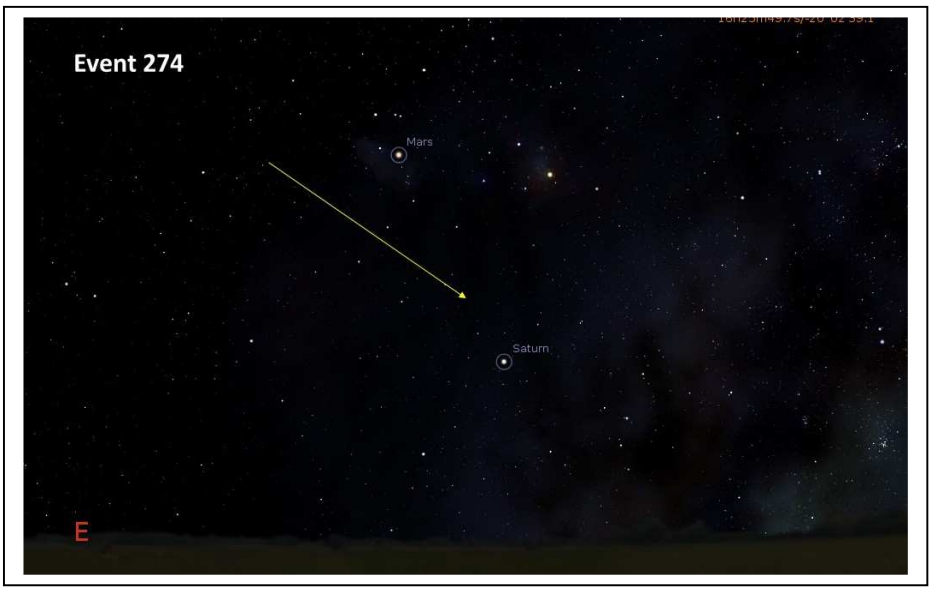

Fig 1. Event 274

Event 274 – 2016 March 23 – Hennopsrivier, Gauteng

Observed by Allen Versfeld at 20h50. He reported 'much brighter than Venus [m_v probably about -6], colour brilliant blue-white, with a scarlet tail, and I think there was a thin red halo around the meteor. Started about seven degrees left of Mars, headed down and to the right at an angle of about thirty degrees from the horizon, covering a distance of about ten degrees across the sky. It brightened then dimmed evenly, no fragments, lasted about two or three seconds and the train persisted for maybe half a second'. From Allen's description I calculate the path from approximately RA16h, Dec -14° to RA16h38, Dec -20°.

Event 275 – 2016 April 28 – Three Rivers East and Centurion, Gauteng
Observed by Riaan Coetzee at 18h15. First seen at azimuth about 224°, [that is slightly to the left of Canopus], and descended towards the left [towards Achernar] at an angle of 80°. Brighter than both Moon [which was not visible at the time] and all observable stars, duration 1.5 seconds. Orange, blue and white colours were noted, and 'I could see the leading edge glow orange'.

Observed by Franco Megannon at 18h20. 'Bright meteor trial over Centurion, lasted about a second and ended in bright white flash. Trail from the north-west and in a steep angle. Brighter than Jupiter but not as bright as the moon'.

Event 276 – 2016 May 3 – Bredell, Gauteng
Observed by Tim Cooper during a dedicated watch on the eta Aquariids at 02h53, $m_v = -4$, white, very fast, duration less than 1 second, start 21h40, +08°, end 20h15, +22°. The fireball was an eta Aquariid.

Event 277 – 2016 May 4 – Louis Trichardt, Limpopo
Observed by Kos Coronaios during a dedicated watch on the eta Aquariids at 02h38, $m_v = -3$, white, fast, duration 1 second. The fireball was an eta Aquariid.

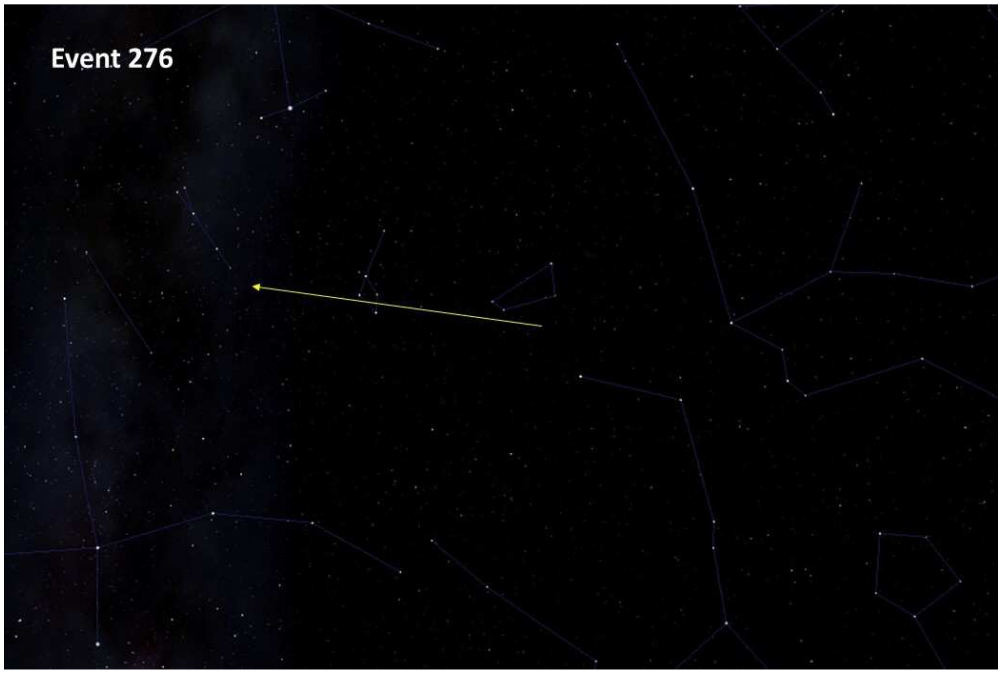

Fig 2. Event 276.

Event 278 – 2016 May 5 – Pietermaritzburg, KZN

Observed by Ebrahim Ally at 03h39, while sitting in a car, just before sunrise, facing south east, and altitude 30-40° and moving from left to right. 'Duration was about six seconds from horizon to horizon, and the fireball was visible throughout. The tail was mostly white with reddish 'sparks' coming off at different angles and disappearing while the fireball varied in intensity and occasionally 'sputtered'. It seemed like the object was disintegrating but didn't show signs of slowing or coming closer to the ground; the trajectory was flat across the horizon. About the same brightness as the full moon if not a little brighter [the moon was new at the time, so the observer was relying on memory] but not bright enough to dazzle or cast a shadow'. The fireball left a persistent train visible for about half a second. No sounds heard, but the windows of the car were closed. Given the description, I estimate the path very approximately from Pegasus, through Phoenix, to Carina.

Event 279 – 2016 July 25 – Cape Town, W Cape

Observed by Angela McLeod from Plattekloof Hill at about 04h10, 'driving eastward on the N1 freeway, appeared to be descending over Bellville/Kraaifontein direction, close collection of orange-yellow lights at least as bright as the full moon, appeared to have a tail, heading downwards, and then when I looked again there was this comet-like light [persistent train?]. Duration 5-10 seconds then abruptly disappeared. Tail 10-15 times larger than the head. No sound heard. From further discussion with Angela, I roughly estimate the path from 07h00, -38° to 07h52, -15°.

Observed by Wayne Jooste from Blouberg, at about 04h20, 'walking to my bakkie my attention was drawn to a rather large bright fireball fall from the sky. I was facing in a SE direction and the fireball moved in what appeared to be a Northerly direction, I only had sight of it for around 3 seconds as it was so low that it went behind another building. It was much brighter than anything else in the sky'.

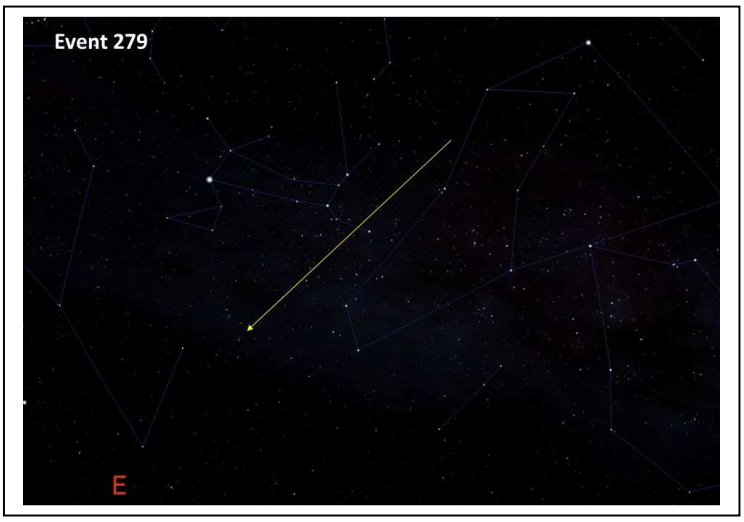

Fig 3. Event 279

Event 280 – 2016 August 30 – Cape Town

Observed by David le Roux at 16h42. N1 close to the docks, driving towards Tygerberg. Duration 3 seconds, slow moving, colour green, direction south to north (right to left) descending at an angle of about 70°. Very bright [it was not quite dark], broke into four fragments about 30° above the horizon, left 1 second train.

Event 281 – 2016 December 30 – Grootvadersbosch nr Heidelberg, Cape

Observed by Anslyn John and Klaas-Douwe Dijkstra at around 21h45. Much brighter than any other object visible, brightness perhaps m_v –3 or possibly brighter, colour pale orange, slow moving, took about 8 seconds to cover 90° path. Pale grey tail followed the head for the entire passage, but no persistent train was seen. No sounds heard. From their descriptions of the path I estimate the start and end points from 18h24, -75° to 01h00, -05°.

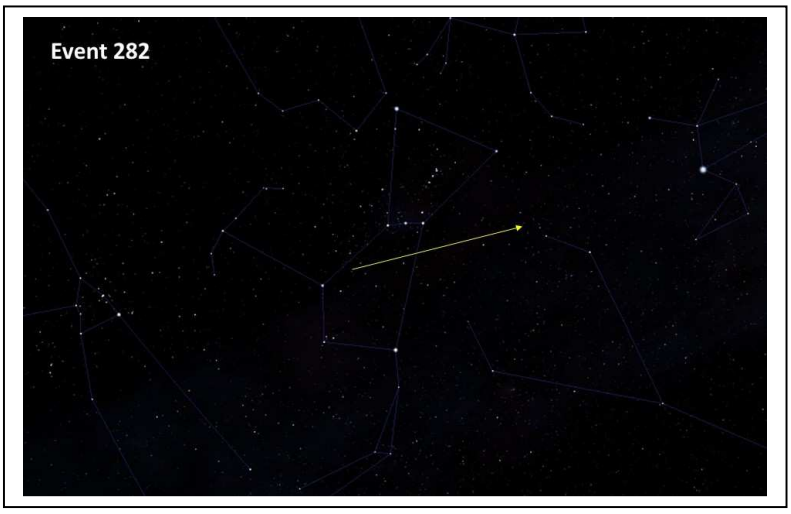

Fig 4. Event 282.

Event 282 – 2017 January 18 – Geelhoutpark, Rustenburg, North West
Observed by Mariehette Ogle at 18h23. Facing NNE, duration 4-5 seconds, at the end of its path it broke into two large and several smaller fragments. Left a persistent train visible for about another two seconds. Much brighter than the brightest star visible at the time (Sirius). Fireball and train were yellow, definitely not white. No sound heard. Mariehette provided a sketch showing the path below the stars in Orion's Belt (at the time azimuth 35°, altitude 55°) headed towards the direction of Sirius.

Event 283 – 2017 April 6 – Makhado, Limpopo
Observed by Kos Coronaios at about 02h20, seen through thin cloud, m_v = –3, colour white, speed fast, start and end points approximately 19h30, -55° to 21h50, -03°. No persistent train. The path is consistent with a member of the Virginid ecliptic complex of radiants active at this time, and known for the tendency to produce fireballs.

Fig 5. Event 283

Event 284 – 2017 April 15 – Faerie Glen, Pretoria, Gauteng

Observed by Neville Young at about 20h30. m_v = –4, green colour with red immediately following the meteor. Passage from about gamma Velorum to alpha Crucis, very slow, duration 6 seconds, and disintegrated into three fragments. Persistent trail visible for about last 5°. Neville commented 'no sounds heard although a visitor said she heard something'.

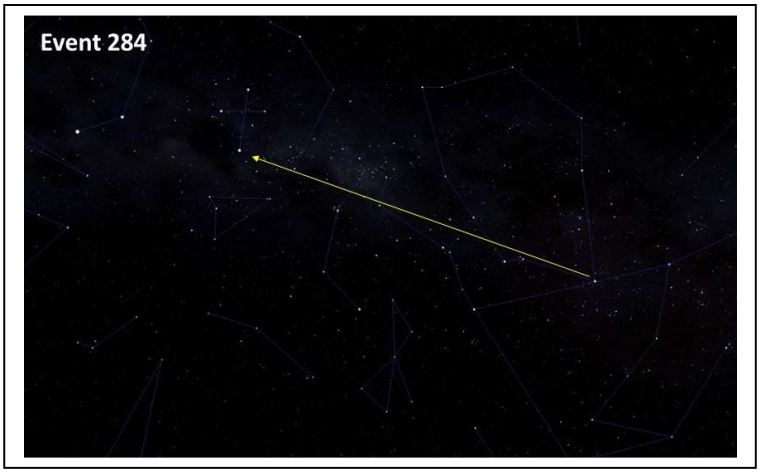

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Fig 6. Event 284

Pro-am collaboration with SAAO covering the 2014MU69 occultation event.

Clyde Foster

On 3 June 2017 it was anticipated that the Kuiper Belt Object (KBO), 2014MU69, would occult a 15th magnitude star in Sagittarius. The projected narrow shadow path, estimated to be only 50km across, extended across the South American and South African regions. This KBO, estimated to be 25-45km in size, is the next objective of the NASA New Horizons spacecraft, which will perform the flyby on 1 January 2019. Two further occultations are expected to occur this year, and these three events provide a rare opportunity to obtain further information about this small, very faint (27mag), object. 2014MU69 was discovered, and has only been detected directly, by the Hubble Space Telescope.

It was a pleasant surprise to receive an invitation by the South African Astronomical Observatory (SAAO) to support them in a pro-am collaboration effort to monitor the occultation in support of the NASA New Horizons team. A number of international teams were being deployed, using 16" Skywatcher Dobsonians to both South America and South Africa in order to set up an observing grid covering the shadow path. My home location in Centurion Gauteng was well north of the projected path, so it was agreed with SAAO that I should consider

relocation of my Celestron 14” Edge HD SCT and auxiliary equipment to Bloemfontein, and more specifically the Boyden Observatory just north east of the city. Although outside the high probability path, it was still possible, due to the limited information about the KBO, that the occultation may be detected. Even a “no-detection” result could still provide valuable information. Having visited the Boyden Observatory a number of times over the last few years, it was an excellent opportunity to build further on my relationship with Boyden and the Physics/Astrophysics department of the University of the Free State (UFS), who are responsible for the maintenance and operation of the observatory. Boyden kindly allocated one of the historic small observatory buildings for my use over the period I would be there.

Boyden Observatory was set up in South Africa in 1927, when Harvard College Observatory took the decision to relocate its Boyden station, at that stage based in Arequipa, Peru. It has gone through various ownership changes, and challenges, over the years, but I am glad to say has survived. Some of its most famous and historic instruments are the Boyden 60” reflector, previously the Rockefeller, the 13” Boyden refractor and the 10” Metcalf refractor. The more modern 16” Watcher robotic scope is managed by the University College Dublin. The Observatory also houses an amazing library, containing a multitude of historical documents and books, as well as various exhibits.

Various tests were undertaken from my home observatory in preparation, but, given the local urban sky conditions, it was evident that it would be a very challenging exercise. Given the expected duration of the occultation of less than 2 seconds, exposures of 0.5s, with a minimum S/N ratio of 5-10 were key requirements. Binning with my ZWO ASI290MM camera, combined with a focal reducer, were important factors. During this period of testing and self-study, I was ably supported by input and advice from Tim Haymes of the BAA as well as Anja Genade of SAAO.

The relocation took place on the Wednesday prior to the occultation, allowing 3 days and nights to set up and resolve any last minute issues,

where I was grateful for the assistance and support of the UFS Physics/Astrophysics department.

The target field was acquired a few hours before the occultation, and was delighted to note that the target star was easily detected. With projected occultation time of close to 03:10UT, data was a captured at 2fps from 02:47UT to 03:32UT. 4.6Gb of data in 5457 frames were captured in FITS format. Initial indication is that the data was of sufficiently good quality(s/n), and is currently being analysed by SAAO and it will be interesting to see the consolidated results from all observers. For me it was a huge learning curve but an exciting and rewarding experience.

My sincere appreciation to Prof Matie Hoffman and Dawie van Jaarsveld of Boyden Observatory and the UFS Physics/Astrophysics , Anja Genade of SAAO, Tim Haymes of the BAA, and the ASSA."

MU69 Occultation Travel Report

Henry Throop

NASA's New Horizons spacecraft flew past Pluto on July 14, 2015. The historic flyby was executed perfectly and the spacecraft sent thousands of images, spectra, and other measurements back to Earth. Literally within a day of their receipt on the ground, these observations revolutionized our knowledge and understanding of the Pluto system. What they dramatically and clearly showed was that although Pluto was cold and frozen, it was not geologically dead. Its surface looked 'young': active geology had recently sculpted mountains, plains, and vast areas of terrain across the planet. While we expected to see a surface covered with impact craters from collisions with asteroids and comets in the Kuiper belt, what we found is that the surface was so young and active that it had already covered up the scars of many of these recent impacts. For some as-yet unknown reason, Pluto's core was warmer than we expected — perhaps

maintained by radioactivity, or by chemical processes within Pluto's interior.

Although Pluto is billed by many (including myself, and many on the New Horizons team) as being the last planet in the solar system, it is undeniable that Pluto is just one of thousands of bodies in the Kuiper belt. Perhaps it is currently the largest and brightest, but this will change through time as the word 'planet' is redefined again and again. The Kuiper belt is an important part of our solar system — a reservoir of primitive material, and a tracer of the gravitational dynamics that have sculpted the rest of the planets' orbits. That is, as Jupiter, Saturn, Uranus, and Neptune were formed, their interactions kicked around these Kuiper belt objects (KBOs), and by studying them, we can unravel the history of the solar system.

The Pluto system was New Horizons' primary target. But the New Horizons team had always hoped that, after Pluto, our spacecraft would be healthy enough to continue and fly past a KBO. During 2016, we were given permission by NASA to fly the spacecraft to a target: the KBO called "2014 MU69." We'd discovered this target during a search with the Hubble Space Telescope. Its orbit took it close enough so that with a small turn, New Horizons could fly past it. The New Horizons team is currently planning for an encounter with MU69 on 1 January 2019.

MU69 is amongst the faintest objects ever discovered by Hubble: 27th magnitude as seen from Earth, compared with Pluto's 14th. However, the Hubble data didn't give us enough information to plan our observations. For instance, we don't know if MU69 is large (50 km) and dark, or small (10 km) and bright. Both of these would look identical from Hubble's vantage. And, Hubble's astrometric accuracy is insufficient to determine MU69's position to within a few thousand km, making it difficult to plan exactly where to point our cameras at the flyby.

But there is another possibility to direct observation: a stellar occultation. In this case, we can use a relatively small telescope to observe MU69, not

by resolving the KBO itself, but by watching as it blocks out the light from a distant star. As it turns out, there are several stars that MU69 is passing in front of during June and July 2017. And by observing these, we can measure the physical parameters of MU69 and help plan the New Horizons encounter.

The stellar occultation works a bit like a solar eclipse. Just like the eclipse shadow pass crosses the Earth on a specific line, so too the stellar occultation. Most people on Earth won't see it. But for those in the right place, at the right time, the star will appear to blink out, and reappear several seconds later.

As luck has it, the shadow path for one of the occultations was right through South Africa. The occultation on 3 June, 2017 started in St. Lucia, passed through Lesotho, Carnarvon, and Clanwilliam, before crossing the ocean and passing through Argentina and Chile.
I was fortunate to be part of a team of NASA scientists, students, and amateurs who observed this occultation. Due to its importance to New Horizons, we spent months organizing a plan - by far the largest stellar occultation observation ever undertaken. We wanted to maximize the odds of seeing the event from many sites across its path. We did this by using portable telescopes, coupled with observations from any fixed sites near the path, including Sutherland and Bloemfontein.

The idea was that our team would spread themselves out along a north-south line through the expected occultation central position. We separated these lines by 10-20 km N-S, so that each observer would get a different 'chord' of the observation — a slightly different position and timing. At the time of the event, each observer would be taking high-cadence images with the CCD, and by analysing the images for when the star disappeared, we could tell precisely at what time the KBO passed each observer. By combining all of the observations, we'd be able to piece together the position, shape, and size of the KBO.

Our team of roughly 25 observers arrived in Cape Town on June 29. Our telescopes had been sent a few days earlier: we had shipped 10 brand-new identical 16-inch Dobsonians with goto controllers and low-noise CCDs. A few groups brought additional hardware, including a 24-inch portable.

Meanwhile, a similar-sized team landed in Argentina and conducted their own work in parallel to ours.

We spent two nights in Cape Town checking out the equipment, and learning how to find our target field in the beautiful southern skies! One telescope was damaged in transport: the primary mirror became dislodged and could not be reattached. One motor drive failed, and one CCD was inoperative — so we dedicated one system as a 'spare', enabling us to observe with the rest. The weather during these practice nights was a bit cloudy, but not abnormally so for this time of year. We spent a long evening with Martin Lyons from the Cederberg Astronomical Observatory, who proved to be a veritable treasure of local information and technical know-how, as he advised us on sites, weather, collimation, and more. While many on our team are professional astronomers, that doesn't mean we know very much about hardware… I am continually amazed by the ingenuity and knowledge of the South African amateur network.

Two days later we drove to Clanwilliam — near the centreline, and where we planned to set up for the event itself. We spread out along a N-S path, and started knocking on farmhouse doors. Almost always, the locals were appreciative and went out of their way to help us.

We had two more nights of 'dry runs' scheduled in Clanwilliam before the event. Equipment problems were solved, and our team was running smoothly. But… the clouds continued to build. While we could see our target field at times, the prediction for 3 June was looking increasingly pessimistic.

We scheduled a group meeting. Should we stay in Clanwilliam, where we'd established good sites and local connections? Or should we head east, to Sutherland, where the weather might be better? Or should we head *way* east — past Carnarvon to Vosburg, 500 km away — where the weather was supposed to be clear, but where we had no local knowledge, and didn't even know if we could find guesthouses. In the end we decided to hedge our bets: half the group stayed at their sites in Clanwilliam, while the rest (including myself) drove through the night to the Karoo.

The next morning we went out and scouted for sites — again! But this was again quite easy: the locals were interested and enthusiastic in helping us. Our Afrikaans wasn't very good, but we all managed to track down a good site. The group I was observing with had received permission to set up on an ostrich farm 55 km south of Vosburg. Others had talked with game ranchers, churches, parks, and schools, with some help from the local SAPS.
After finding the sites, our subgroup met in Vosburg for the evening. For what? A braai, of course! Our Cape Town-based security team definitely knew how to cook… as well as boast about who had the best boerewors technique.

As the fires cooled, we readied for the occultation, which was now about eight hours away. The 'blink' itself was expected to be a three-second event starting around 5:09 AM that morning. Our goal was to record images for 45 minutes centred on the event. We would take imaging data continually at an exposure time of 0.5 seconds, which would give us a good balance between time resolution and data quality. Too long an exposure and we would risk missing the star blinking on and off; too short, and the star would be lost in the background noise. So as to have a consistent dataset, all teams (on both continents) used the identical exposure settings, on our identical telescopes.

A little past midnight, we headed out to our site. We wanted to have sufficient time to set up and fix any difficulties, but we didn't want to get set up too early and find ourselves stuck with condensation.

By 03h00 we were aligned, collimated, and on the field in Sagittarius. Focus was good. Feeling some slight winds, we moved our bakkies around to use as windbreaks for the lightweight Dobsonians. An emergency call came in — one telescope's primary was loose, and needed repair, so part of our group headed to help them out. (They ended up fixing it before help arrived.) 04h00 came, and we were looking good. We snapped a few group pictures, dressed up warm, and kept waiting as the scope continued to track well. We turned off all our lights, made sure no phones would disturb us, and waited until 04h45. Time to start exposing! Our CCD started integrating and reading out, until we had 45 minutes of data in 5400 frames. We let out a cheer when 05h09 came — the expected midpoint — but with the star at 15th magnitude, and our computer screens dimmed, we didn't even try to directly observe the star blink out. We continued to collect data for the rest of 45 minutes, as the MU69 system slowly passed in front of our target star.

With our prime mission complete, we couldn't resist putting on an eyepiece and taking a tour around the beautiful southern sky, that was new to most of us. Saturn was brilliant, and the clear 180-degree Karoo skies let us catch Mercury and Venus both just a few degrees up from the horizon.

We are all back home now, and our data is being analyzed. Every single team that observed recorded a full data set. Our bets on the weather paid off. And now we're packing up and getting ready to do it all over again: MU69 occults another star visible from Tierra del Fuego, Chile on 17 July 2017. And then, it's onward to 1 January, 2019 to have another go at MU69.

Dr. Henry Throop is a Senior Scientist with the Planetary Science Institute in Mumbai, India, and a member of the New Horizons science team. While teaching at the University of Pretoria from 2012-2015, he was a frequent speaker at the ASSA-Pret. and ASSA-Jhb. Centres. Henry and the rest of the MU69 team extend their hearty thanks to the many members of the astronomical community in South Africa who assisted with this trip

Catching a Glimpse of New Horizons

Amanda Sickafoose

In the early hours of the morning on 3 June 2017, while most locals are sleeping, dozens of astronomers across South Africa will be looking up at the night sky in hopes of viewing a shadow from a mysterious, distant object. They are part of a large, international effort to study the target of NASA's New Horizons spacecraft extended mission. [1] New Horizons stunned the world in 2015 when it passed through the Pluto system and returned unprecedented images and information about Pluto and its five moons. The extended mission will allow the spacecraft to collect data on an even more remote object, called 2014MU_69 (Figure 1).

2014MU_69 was discovered by the Hubble Space Telescope. It is dynamically classified as a classical Kuiper Belt object. Because it is very faint, with a 26.3 visual magnitude, little is known about its physical properties. A stellar occultation, during which the light of a distant star is blocked by 2014MU_69, has been predicted to be observable from specific regions of the Southern Hemisphere on 03 June (Figure 2). If successfully observed, this fleeting event could allow measurement of 2014MU_69's size and shape, could detect rings, dust or debris, and could improve the positional accuracy, all of which would be vital information for planning the spacecraft encounter. 2014MU_69 is located nearly 6.5 billion kms away with an estimated diameter of approximately 40 km, and the entire occultation will only last roughly 2 seconds. Thus, the observers need to be in exactly the right place, at the right time, with the right equipment to detect the brief dip in the starlight.

To optimize the likelihood of successful observing opportunities (and to avoid bad weather!), observers will be stationed in South Africa, Namibia, Chile, Brazil, Uruguay, and Argentina. Locally, SAAO observers will be using both the 74-inch telescope and the three Las Cumbres Observatory telescopes [2] in Sutherland. Multiple members of the ASSA (Astronomical Society of South Africa) are also contributing to the effort. In Southern African alone, there are roughly three dozen overseas visitors who pre-shipped more than a dozen portable telescopes and specialized cameras (Figure 3).

"It is impressive to have so many people visiting South Africa and to see the amount of effort put in to taking the data. It's a particularly challenging observation that can't be done without international collaborators. If we are successful, this will be an occultation observation by the faintest object ever and will allow new, accurate measurements to help support New Horizons," says Anja Genade, an SAAO/UCT student in the NASSP program whose research involves stellar occultations.

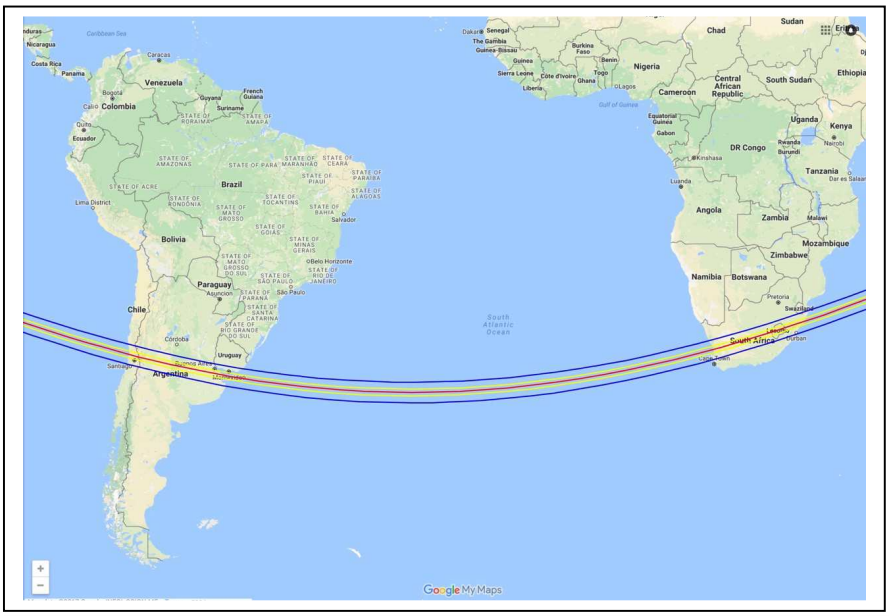

Fig 2. The predicted shadow path for the 03 June 2017 stellar occultation by 2014MU69. The red lines represent the centerline of the shadow, yellow lines represent 1-sigma error bars, and blue lines represent 3-sigma error bars. Observing stations will thus be located in South America and Southern Africa. (Map courtesy of M. Buie and S. Porter of SwRI.)

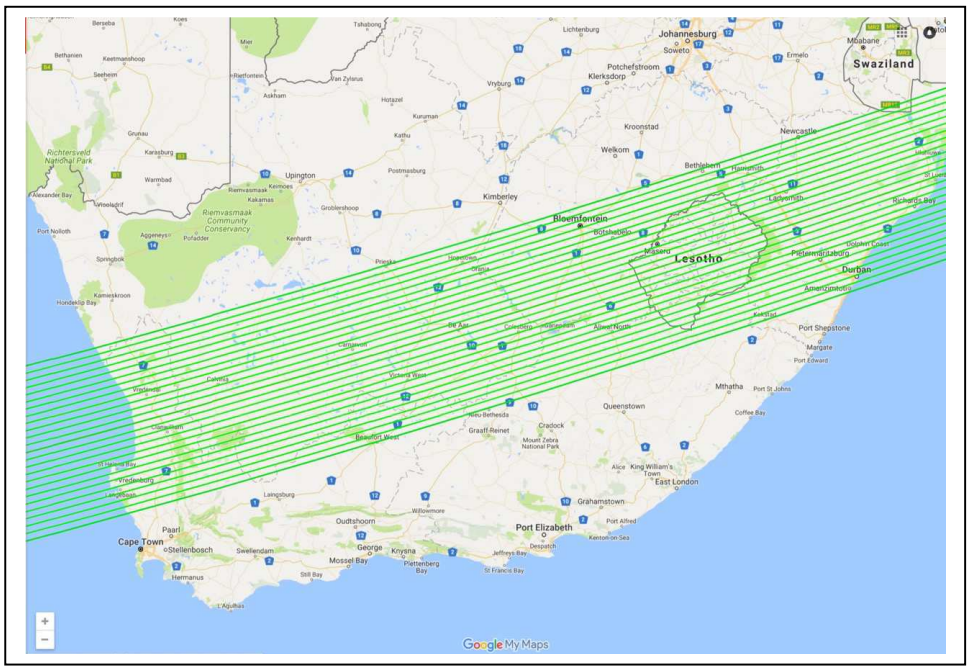

Fig 3. Map of Southern Africa showing parallel locations centred on the predicted shadow path, creating a picket fence *coverage across the full 3-sigma error bar. This represents the 10-25 km spacings along which portable teams can be stationed, in an attempt to ensure that the shadow is detected without slipping in between two stations. (Map courtesy of M. Buie and S. Porter of SwRI.)*

Currently, the spacecraft (Fig 1. See cover) is approximately halfway between Pluto and 2014MU_69, and it is scheduled to fly by the target on 1 January 2019. This will be the most distant Solar System object ever encountered by a spacecraft. Pluto was revealed to be a dynamic, exciting object by New Horizons, and we are sure to expect further surprises and enlightenments from the extended mission as it explores the edge of our Solar System.

1 https://www.nasa.gov/mission_pages/newhorizons/main/
2 https://lco.global/
3 https://assa.saao.ac.za/

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: Magnetic field structure of intermediate-velocity gas in the local ISM
Speaker: Jeroen Stil (University of Calgary
Date: 6 April
Time: 11h00 – 12h00
Venue: SAAO Auditorium

Abstract: Some magnetic structures on scales of hundreds of parsecs revealed by Faraday rotation at high Galactic latitude have been associated with intermediate-velocity (IV) gas. The interaction of IV gas with its magnetized surroundings is an important part of dynamo processes that build up large-scale magnetic fields in galaxies. Nowhere can this interaction be observed in more detail than in the local interstellar medium. After a brief introduction, I will present new results for a nearby

IV filament using observations of polarization of diffuse Galactic synchrotron emission from the GALFACTS survey, made with the 300-m Arecibo radio telescope. These data reveal a complicated magnetic structure that is related to the distribution and kinematics of the neutral gas and plasma**.**

Title: An extinction-free view of merging galaxies and their constituents
Speaker: Cristina Romero-Canizales (Diego Portales University)
Date: 4 May
Time: 11h00 – 12h00
Venue: SAAO Auditorium

Abstract: The interaction of gas rich galaxies via mergers or close encounters can give rise to sudden, violent star formation (SF), often accompanied by the presence of an AGN. The merger gives rise to a system whose energy is mostly emitted in the IR with a luminosity above 10E11 L_sun. These dusty environments are the scenery of supernova explosions at a high rate as well as of super-massive black hole (SMBH) growth and at the same time, they represent excellent laboratories to study the evolution of galaxies. In this talk I will guide you trough a journey of the different science that can be done when studying mergers and I will present exciting observations on a “baby” AGN and a tidal disruption event

Astro-Coffee

Title: GMRT upgrade: Current status and early science results
Speakers: Assoc Prof Ishwara Chandra CH & Reader Dharam Vir Lal
National Centre for Radio Astrophysics, Tata Institute of Fundamental Research
Date: 13 April
Time: 13h00 – 14h00
Venue: 2nd floor auditorium SKA office, Pinelands

Abstract: The GMRT is among the world's largest radio telescope at metre-wavelength and is undergoing major upgrade which is nearing completion. The upgraded GMRT (uGMRT) is a SKA pathfinder instrument and will complement several other observatories as essential tool for discovery in several areas of astrophysics. Currently capabilities of wide field, wide band imaging at GHz frequencies is being successfully demonstrated using JVLA, whereas at low-frequencies, around several 100s of MHz, we still have to demonstrate this to fully exploit the scientific value of data. The uGMRT serves as a test-bed to demonstrate wide band, wide field imaging at these low frequencies. We have conducted several test studies using the uGMRT, the results will be presented.

Title: 21cm Cosmology: The End of the Beginning
Speaker: Aaron Parsons, Associate Professor of Astronomy, Berkeley
Date: 25 May
Time: 13h00 – 14h00
Venue: 2nd floor auditorium SKA office, Pinelands

Abstract: Since it was first proposed nearly two decades ago, measuring 21cm emission from neutral hydrogen in our early universe has tantalized us as a powerful probe of both cosmology and astrophysics. While the science case for 21cm cosmology, particularly during the Epoch of Reionization, is well established, the technical path toward measuring this signal has been more problematic. PAPER has recently distanced itself from its competitors, applying major technical breakthroughs to set the first physically meaningful upper limits on 21cm emission during reionization, and improving those limits a year later to show the presence of significant early heating. Even as PAPER's final season is under analysis, we are re-tooling our array to become HERA. New 14-m dishes are replacing PAPER's smaller elements, giving HERA the sensitivity to drive beyond the detection phase of 21cm cosmology, into the exciting era of data-driven modeling. The results will revolutionize our understanding of galaxy and star formation and even improve upon CMB cosmology.

UWC

Title: Polarization Leakage in Epoch of Reionization Windows
Speaker: Khan Asad - UWC/Rhodes
Date**:** 21 April
Time**:** 14h00 – 15h00
Venue: Rm 1.35 New Physics Building, UWC

Abstract: The redshifted 21-cm signal coming from the HI of the Epoch of Reionization (EoR; z~6-14) will be one of the most interesting beacon of observational cosmology once detected. Low frequency radio arrays have been and are being built all over the world to detect this signal, for example, LOFAR, MWA, PAPER, PaST, HERA, and the planned SKA. Like most cosmological observations, the greatest difficulty in its detection is removing the foreground radiations. After removing the point-like extragalactic foregrounds, we are left with the diffuse Galactic foreground which is polarized because it is created through the synchrotron mechanism. The total intensity of the diffuse foreground can be removed to a large extent utilizing its spectral smoothness. But its polarized counterpart is not smooth along frequency. We would not care about this polarization, because the EoR signal will be detected in total intensity, unless it could contaminate the total intensity. The errors of the telescope can do exactly this – a small portion of diffuse polarized foreground can leak into the total intensity mainly because of the primary beam of an antenna.
In my PhD thesis, defended on 23 Janurary this year, I have presented a pipeline that can simulate realistic EoR observations taking into account the direction independent (DI) and dependent (DD) systematic effects of LOFAR. We have tested various DI and calibration errors, but finally focused on one DD effect, the primary beam. We have predicted the level of leakage caused by the LOFAR primary beam, and compared it with a simulated EoR signal. We have also tested various leakage correction strategies.

We have found that the leakage, if uncorrected, is comparable in amplitude to the expected EoR signal toward some directions, and the primary beam of LOFAR used for this prediction has an error of around 10%. The fractional leakage is almost constant over the instrumental k-space, i. e. the 2D cylindrical power spectrum, and it is higher in the fields that remain farther away from zenith. We have found a potential 'EoR window' above the chromatic side-lobe wedge of the instrumental k-space where the EoR signal dominates leakage, and this window takes up almost the whole k-space if 70% leakage is removed. The fractional leakage does not vary significantly as the field of view is increased, because the increment of leakage with distance from the phase centre is balanced by the decrement of power. These results show that leakage will not be one of the primary limiting factors in detecting the EoR signal with LOFAR, but it still has the potential of becoming a major issue for the more sensitive future telescopes like SKA.

Title: The Latest Progress of 21CMA and TREND Experiment
Speaker: Dr. Junhua Gu (NAO, Chinese Academy of Sciences)
Date**:** 26 April
Time**:** 14h00 – 15h00
Venue: Rm 1.35 New Physics Building, UWC

Abstract: This talk will cover two experiments that are being performed in the remote area of northwest China. The first one is the 21 Centimetre Array (21CMA), which is a radio interferometer for the detection to the Epoch of Reionization in low frequency radio band. This project began around 2005, and has run for about ten years. In this talk, the speaker will give a brief introduction to its latest progress. The other aspect of this talk is the Tianshan Radio Experiment for Neutrino Detection (TREND), which is running at the site of 21CMA. It is an antenna array that is aiming to detect the cosmic high energy neutrinos. We regard it as a promising project towards the future neutrino telescope, which will open a brand new window for detecting the universe

Title: Parity-wise alignments of CMB multipoles
Speaker: Dr. Pavan Aluri
Date: 26 May
Time: 14h00 – 15h00
Venue: Rm 1.35 New Physics Building, UWC

Abstract: Signals of violation of statistical isotropy on large angular scales of CMB sky have been reported since NASA's WMAP first year full sky data release. These do not conform to the standard cosmological model based on Cosmological principle. These instances of isotropy violation persisted in data from WMAP to a completely different full sky PLANCK mission, albeit with varying significances. In this talk, I will discuss about a specific CMB anomaly based on an earlier finding that the power in odd multipoles of CMB temperature anisotropies is more than that in even multipoles, indicating a parity asymmetry preference. Following this, in our recent work, we probed any directionality associated with even-only and odd-only multipoles separately. Interestingly we found that the regions spanned by the even/odd multipole collective axes also contain anisotropy axes corresponding to parity even/odd symmetry or phenomena.

Title: Wide-Field Polarimetric Imaging
Speaker: Preshanth Jagannathan (NRAO/UCT)
Date: 2 June
Time: 14h00 – 15h00
Venue: Rm 1.35 New Physics Building, UWC

Abstract: Next generation radio surveys aim to achieve high fidelity spectro-polarimetric imaging across wide-fields of view. This poses a complex imaging problem that requires that instrumental effects be corrected across the entire aperture of the array antennas. In this talk I will present the role of the antenna gain pattern or primary beam, in imaging and how well we need to determine the PB in order to be able to correct for it during imaging. I will also present an algorithmic solution in

the form of Full Mueller Imaging which accounts for the frequency and time dependence of the array antennas.

NASSP

Title: Travel through Space and discover the mysteries of Sprites: First recordings of these dazzling lights in South Africa
Speaker: Professor Michael Kosch from SANSA.
Date: 12 April
Time: 10h00-11h00
Venue: Astronomy Seminar Room, 5th Floor RW James Bld

Abstract: Sprites are a gas discharge phenomenon in the mesosphere and upper stratosphere powered by lightning strikes from large convective thunderstorms. They are very bright but very brief and, although quite common, have never been recorded before now in South Africa. This presentation will describe the background and physics associated with sprites as well as show first recordings from Sutherland in 2016.

Title: Where are the baryons in the Universe?
Speaker: Dr Yin-Zhe Ma, UKZN
Date: 19 April
Time: 12h00-13h00
Venue: Astronomy Seminar Room, 5th Floor RW James Bld

Abstract: Previous studies of galaxy formation have shown that only 10% of the cosmic baryons are in stars and galaxies, while 90% of them are missing. Hydro-dynamical simulation shows that the missing baryons are in a state of diffuse plasma with temperature 10^5 to 10^7 Kelvin, which is hard to be directly observed by X-ray observations. In this talk, I will present three observational studies that coherently find significant evidences of the missing baryons. The first is the cross-correlation between the kinetic Sunyaev-Zeldovich maps from Planck with the linear reconstructed velocity field. We find significance (4.6 sigma) detection of

the peculiar motion of gas on Mpc scales, for which we fit the baryon fraction. The second study is the cross-correlation between the thermal Sunyaev- Zeldovich effect with gravitational lensing map and fit the data with halo model. The third study is to stack the pairs of luminous red galaxies and subtract the halo contribution, which leads to the detection too hot nor too cold but are diffused till 5 virial radius of dark matter halos, which help us to understand the process of galaxy formation.

Title: The MeerLICHT/MeerKAT optical-radio synoptic survey
Speaker: Professor Paul Groot, Radboud University
Date: 26 April
Time: 12h00-13h00
Venue: Astronomy Seminar Room, 5th Floor RW James Bld

Abstract: Time-domain astronomy is taking big strides in uncovering the variable and transient universe, but is, almost always, still based on single electromagnetic bands (optical, radio, X-rays etc.). With the upcoming MeerKAT + MeerLICHT combination we will be breaking this barrier by creating the first-ever multi-band, 'always-on', optical-radio synoptic survey, where the MeerLICHT optical telescope will follow the MeerKAT radio array in its pointing on the sky. The MeerLICHT telescope is the prototype of the BlackGEM array, and consists of a single telescope with a 65cm primary mirror, a 2.7 square degree field-of-view, sampled at 0.65"/pixel with a single, huge, 10.5k x 10.5k CCD detector. The MeerLICHT telescope is now being tested at Radboud University and will be shipped to Sutherland in mid-May, for start of operations in July 2017.

Title: Is the Universe Isotropic?
Speaker: Yabebal Tadesse Fantaye, AIMS
Date: 10 May
Time: 12h00-13h00
Venue: Astronomy Seminar Room, 5th Floor RW James Bld
Abstract: The two fundamental assumptions in cosmology are that the Universe is statistically homogeneous and isotropic when averaged on

large scales. Given the big implication of these assumptions, there has been a lot of statistical tests carried out to verify the validity. Since the first high-precision Cosmic Microwave Background (CMB) data release by the WMAP satellite, many anomalies that challenges the isotropy assumption, including dipolar power asymmetry on large angular scales, have been reported. In this talk I will present the status of different statistical tests of cosmic isotropy from the Planck experiment

Sky Delights: A Crown on beautiful locks of Hair

Magda Streicher

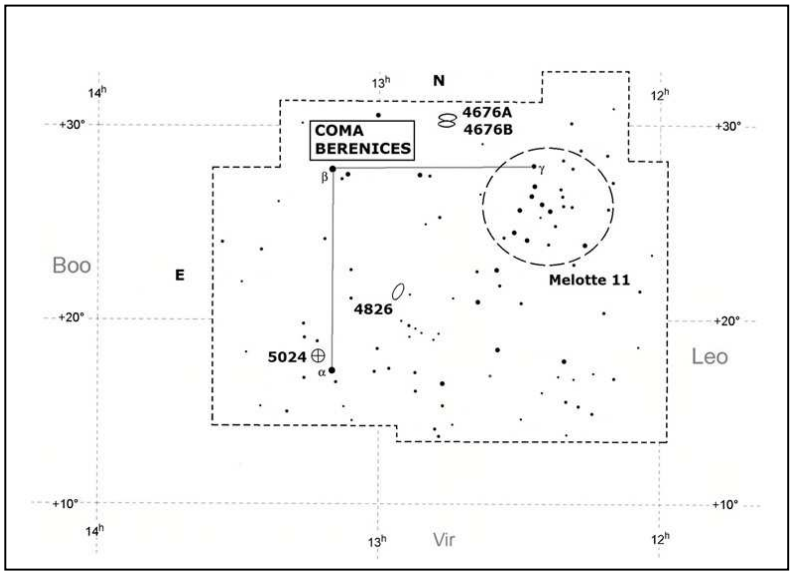

Fig 1. The constellation Coma Berenices.

The constellations Coma Berenices and Corona Borealis are two different constellations, but when one of them comes to mind, so does the other. These two constellations represent the lovely maiden with the beautiful hair – Coma Berenices and the crown, Corona Borealis, on her head. The two constellations are visible in the northern hemisphere in early summer, and into winter in the south. Corona Borealis was the only crown of stars named by Eratosthenes and the Greek astronomers; only later did the Southern Crown we know as Corona Australis today gain its place in the starry skies.

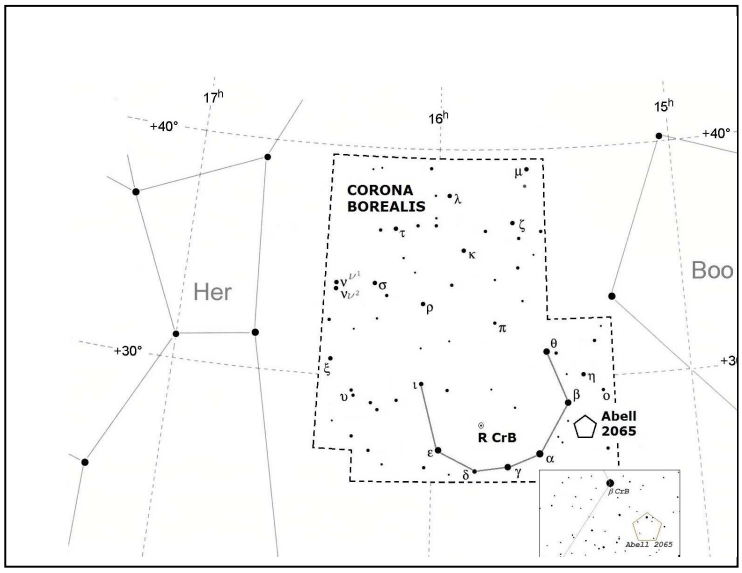

Fig 2. The constellation Corona Borealis.

Coma Berenices is commonly referred to as Berenice's Hair, but it was first called Ariadne's Hair, as in Eratosthenes' description of the constellation. Berenice of Cyrene was the

wife of Ptolemy. The ancient city of Berenice, named for the queen, still exists in Libya, but with its name transmuted into Banghazi. However, the constellation is also famous for marking the North Pole in RA 12h51m - DEC: +27°.

The constellation is well known for the naked-eye open cluster **Melotte 111**, also known as the Coma Star Cluster, which is relatively close to us, just 290 light years away. Containing more than 200 stars, Melotte 111 is more than a handful, with stars brighter than magnitude 8. This large outstanding cluster spreads out southward from the 4.4 magnitude gamma Coma Berenices, which is not a member of the group. The cluster can be appreciated through binoculars and is clearly visible against a dark transparent night sky.

The best example of a colliding pair of galaxies, **NGC 4676A** and its companion **NGC 4676B**, is situated 1.2 degrees from the border line with the constellation Canis Venatici. The pair are popularly known as The Mice, so named by the Russian astronomer B.A. Vorontsov-Vel'Yaminov. The two spiral galaxies, about 280 million light years away, are ripping each other apart and perhaps also a part of the Coma cluster of galaxies. Only a Hubble picture could capture the beauty of the two bodies, showing each leaving a long tail of gas and stars behind, suggesting a pair of mice at play.

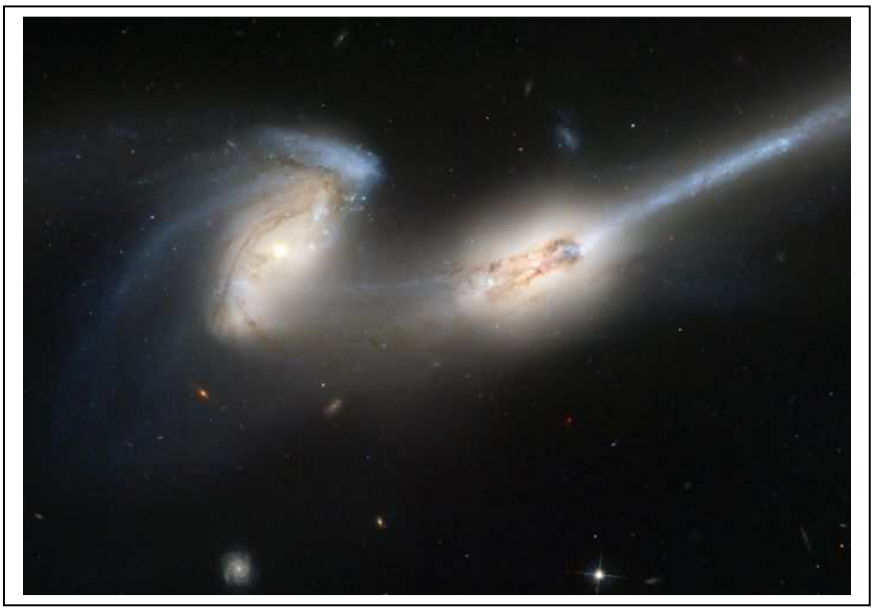

Fig 3. NGC4676A and B "The Mice"

If you are brave enough, try, in this galaxy-packed part of the sky to, observe NGC 4206, 4216 and 4222, the finest trio of edge-on spiral galaxies in the entire sky. They are situated in the far north-western part of the constellation.

A much easier task is to explore **NGC 4826**, also known as Messier 64, which is situated alongside the jewels of the crown. Perhaps better known by its common name, the Black Eye galaxy, it is easily seen through an amateur telescope and displays its bright eye-like appearance with a shade of black on the southern rim. It brightens up rapidly towards the nucleus. The Black Eye galaxy was discovered by Edward Pigott in March 1779, and independently by Johann Elert Bode in April of the same year. Charles Messier observed and documented the galaxy in 1780.

Fig 4. NGC4826. The "Black Eye" Nebula

Finding a globular cluster in "Galaxy World" is a welcome surprise in this part of the sky. **NGC 5024**, better known as Messier 53, is situated only one degree north-east of alpha Coronae Borealis. It displays a bright globe of frosty light with a very dense core. It is a beautiful globular with faint stars resolved on the edges, an object to admire.

Now for the crown on Ariadne's locks of hair, this is honoured with a place, with more than one name in the starry night sky. Corona Borealis is the constellation which has arguably had the most names since antiquity. Ariadne was the daughter of Minos, king of Crete. The names given to the

constellation have therefore all been aimed at honouring her – Ariadnaea Corona, Corona Ariadnae, Corona Ariadnes, Cressa Corona, Corona Gnosida, Corona Cretica, and also Ariadne's Tiara. Many other names are attached to the constellation, but it is now best known simply as Corona Borealis.

The jewels in the crown are the extremely faint galaxies in **Abell 2065**, better known as the Corona Borealis Cluster of Galaxies. Much has been written about this group, the observing of which requires an extremely clear, dark night sky and a fairly large telescope with magnification of at least 600X in order to try to identify some of the galaxies.

This massive group, which holds about 400 galaxies, is about one billion light years away from us. The brightest galaxy is only approximately magnitude 16, making visible observation by an amateur almost impossible, although a few amateurs have claimed that they were successful in observing a few of them. But one has to stress once again that you need extremely clear, dark skies that are far from any light pollution.

Abell 2065 forms a triangle to the west with alpha and beta Coronae Borealis, more specifically, only 1.5 degrees south-west of beta Coronae Borealis. Try to observe it, despite the apparent difficulties – fortune does not favour the un-brave! Given the northern location where I live, my best shot at observation was in 2011 with the purest, clearest, driest night sky and naked-eye vision of nearly 7. The starting point was the magnitude 7.3 star HD 137003. Only 22' west of HD 137003 pinhead-size only two faint points could be spotted with averted vision. Some mapwork confirmed that these were LEDA 93831 en LEDA 93830. Afterwards, I wondered whether I had actually seen them, like phantoms in the night. The constellation is home to staggering numbers of galaxies, which topped the whole experience of an extremely difficult observation.

An exciting star, and one of the most special ones to be found, is situated inside the half-moon crown just to the north-east of the stars Beta, Gamma and Delta Coronae Borealis. The star **R CrB** is an eruptive variable star that varies in luminosity in two modes: one low-amplitude pulsation (a few tenths of a magnitude) and one irregular, unpredictably sudden fading companion. The prototype star R Coronae Borealis was discovered by the English amateur astronomer Edward Pigott in 1795, who first observed the enigmatic fading of the star then. Only about 100 RCB variables have been identified, making this class a very rare kind of star. The fading is caused by a condensation of carbon to soot, making the star fade in visible light while measurements in infrared light exhibit no real luminosity decrease. R Coronae Borealis variables are typically supergiant stars in the spectral classes F and G (by convention called "yellow"), with typical C_2 and CN molecular bands, characteristic of yellow super-giants. RCrB star atmospheres do, however, lack hydrogen by an abundance of 1 part per 1 000 down to 1 part per 1 000 000 relative to helium and other chemical elements, while the universal abundance of hydrogen is about 3 to 1 relative to helium (*Wikipedia*).

On both sides of RCrb two asterism can be seen. A few stars in a grouping half a degree east displays a quite clear Chinese hat, and a half a degree west a lovely elongated string of stars from north to south.

The beautiful maiden with the crown on her head generously and eagerly hands out her jewels to us to take and appreciate.

Object	Type	RA	DEC	MAG	SIZE
NGC 4676A NGC 4676B	Galaxies	12h46m.2 12h46m.1	+30°43’.8 +30°43’.3	14.4 14.7	1.4’x0.6’ 1.4’x0.6’
NGC 4826 Messier 64	Galaxy	12h56m.7	+21°41’	8.5	9.2’x4.6’
NGC 5024 Messier 53	Globular Cluster	13h12m.9	+18°10’	7.5	12.6’
Melotte 11	Open Cluster	12h25m.6	+26°06’.8	5	8’
Abell 2065	Galaxies	15h22m.7	+27°42’.4	15-16+	15’
R Coronae Borealis	Variable Stars	15hm48.6	+28°09’	5.7-14.8	*

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