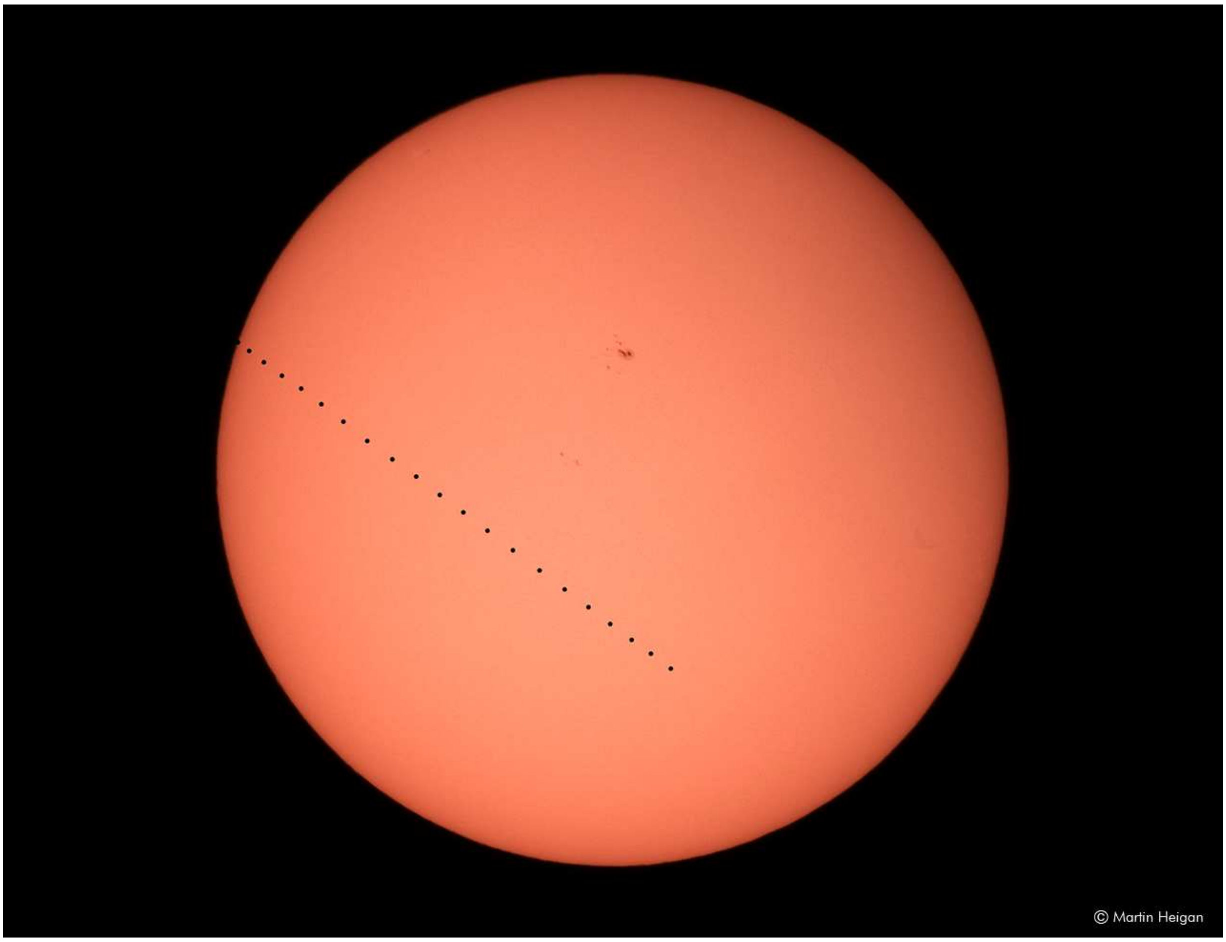
ISSN 0024-8266

mnassa

monthly notes of the astronomical society of southern africa

Volume 75 Nos 5 & 6 June 2016



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Amateur Spectroscopy

Cover: Transit of Mercury, 9 May 2016. This time lapse image by Martin Heigen captures the transit beautifully. For further detail see article on page 102.

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News Note: National Strategy for Multi-wavelength Astronomy

Press release

The Department of Science and Technology (DST) has released the National Strategy for Multiwavelength Astronomy, which is intended to allow South Africa to take full advantage of its geographical advantages, and to maximise the return on investment made in astronomy.

Developed in a consultative process involving the astronomy community, the National Research Foundation (NRF) and the DST, the strategy highlights the current status of astronomy in South Africa and its importance to the country's socio-economic landscape.

The Minister of Science and Technology, Naledi Pandor, says astronomy is a field in which Africa has traditions stretching back thousands of years. The development of astronomy in Africa over the past decade has been phenomenal. South Africa is now in a remarkable era of astronomy, hosting the Southern Africa Large Telescope (SALT) and part of the iconic Square Kilometre Array (SKA), which are among the world's biggest astronomy projects.

The country's advantages include its geographic location, with access to the southern skies, high-level government support, infrastructure investments, dark skies and radio-quiet zones.

"The time is ripe for a National Strategy for Multiwavelength Astronomy to ensure that we can exploit these advantages to the full – delivering world-class research, driving transformation, and adding major value to the knowledge economy of South Africa through human capital development and technological spin-offs," says Minister Naledi Pandor.

The strategy also sets out strategic objectives and a strategic agenda defined by the key priority areas for astronomy, and outlines relevant cross-cutting support programmes needed to give effect to the vision. It also guides the DST and NRF in their work in astronomy and related endeavours.

The NRF has developed an implementation plan for the strategy – also in close consultation with the research community – which outlines the proposed programmatic focus and consequent financial implications for astronomy initiatives in South Africa. The roll-out of the plan will be jointly considered on an ongoing basis between the NRF and the DST, taking into account available financial allocations and the level of support for astronomy in this regard.

While the strategy and plan were being developed, the Centre for Research on Evaluation, Science and Technology (CREST) was commissioned by the DST to carry out a scientometric study on astronomy research outputs. The study shows that South Africa's research output in astronomy and astrophysics has grown and increased in global ranking, demonstrating excellent scientific returns on the investments made in astronomy.

The Minister thanked the NRF, experts and the astronomy community for their valuable contributions to the development of these instruments.

<http://www.dst.gov.za/images/Attachments/Final_MultiWavelength_Astronomy_Strategy_July_2015.pdf>

Scientometric Study

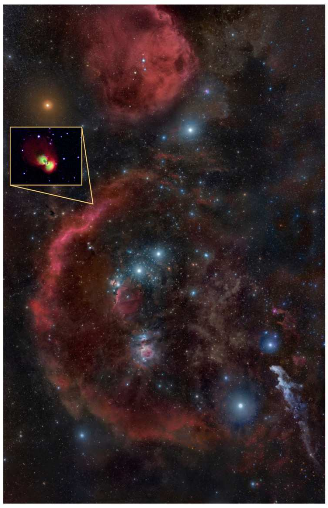
South Africa’s article output in the fields of Astronomy and Astrophysics has grown in absolute numbers from 183 in 2004 to 580 in 2013: an

overall increase of 216% and average annual increase of 15.1%. At the same time the country has improved its relative position in the world from the 33rd to the 23rd ranked country. These outputs are based on journal papers published in the Web of Science journals.
See: http://www.dst.gov.za/images/Attachments/Bibliometric analysis of astronomy research outputs_Final revised report 16 February 2016.pdf.

Echoes of Ancient Exploding Star on our Stellar Doorstep

Press Release

A team of astronomers has identified a rare star that exploded around 1 500 years ago. At the time, the star would have outshone all the stars of the Orion constellation, reaching a similar brightness to Jupiter in the night sky.
Dr Brent Miszalski, SALT astronomer at the South African Astronomical Observatory (SAAO), said: “Putting together the pieces of this cosmic puzzle has been a detective story bringing together the very latest astronomical equipment and millennia-old Chinese records of the variable night sky.”
The find was reported in a recently published paper by a team of astronomers based in South Africa, England, Chile, Spain and Mexico.



Amateur astronomers found the peculiar looking nebula, called Te 11, in the Orion constellation in 2010. Astronomers weren’t sure what to make of it, but have now resolved the conundrum. First observations of this star at the centre of the nebula (a cloud of gas and dust in outer space) showed it to be a double star system in a close orbit of almost 3 hours.

Fig 1. Fig. 1 Location of Te 11 in the constellation Orion (background image by Rogelio Bernal Andreo).

The team responsible for this discovery, a group of astronomers with expertise in the envelopes of old stars led by Dr Brent Miszalski at the SALT/SAAO, were soon joined by UCT astronomers Professor Patrick Woudt (Head of Astronomy at UCT), Professor Brian Warner and PhD student Ms Mokhine Motsoaledi, who had also directed their attention to this unusual star.

By noticing variations in the brightness of this star over several years, Professor Woudt and colleagues amassed high-speed observations recording the changes in the binary's light. The jumps in the light curve imply that the star is a dwarf nova (a star hiccuping material nibbled off the companion). "Such a combination of a dwarf nova with a nebula is extremely rare," said Prof Woudt.

Key to working out the nature of the Te 11 nebula was calculating its distance. Here the huge light collecting power of the 11-metre Southern African Large Telescope (SALT) in Sutherland was used to peer into the heart of the nebula, pinning down the temperature of one of the stars present. This was worked into the modelling of the light curve to yield a distance of around 1 000 light years – putting Te 11 on the edge of the Orion-Eridanus superbubble. This distance confirmed the nebula could not be the ejected envelope of an old star like the Sun.

Looking back in time at Chinese historical records, Professor Warner found that there was a bright "guest star" in Orion during 483 BCE near the position of Te 11. "This remarkable connection suggests that Te 11 is the leftovers of this explosion of more than 1 500 years ago," said Professor Warner.

"Pairings in astronomy as found in Te 11 are exceedingly rare, but it is anticipated that planned studies of the night sky will find a whole lot more," said Professor Woudt.

South African astronomers are looking forward to using the upcoming MeerLICHT facility in Sutherland that may help find similar objects to Te 11.

MeerLICHT will be a dedicated wide-field optical telescope that will robotically follow the gaze of the Meerkat radio telescope array, a

precursor array that will form part of the Square Kilometre Array, which will start early science this year.
Professor Woudt said: “Planned surveys with MeerKAT and MeerLICHT will scan the southern skies for more of these unusual objects, which can tell us more about the formation and the evolution of these compact binaries in the Milky Way.”
With a binary period of only 2.9 hours, the two stars in Te11 are separated only by about twice the Earth-Moon distance.
There is a long history of scientific collaboration between the University of Cape Town and the SAAO, which operates SALT on behalf of an international group of partners. UCT and SAAO have a number of joint staff positions and are partners in the MeerLICHT project.
MeerLICHT is a robotic telescope that will soon be installed in Sutherland and which will be permanently tied to the observing schedule of MeerKAT.
As demonstrated in the case of Te 11, the Southern African Large Telescope proved fundamental in understanding the faint source of the transient signal.

“The unique combination of SALT, MeerKAT and MeerLICHT bodes very well for peering deeper into the transient southern skies in the coming years,” said Professor Woudt.

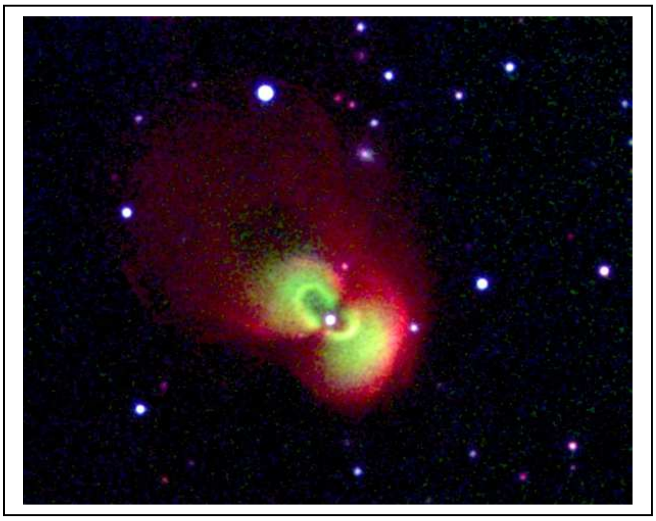


Fig. 2 Colour image of Te 11 made from images showing light from Hydrogen and Nitrogen (red), Oxygen (green) and visual light (blue).

News Note: A Night under the Stars

Kechil Kirkham

Students studying astronomy get to go on field trips, look through telescopes, visit the SAAO at Sutherland, and have their interest in the subject stimulated. In fact it is not astronomers we need in South Africa to develop and keep our big telescopes operating, it is computer scientists and engineers. Astronomers using data from SALT, MEERKAT and the SKA are part of a global pool of scientists, and can be located anywhere on the planet. Computer science and engineering students are not targeted for astronomy field trips (apart from those on the NASSP programme), which is why I, whilst working on systems engineering for the Square Kilometre Array, have been taking students to Anysberg Nature Reserve along with Cape Centre members.

(left) Fig 1. Prof Gottschalk and students

(below) Fig 2. John Richards talking to students.

This year on March 19th, I took a group of students from the University of the Western Cape, UWC and the Cape Peninsula University of Technology, CPUT, on a trip organised with Prof Keith Gottschalk, ASSA member, to introduce them to the night skies. This is the second such event which Cape Centre members attended with telescopes. It is a superb combination. We are not their lecturers, and there are no exams to prepare for: students are free to allow their curiosity to take charge, in fact free to do whatever they want for a few days. Altogether it was a huge success; there were clear skies, the students had a fantastic time, and were a great bunch. The seeing was so good we had an hour of strong zodiacal light on Sunday morning pre-dawn.

Nine students, 8 amateur astronomers plus a photographer, Kerry Paterson's friend Bevan, who did the cooking (good job!), and John Richard's partner, plus 2 drivers attended. The students were on target for the event, that is, computer science, engineering, maths, and a physicist who is determined to become a cosmologist. Only one, the Geography student, had been on any field trip or camped before. Most had never been out of a city or seen the Milky Way. The 3 days were total immersion in astronomy, and we on the astronomy side felt like stars with companion white dwarfs + accretion discs - thoroughly leeched! By the end of the trip they could set up Dobsonian telescopes, find objects, and understood many basic astronomy concepts. More importantly they were inflamed with fascination for astronomy and wanted to return to the night skies as soon as possible.

Fig 3. Learning to use a telescope.

The trip was paid for by an anonymous donor and the SKA. I am now working on a follow-up programme with the SKA to make sure that the students' interest is kept up. These are the people we need in the future, and if this trip was anything to go by our instruments are in good hands.

Anysberg Nature Reserve is run by Cape Nature and has many astronomy-friendly facilities which were developed by Over The Moon Tours (Chris de Coning and I). This includes two 8" Dobsonians waiting to be put to use, a planet trek, and a star-gazing platform. There are wide open horizons and best of all - dark, dark skies.

News Note: SALT: calibration of High-Resolution Spectrograph

Press release

30 May 2016 - Since last week, the Southern African Large Telescope (SALT) in Sutherland has been testing a Laser Frequency Comb, which is a calibration device that uses powerful lasers and photonic crystal fibres to produce the equivalent of a ruler that is both extremely long and has very finely spaced graduations. The pioneers of this decade old technology were awarded the Nobel Prize in Physics in 2005.

A team of laser physicists from the Heriot-Watt University, Derryck Reid and Richard McCracken, along with astronomers from SALT and South African Astronomical Observatory (SAAO), Éric Depagne, Rudi Kuhn, Nicolas Erasmus and Lisa Crause, installed the Laser Frequency Comb device on the SALT’s High Resolution Spectrograph (HRS) to perform the first routine comb-enabled scientific observations on a 10m-class telescope.

"The Laser Frequency Comb is a significant improvement in the way astronomers will calibrate their spectra in the future", says Éric Depagne, project leader and HRS Instrument scientist. "It allows reaching much higher accuracies when measuring radial velocities, while adding something that is completely missing when using standard calibration sources – traceability. Since the electronic components and the optical devices are all linked to calibrated atomic clocks, we are sure that if we repeat the measurements in 20 years, they will be comparable to those we do today. And that is something fundamentally new".

Professor Derryck Reid from Heriot-Watt University said: “We’ve been developing the Laser Frequency Comb at Heriot-Watt University for 10 years and to finally demonstrate it on the SALT telescope is really exciting. Its accuracy and precision allows astronomers to derive precise fundamental parameters for a wide range of astronomical objects, from the existence of planets around distant stars, to the determination of the variability of the first generation of stars and the measurements of isotopic ratios that provide detailed information on the nature of supernovae".

Astronomers determine the composition of stars by using spectrographs to split the light into various colours, exactly like water droplets produce rainbows when it rains. Each element we know in the Universe has a unique signature. Sodium, for instance produces bright yellow light, Neon glows red, and Magnesium has a blueish hue. By identifying the individual signatures of elements in the spectra of celestial objects, astronomers can infer the chemical composition, and many more parameters, such as the speed at which objects move relative to the earth, their temperature, and their mass.

In certain studies, astronomers must look for small changes in the colour of light emitted by stars. For example, the gravitational pull of a planet orbiting a star imprints a tiny wobble on the star, causing the colour of the star's light to fluctuate by a small amount. As astronomers search for smaller, more "Earth-like" planets they need better tools with which to measure these tiny fluctuations. The Laser Frequency Comb could provide the precision measurement capability which is needed for this exciting new science.

Click on the link for images of the Laser Frequency Comb and the HRS: https://cloudcape.saao.ac.za/index.php/s/kD0beq63WBxnQCt

News Note: Transit of Mercury 9 May, 2016

Transits of Mercury occur 13/14 times per century, always in either May or November. Previous ones occurred on 1999, 2003, 2006, and the next will be on November 11, 2019 and then on November 13, 2032.

Several ASSA members observed the transit from all over South Africa, and one from Canada; unfortunately for most the weather was not good! But many persevered and did get some remarkable images. Below is a selection of observations and images sent to MNASSA. Published in no particular order below, and I have archived all the images that I was regrettably unable to publish. I have also had to edit severely the length of the articles received, but as with the images articles are archived for possible future use. Many thanks to all those who responded and contributed, and I think the article is a fair record of the 2016 transit of Mercury.
Editor.

1 Cape Town

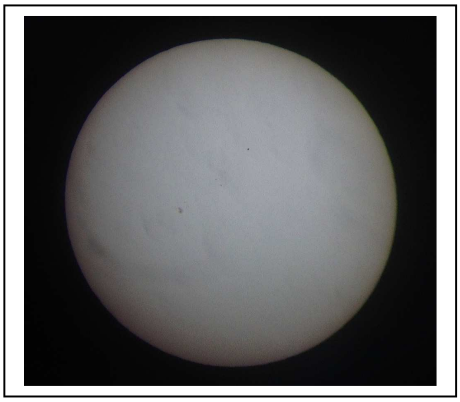
Cliff Turk reports that the weather was bad in Cape Town, but managed to get this image of the Mercury Transit at 13:49 UT with a Canon 450D through a Celestron 8 at f 6.3. Light hazy cloud made it difficult to focus, so just about 8 images were taken and the focus was moved slightly between each one.

Fig 1. Mercury transit.

2 Paarl

Willie Koorts reports that 10 members and eight telescopes represented OOG (Orion Observation Group), who observed the transit from the Afrikaans Taal Monument in Paarl. The weather was 100% cloud for the

ingress, but it cleared about an hour and a half later! There was much jubilation for the 20+ members of the public that attended..



(Above) Fig 2. A field of telescopes

(Right) Fig3. Cellphone image from a 5-inch telescope.

3 George

Three members of the Garden Route Centre, GRASSA, set up telescopes in the George Botanical Gardens.

Fig 4. Two telescopes ready and waiting.

The weather was poor with 7/8 cloud and well after ingress the sky partially cleared for about a dozen members of the public, who were there to see the transit directly or by a projected image through a 6" Dobsonian.

Fig 5. Case Rijsdijk points out Mercury on a projected image.

Lucas Ferreira was trying the do some time-lapse imaging, but without much success due to clouds.

4 Centurion

Clyde Foster reports that his objective was to capture images using two telescopes which would provide him with both a full solar disk view as well as, hopefully, a close up view of Mercury as it progressed across the face of the Sun.

The first was a 110mm FLT f7 Williams Optics refractor, white light solar filter and Canon eos 60DA DSLR provided a full disk image of the Sun and was the primary instrument to capture the transit.

The second was a 355mm Celestron Edge Hd SCT, 250mm Diameter White Light Solar Filter and ZWO ASI224MC Camera which would give close images of Mercury, and hopefully resolve a discrete disk.

With the above he was able to confirm Mercury's ingress onto the solar disk at 13:15:32(11:15:32UT).

Fig 6.

Mercury's ingress, is shown as a tiny spot on the limb at between 2 and 3 o'clock position. The dark spot to lower right of centre is a sunspot group. The blue colour is due to the combination of the solar filter and the DSLR.)

Fig 7. Showing a high magnification capture at 14:05 local time (12:05UT) with the 355mm SCT.

5 **Glencairn**

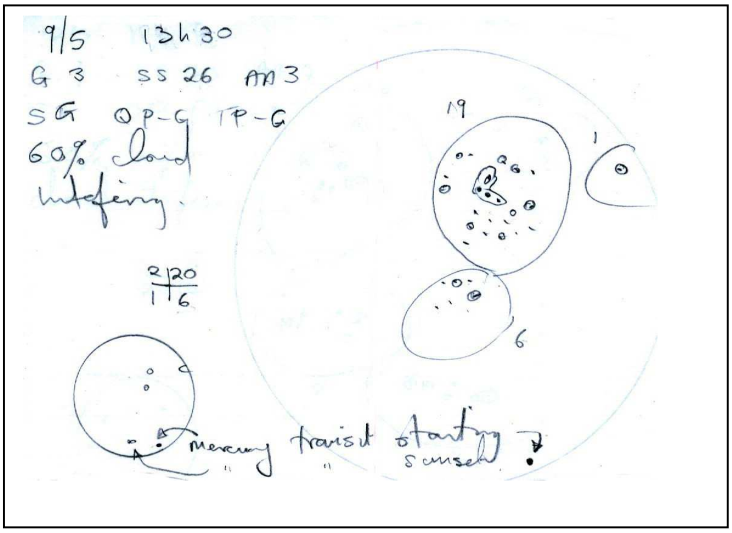


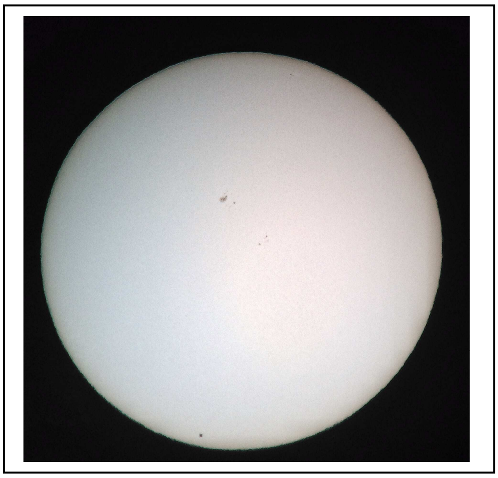
Fig 8. Jim Knight sent in this sketch of the event and added the following notes to help with deciphering it:

From the top down: Date and time in UTC

Second row G = groups of spots, SS = total number of sunspots visible on Sun and AA = activity areas comprising the bright faculae and of course the spot groups.
Third row S = seeing during the observation, Q = quietness and T= transparency. Viewing condition - cloud etc. and its influence on the observation.
Distribution of groups and spots = 2 groups and 20 spots in the northern hemisphere and 1 group of 6 spots in the southern hemisphere.
The small diagram - approximate of the groups on the solar disk and showing the position of the planet when we first looked and again when the sun went behind the mountain in the afternoon and the viewing was over.
The large diagram is of the details of the spots and their cores found in each group. The drawing is not a detailed drawing of the spots or their spatial distribution but to allow the spots to be counted at the end of the session.

As observations can take over half an hour when the cycle is at a maximum, and the seeing conditions change continuously, it allows one to make an accurate count rather than a guestimate based on memory.

6 **Mississauga Ontario, Canada**.



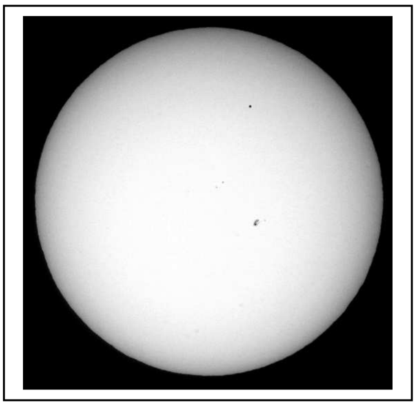
Bruce Dickson, ASSA member in Canada imaged the transit with his 4.5" APM refractor, Herschel wedge and 14mm Delos eyepiece and imaged with an iPhone. He had about 30 people join him and look through his telescope during 2.5 hours of observing.

Fig 9.

7 Hermanus

Pierre de Villers reports that members of the Hermanus Astronomy Centre set up three telescopes equipped with solar filters to view this at two sites: First at Curro Hermanus which attracted about 130 learners and parents. *(see Fig 10, left).*

Then subsequently at Gearing's Point where at least 40 people witnessed this rare astronomical phenomenon which leaves all privileged observers awe-inspired and humbled. The most frequently heard learner comments were "Wow", "Cool" and "Awesome", while adult's comments were the more restrained "Amazing", "Fantastic" and "Incredible". *(See Fig 11, left)* Even though the transit started at 13:15 the Sun only broke through the clouds at around 13:45, but fortunately was then visible with a few frustrating "clouded over" periods until almost 17:00.



(left) Fig 12.

(right) Fig 13

8 Johannesburg

Gary Els mentions that here was also a lot of haze and wind throughout the day, which made for capturing the Sun quite a challenge, but over a 2 hour period there was an open window to view and take a few images.

The imaging equipment used was a Kowa spotting scope, solar filter with camera attachment and a Canon 550d SLR; ISO 3200 and shutter speed of ¼ second

Oleg Toumilovitch also observed from Johannesburg. The image below, Fig. 14, is a stack of 600 frames from a short video. It was imaged with Canon EOS-550D DSLR at prime focus of an 8-inch F/10 TAL-200K telescope with full aperture black polymer filter. Due to constantly moving clouds, the observing conditions were poor, which was the main factor, reducing the resolution of the images. The image shows Mercury just few seconds after Ingress. The so called “Black Drop” effect can be seen in the image, but it arguable whether the effect is produced by limited resolution, poor observing conditions and post-processing of the images, or is it a purely optical effect?

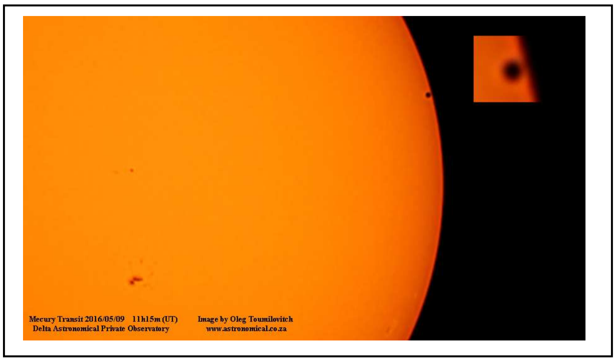


Fig 14

9 Parow

Barry Dumas from his Archer Observatory in Parow used Meade LX90GPS 12” with a Canon 60-Da DX and Canon 550-D DX with a Sigma 150-500 Lens plus a 1.4 x converter to capture Mercury in transit. The image below, Fig. 15, was taken with the telephoto lens. The insert on the upper left shows Mercury within a 12” of arc circle: an enlargement from the main image. The insert on the lower left shows a much less pixelated image, also within a 12” of arc circle was taken with the 12” Meade.

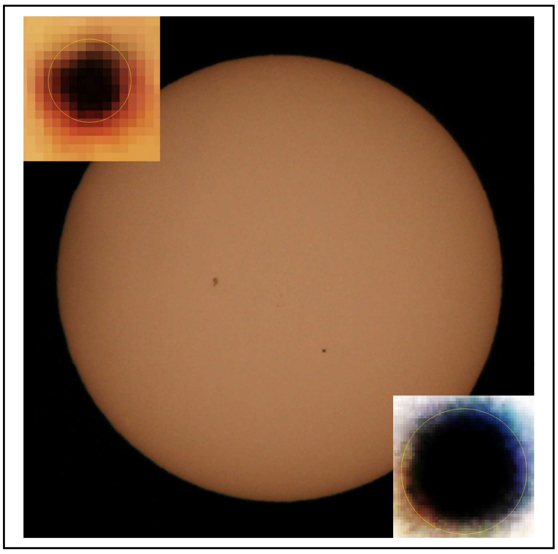


Fig 15.

The yellow circles (calculated) represent the angular size of Mercury during the transit, which was 12” (Fred Espenak). The fuzziness outside the circle is caused by the accuracy of focusing, the condition of seeing (it was cloudy & misty) as well as the quality of tracking during exposure (wind).

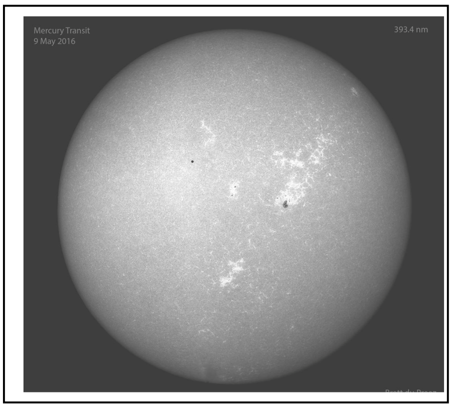
Fig 16.

10 Pretoria

The Pretoria Centre of the ASSA arranged to present the transit from the International Conference Centre at the CSIR in Pretoria. The western and northern balcony at this venue afforded a convenient and unobstructed view of the entire transit.

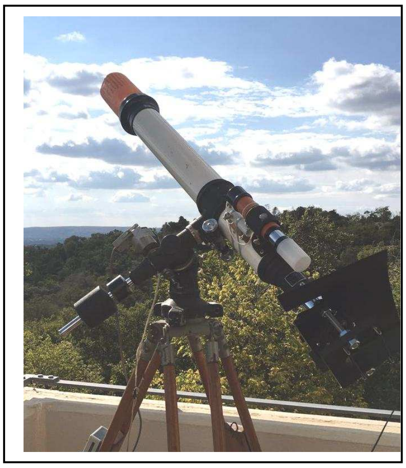
Images of the transit were updated every minute on a website that the conference centre created for the event. The source of these images was a mobile phone camera attached to a 76mm refractor that Jack Bennett bought in the 1960s.

There were about eight telescopes, using techniques ranging from eyepiece projection and visual viewing through the eyepiece, to elaborate video and photographic equipment using H-alpha filters. Neville Young had a solar system model that was used to help explain the transit to the 100+ public that attended.



The Pretoria Centre thanks the CSIR for providing the venue as well as for the tea, coffee and biscuits and even a cash bar.

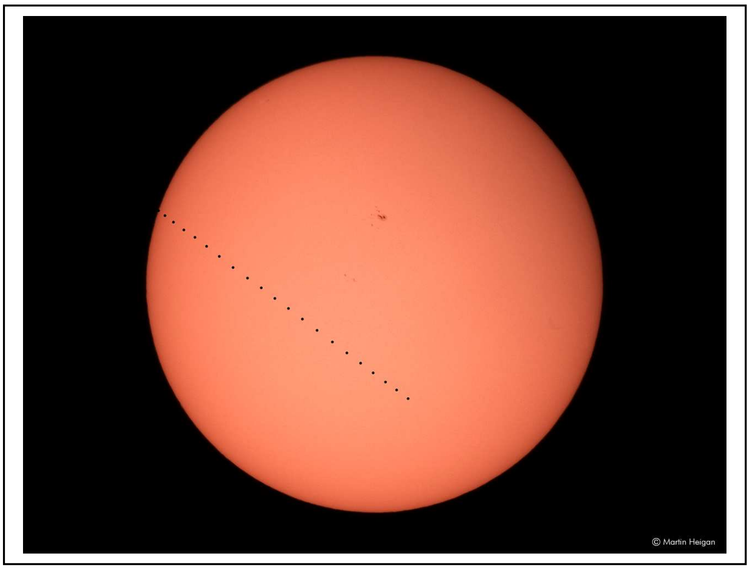
(Above) Fig 17. Bret du Preez image using a 393.4nm filter.



(Right) Fig 18. Bennett Telescope

11 Roodepoort

Martin Heigen reports that it was a bit difficult photographing on the day with partly cloudy conditions; however he did manage to get a composite image of Mercury's path, and also did a HD time-lapse video of the photo sequence.



He used a Canon 60Da DSLR. GSO 6" f/4 Imaging Newtonian Reflector Telescope. 6" Thousand Oaks Optical R-G Solar "White Light" Solar Filter, 2" 2x Tele Vue PowerMate, a Tele Vue Sol-Searcher and a Celestron AVX.

Fig 19.

Meteors and Meteorites – The Facts

Brain Fraser, ASSA

Abstract: Most articles in the media covering meteors and meteorites slavishly repeat a number of erroneous details regarding the subject. This brief paper looks at the common misconceptions regarding meteors and meteorites.

1 Nomenclature

A **meteoroid** is a small rocky or metallic body in outer space, ie. beyond Earth's atmosphere. When it enters Earth's atmosphere it is called a **meteor**, and should it strike Earth's surface, it is called a **meteorite**.

A **fireball** is a brighter than usual meteor, reaching the brightness of a planet, about magnitude –3. Fireballs that become as bright as the full Moon, magnitude –14, are often called **bolides**, but the IAU has no official definition for "bolide".

2 Size and Speed

When an object enters Earth's atmosphere it will produce a bright trail, the brightness of which depends on the size of the object and the speed at which it was traveling.

The size of the object can vary from the size of a grain of sand upwards, with no real upper limit. Meteors larger than 10 metres diameter are rare and quite spectacular when seen. The one that occurred over Russia 3 years ago was estimated to be about 17 metres in diameter and was the largest to have been observed in recent years.

Velocities can range from about 16 km/sec to about 72 km/sec. Typical velocities are in the 20-40 km/sec range.

Small, grain-of-sand sized objects enter Earth's atmosphere every single day and are commonly referred to as "shooting stars", "falling stars", or similar. It is estimated that some 15 000 tonnes of material enter Earth's atmosphere annually. They vapourize in the atmosphere as they heat the air around them. **It is the air that glows and gives off the light, not the small grain of rock.**

3 What happens to the larger objects?

Say football size rocks. Do they "burn up" in the atmosphere, as most TV programs would have us believe?

An object hitting Earth's atmosphere in a near vertical trajectory would take 2 - 5 seconds before it hits Earth. Definitely not enough time to even get nicely warmed up. Objects that hit the atmosphere at an angle around 45 degrees would fare little better, taking maybe 4 - 8 seconds to hit Earth. Take a rock out of your back garden and apply a couple of blow torches to it for 10 seconds and see how much of the rock "burns off". The answer will be about zero**: meteors do not burn up in the atmosphere.**

4 Types of Meteor

There are many types of meteorites, but broadly speaking they can be lumped into 3 categories:

Iron and Nickel.
Stoney rocks.
A combination of 1 and 2.

Type 1 objects will not be affected by their passage through the atmosphere, except for a very thin crust that may form from the heat. Types 2 and 3 may also display this thin molten skin, but they can also be affected by the pressure wave that they encounter and break up into smaller pieces. It is NOT the heat that affects them.

5 Meteor effects

And how about the many reports of meteors "exploding" and producing a massive shock wave? Meteors **do not explode!** Objects made of gunpowder or dynamite can explode (and some other materials do) but this does not apply to meteors.

So what causes the explosions that are so frequently experienced? When an object is accelerated to a speed greater than the speed of sound it produces a "sonic boom". The Concorde and other planes did this regularly.

The speed of sound depends on the density of the medium, as well as the temperature, but can be taken to be about 330 m/sec in Earth's atmosphere. What is not so generally known is that an object DECELLERATING through the sound barrier also produces a "sonic boom". **It is this sonic boom that is mistaken for an explosion.**

If you see a bright meteor and hear an explosion that means that you could be close to where the meteorite has landed. (well within 20-30kms). Working out where the object may have landed now gets complicated, as the explosion may have occurred at a height of 20-50 kms.

6 Summary

Meteorites do not burn up in Earth's atmosphere (except for the very little ones).

Meteorites do not explode. No small ones. No big ones. Absolutely none.

Meteoroids, meteors and meteorites are the same object in different places: space, atmosphere and on Earth.

7 Further reading:

7.1 https://en.wikipedia.org/wiki/Meteoroid
7.2 http://solarsystem.nasa.gov/planets/meteors
7.3 http://solarsystem.nasa.gov/planets/asteroids

Amateur Spectroscopy – Spectra of ETA Carina

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Edited by Case Rijsdijk

1 Introduction

There are three things that can be done with light collected by telescopes:

produce images,
do some photometry, and
do some spectroscopy.

Amateur astronomers have in recent times started doing the first two, with remarkable success, and now more recently, spectroscopy. Using simple, low cost equipment they can produce the spectrum of any object that is accessible by the equipment that is being used. This has opened up a field of observation previously only accessible to professional astronomers using large telescopes. But like everything in life, the more precision one wants, the more expensive the equipment tends to become!

As beginners, all amateurs are doing is taking spectra of known objects, which is great fun and interesting to be able to do this type of science from your backyard. But it also means that as amateurs become more familiar with their equipment they become more skilful. Eventually they can start to make significant contributions to astronomy, by obtaining the spectra of novae, supernovae (SNe), variable stars and comets. One way to do this is by monitoring the alert notices issued by AAVSO where spectral analysis is sometimes called upon. The same applies to the discovery of new SNe: it is now customary to include a spectrum of any newly discovered SN. It is also possible to measure the redshift of quasars if a good enough spectral image can be taken.

Spectroscopy is the study of the different wavelengths/frequencies of light we see from an object. It is a measure of the quantity of each colour of light (or more specifically, the amount of each wavelength of light). It is a powerful tool in astronomy. In fact, most of what we know in astronomy is a result of spectroscopy: it can reveal the temperature, velocity and composition of an object as well as be used to infer mass, distance and many other pieces of information. Spectroscopy is done at all wavelengths of the electromagnetic spectrum, from radio waves to gamma rays; but here we will focus on optical light.

Fig. 1 (next page) shows continuous, emission line and absorption line spectra. Originally light was broken into its constituent wavelengths by a glass prism; today a diffraction grating is used.

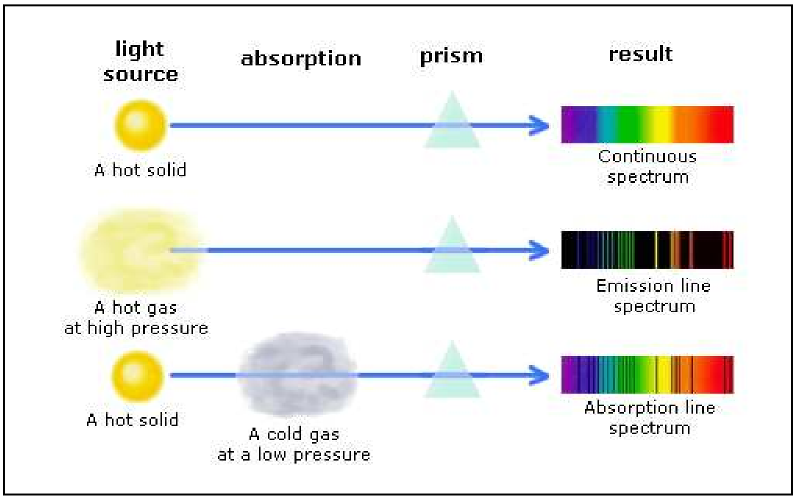

Fig 1. (see text)

A continuous spectrum includes all wavelengths of visible light; i.e., it shows all the colours of the rainbow (Fig. 1 top). It is produced by a dense object that is hot such as dense gas. An emission line spectrum can only be produced by a hot, tenuous (low-density) gas. Importantly, the wavelengths of the emission lines depend on the *type* of gas (Fig. 1 middle). Absorption lines can be best thought of as the opposite of emission lines

(Fig. 1 bottom). While an emission line adds light of a particular wavelength, an absorption line subtracts light of a particular wavelength. Again opposite of emission lines, absorption lines are produced by a *cool* gas. Naturally there must be some light to subtract, so absorption lines can only be seen when superimposed onto a continuum spectrum. Thus, for absorption lines to be seen, cool gas must lie between the viewer and a hot source. The cool gas absorbs light from the hot source before it gets to the viewer. Also note that a gas absorbs the same wavelengths of light that it emits.

2 Typical Amateur equipment.

2.1 Author’s equipment:

80 mm refractor,
Rainbow Optics Transmission Grating (200l/mm),
Nikon DSLR,
An equatorial mounting fitted with a tracking unit.

2.2 Blazed Grating

Fig 2. The grating cell, which screws into the bottom of the eyepiece, contains a glass, blazed diffraction grating [1].

The grating is protected by a second glass disk. The blazed grating directs most of the light into one of the first-order spectra, resulting in a bright spectrum. This grating's performance is superior to that of a non-blazed grating. And unlike a prism, which distorts a spectrum by spreading out blue light more than red, this grating creates an undistorted, constant dispersion across the entire visible spectrum.

2.3 Camera set-up

Fig 3. This shows the grating near the eyepiece with camera adaptor.

2.4 Telescope set-up

Fig 4. This shows the various instruments on the equatorial mounting. Left is the 80 mm refractor with the DSLR camera and grating fitted into the refractor tube where the eyepiece is currently (on the left), with the finder scope on the top. To the right is a 400 mm telephoto lens fitted with a ZWO130 CCD camera, used as a guide telescope.

3 Obtaining an image

The exposure times are dependent on the equipment used and the magnitude of the object. For example, for the spectra of ETA Carina, see below, approx. visual magnitude of 6.5, the exposure was 10 secs at ISO 200. For the spectra of Nova SGR, approx. visual magnitude of 7.5, the exposure was 30 secs at ISO 800. For Vega, approx. visual magnitude of 0, the exposure time was 1 sec at ISO 300. These are all single exposures. It has been said that one can take multiple images and stack these allowing therefore a greater limiting magnitude. This has not tried been tried, as it is suspected that the stacking process may introduce other “noise” type anomalies into the spectrum. One would then not know if these are from the star itself or from photo processing. This will be experimented with in the future.

Accurate telescope tracking is very important, especially when obtaining clear spectra of faint objects when exposures of 90 secs. or more are needed with a single exposure. With regards to aperture, it has been found that there is similar spectral clarity between a 10” reflector and the 80 mm refractor. But a reflector, due to its central obstruction, and the light diffraction around the central obstruction, could introduce “noise” type anomalies into the spectra. A larger aperture may allow for say an extra limiting magnitude of one point.

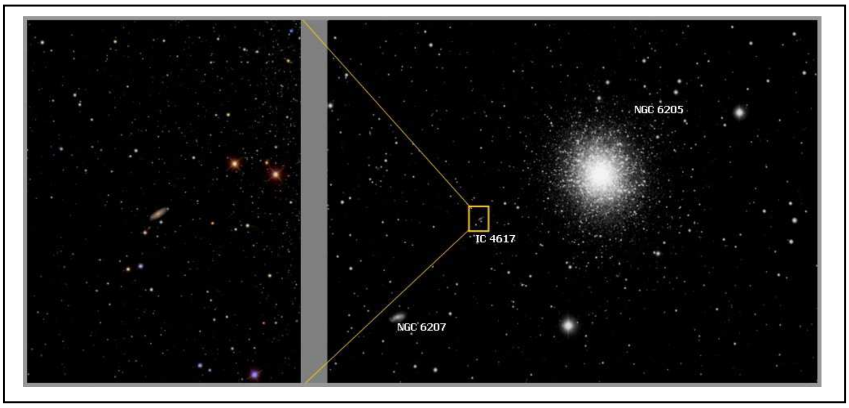

Fig 5. (see text)

When taking the image, one must ensure that the star itself and the spectra are all in the same frame. The red ellipse shows the star as the dot on the left with its spectrum to the right.

The focus must not be as if one is taking a sharp picture. The image must be slightly defocused inwards. So, first focus on the star, and then slightly defocus the spectra by moving the focus inwards towards the mirror or inside the focal length. This is to allow the "spreading" or "flattening out" of the spectra instead of a thin line spectra which would not be able to be analysed.

4 Processing the Image to get a spectrum

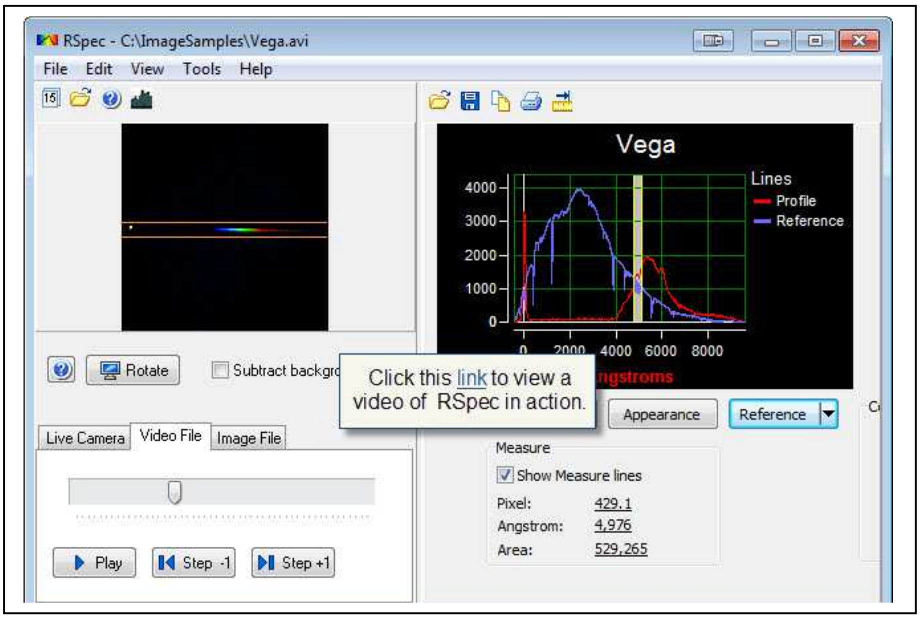

Fig. 6 Screenshot of the software used, RSPEC.

The RSPEC programme is comparing pixels to angstroms [2]. The star itself, the 1st calibration point, is taken as zero angstroms vs the pixel reading number shown by the star. The 2nd calibration point would be the calibration of a common or known emission or absorption line such as the H_β line at 4861Å. The programme is told that the pixel reading at this point is 4861Å. Then further processing and "clean-up", and the end result is shown in Fig. 5 above

5 Further results

5.1 Eta Carina Spectra

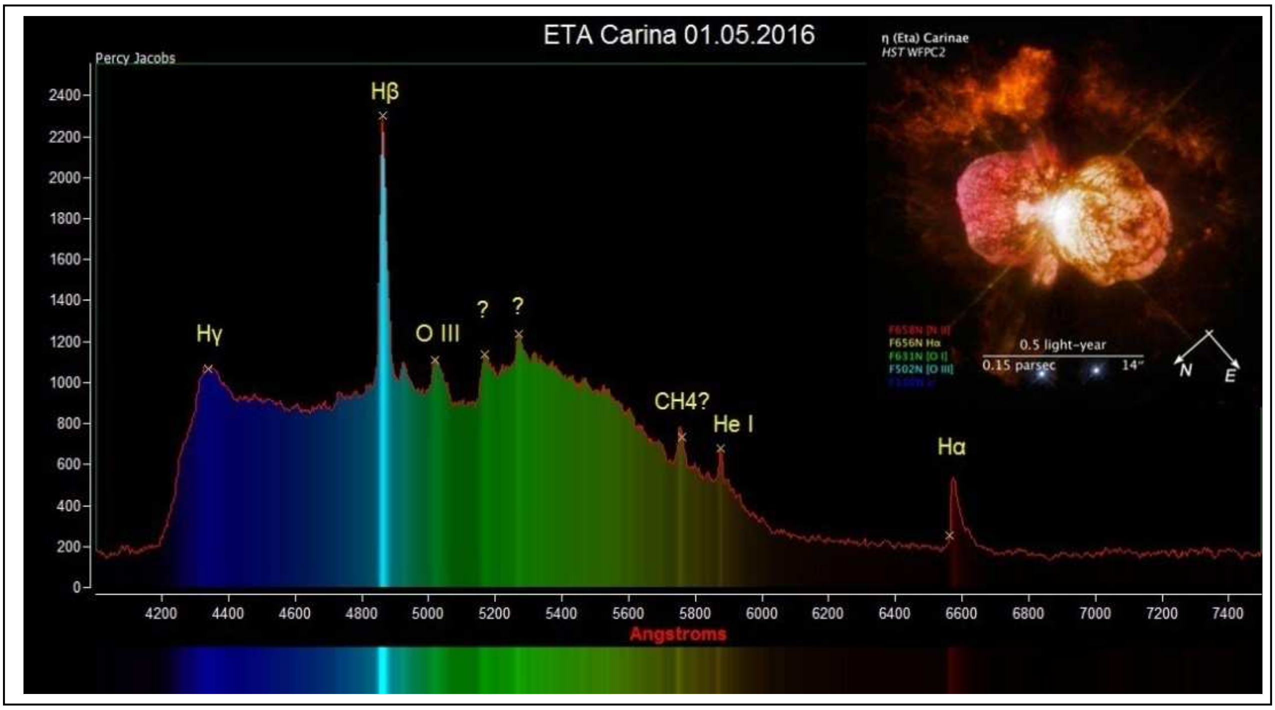

Fig. 7 Showing the final processed image, is the spectrum of ETA Carina, with the inserted picture of the actual star. The inserted picture is only there to show what the target actually looks like.

The identification of the rest of the emission peaks within the spectra was done with the basic tools and library within the RSPEC programme and the use of Walkers Spectroscopic Atlas [3]

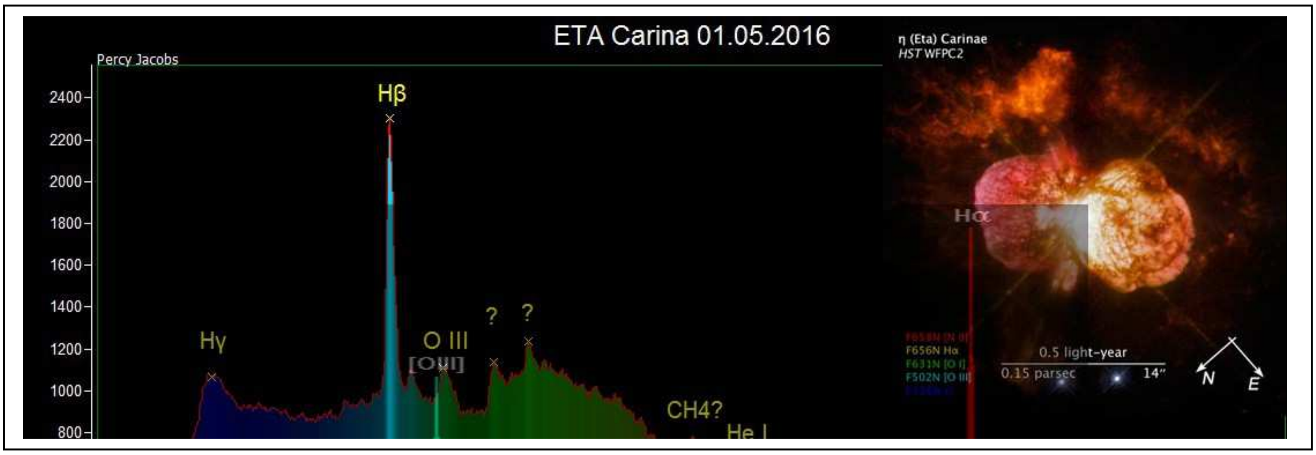

Fig. 8 Doug Sharpe, located in the UK, superimposed a professional spectrograph on top of the one shown above and it matches pretty well.

5.2 Nova SGR 2015 No. 2

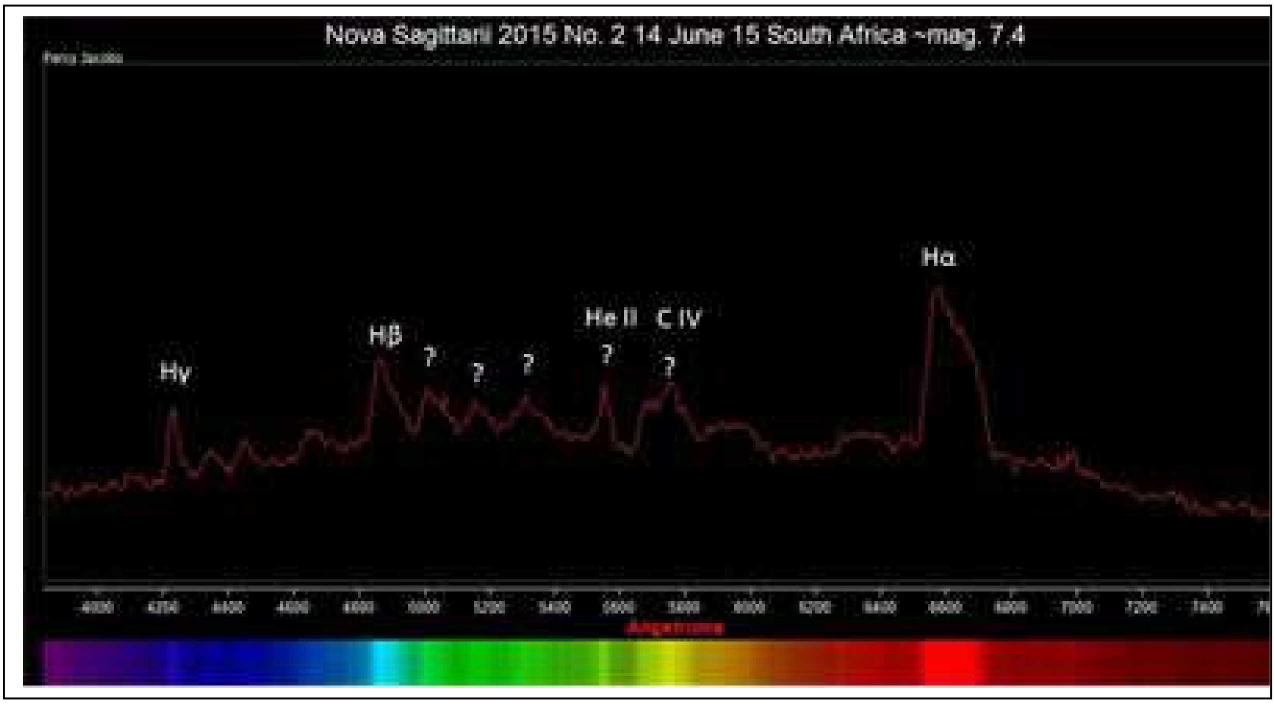

Fig. 9 Using a similar setup, here's a spectrum of NOVA SGR 2015 N0.2

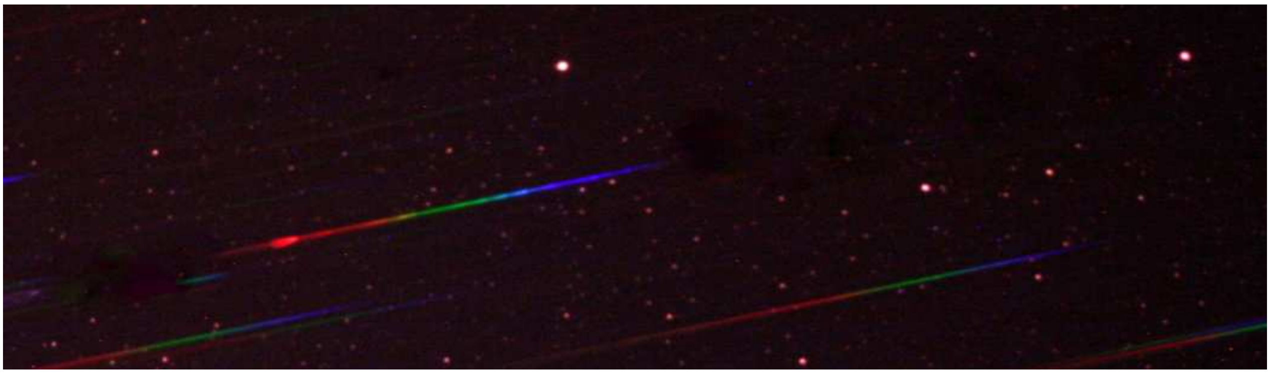

Fig. 10 Image of Nova spectrum. Note the differences and similarities in the two stars. Both are emission spectra and both have strong H_{β} and H_{α} lines.

From this, one can clearly see the differences. This is really exciting: to realise this is all done from the backyard with simple equipment!

5.3 Vega Spectra

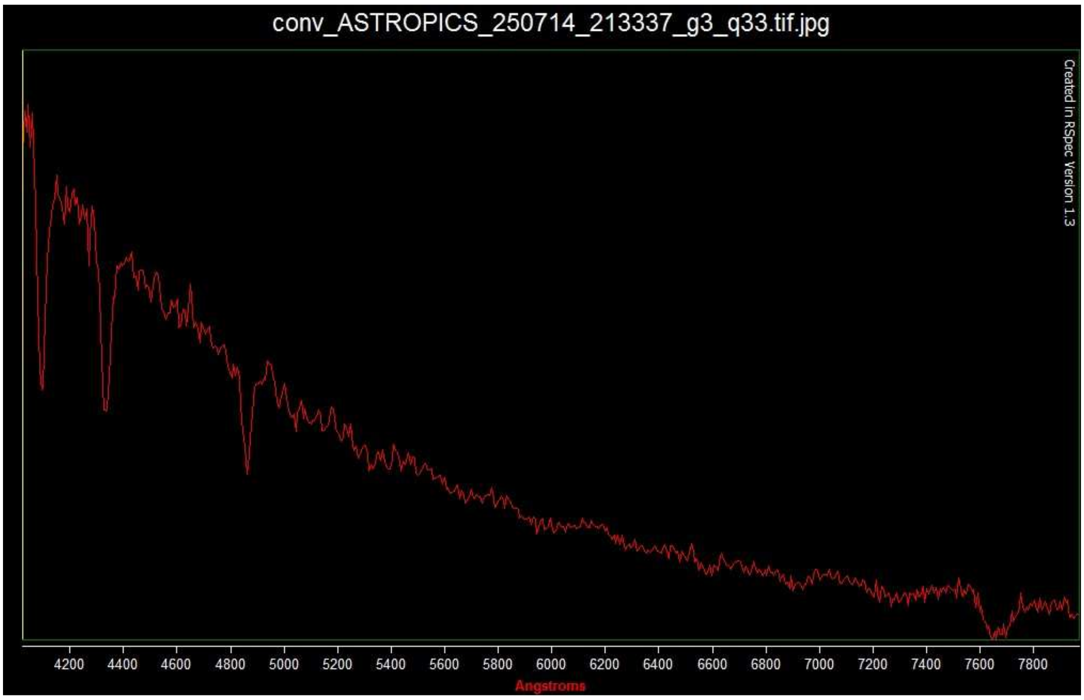

Fig. 11 Vega is a star of A spectral class. Notice firstly the absorption lines and secondly the activity in the spectrum on the blue side and the low activity on the red side of the spectrum

For further details, contact the author or visit the ASSA website [4]

6 References

1 https://en.wikipedia.org/wiki/Blazed_grating
2 http://www.rspec-astro.com
3 Walkers Spectroscopy Atlas http://www.ursusmajor.ch/downloads/spectroscopic-atlas-5_0-english.pdf
4 https://assa.saao.ac.za/sections/photometry-spectroscopy

On the Bookshelf

Playing the numbers game this month – both good reads! But I hope that other members will submit a "good read" – assuming the ASSA members still read!
Editor

1 Just Six Numbers

The by-line for this slightly odd shaped book is "The Deep Forces that shape our Universe". Sir Martin Rees is known as an internationally renowned cosmologist, is the Royal Society Research Professor at Cambridge University and is the Astronomer Royal, he is also a member a several Science Academies, and is thus more than qualified to write on this topic. He discusses the following 6 numbers:
our cosmic habitat I – planets stars and life
the large number N – gravity and the cosmos
stars and the periodic table, and E
dark matter and Ω
is cosmic expansion slowing or speeding up – λ
primordial ripples – Q

This is a really worthwhile read and answers many of those questions you always wanted answered. It could equally well have had the title "Where have we come from, where are we going and are we alone"?
Case Rijsdijk

2 The Nine Numbers of the Cosmos

Michael Owen-Robinson is Professor of Astrophysics, and Head of the Astrophysics Group, at Imperial College, London. He is internationally recognized expert on observational cosmology and his book *The Cosmological Distance Scale* is a classic, and is thus well qualified to write this volume!
He covers a wide range of topics including things like; how old is the Universe? How far away are the galaxies and how fast are they travelling away from us? How do galaxies form? He answers these, and many more questions, in an original and intriguing way.

He encapsulates our current knowledge of the origin and nature of the Universe into nine numbers and concludes with a look into the future, saying that the origin of the Big Bang will be a mystery till the end of the 21^{st} century – and probably not even in the year 3 000! A very worthwhile and lucid read.
Case Rijsdijk

3 Light relief with numbers!

The following is a Limerick:

$$\frac{12 + 144 + 20 + 3\sqrt{4}}{7} + (5 \times 11) = 9^2 + 0$$

Answer on the last page.
Sent in by Chris de Coning

Colloquia and Seminars

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

Also included in this section are the colloquia/seminars at the SAAO, UWC and the Astrophysics, Cosmology and Gravity Centre at UCT, ACGC. Also included are the SAAO Astro-coffees which are 15-20min informal discussions on just about any topic including but not limited to: recent astro-ph papers, seminal/classic publications, education/outreach ideas and initiatives, preliminary results, student progress reports, conference/workshop feedback and skills-transfer.

SAAO

Title: A New Approach for Wide Field Time Series Photometry: applications for variable stars and asteroids
Speaker: Prof. Yong-Ik Byun (Yonsei University, Seoul, South Korea)
Date: 21 April
Time: 11h00 – 12h00
Venue: SAAO Auditorium

Abstract: Early work with YSTAR 0.5m wide field telescopes revealed the presence of variable photmetric trends within the FOV of 2 degrees. Experiments with other wide field survey data also confirmed such trends. We developed a robust and efficient approach to make multi-aperture photometry and remove existing trends for wide field time series observations. The merit of this approach is as follows: we find an optimal aperture for each star with a maximum signal-to-noise ratio and also treat peculiar situations where photometry returns misleading information with

a more optimal photometric index. We also adopt photometric de-trending based on a hierarchical clustering method, which is a very useful tool in removing systematics from light curves. Our method removes systematic variations that are shared by light curves of nearby stars, while true variabilities are preserved. I will outline the procedure and examples of new scientific results obtained by this improved procedure, together with our current work with KMTNet observations.

Title: Unconventional Radio Astronomy
Speaker: Jonathan Zwart (UWC/UCT)
Date: 5 May
Time: 11h00 – 12h00
Venue: SAAO Auditorium

Abstract: Imaging – be it optical or radio – is a fine art, as is the ensuing extraction of celestial sources. Typically one finds peaks down to some threshold (5 sigma, say) and writes off what's left. But there is information down there – physics that Bayes' theorem can get at and an avenue that's crucial for forthcoming surveys. So I'll explain how we can wring out that information and what we can discover from it.

But it's also possible – in the radio at least – to examine the raw interferometric data in order to bypass imaging completely. In another coup for Bayes, this challenging exercise sheds light on the systematic coupling of sky and telescope, a task currently impossible via the imaging route. I'll update you on the latest results from this exercise.

Title: The SALT Gravitational Lensing Legacy Project
Speaker: Lucia Marchetti (Open University Milton Keynes (UK)
Date: 12 May
Time: 11h00 – 12h00
Venue: SAAO Auditorium

Abstract: The study of strong gravitational lensing is a powerful tool for modern cosmology enabling the study of galaxy populations otherwise too faint for detailed analysis. However, its study is still in its early stages mainly because of the difficulties in identifying large, robust and unbiased samples of lensing systems, especially at high redshift.

The identification of large samples of lensing systems has been recently enabled by the advent of the Herschel Space Observatory. Because of the negative K-correction of galaxy SEDs in the sub-mm, the observed sub-mm flux of a galaxy hardly changes over the $1<z<5$ range. For this reason Herschel, providing over a thousand-fold improvement in sub-mm survey mapping speed, along with the flux magnification due to lensing, allows us to detect lensing systems with background sources at much higher redshifts much more effectively than any other optical-based surveys.

In the course of its four year lifetime, Herschel has mapped approximately 1000 deg^2 of the sub-mm extragalactic sky. With our ongoing "SALT Strong Gravitational Lensing Legacy Project" we pioneer a major new strong gravitational lens selection method, combining Herschel wide-area sub-mm observations with multi-wavelength ancillary data, generating a ~500-lens homogeneous sample and obtaining SALT spectroscopy for most of them.

This is a 3-year project, started in late 2015 with a strong synergy with other observing programs with e.g. HST and ALMA.

In this seminar I will introduce the project and its scientific goals, report on its present status and first results and outline opportunities for future collaboration with South African astronomers as well as for student projects.

Title: The LOFAR Reionization Key Science Project: Current Status
Speaker: Leon Koopmans (Kapteyn Astronomical Institute)
Date: 19 May
Time: 11h00 – 12h00
Venue: SAAO Auditorium

Abstract: The Low Frequency Array (LOFAR) is currently the most sensitive low frequency array in the world, in part designed to detect the feeble 21-cm emission of neutral hydrogen from redshifts between z=11 and z=6, an era called the "Epoch of Reionization" (EoR). During the EoR the first (Pop III and II) stars not only ionized neutral hydrogen, but also caused radiative/mechanical feedback, enriched the ISM/IGM with metals, formed galaxies and black holes, etc. The EoR forms the foundation for much of what we see in the present-day Universe. I will review the LOFAR EoR Key Science Project that we are currently undertaking to detect this 21-cm emission, to quantify it, and to learn about new physical processes in the infant universe. I will also present the daunting challenges that we are facing, as a lesson learned for SKA

Title: Star formation in the Milky Way and implications for other galaxies
Speaker: Jill Rathborne (CSIRO)
Date: 24 May
Time: 11h00 – 12h00
Venue: SAAO Auditorium

Abstract: The past decade has provided a wealth of new observational information about star formation on all scales. The key physical processes that determine how molecular clouds contract to form stars can only be investigated in detail up close in the Galaxy, and much of this knowledge has come from in-depth case studies of individual star-forming regions. In contrast, extragalactic studies have focused on the collective effects of star formation, integrated over entire star-forming regions or, often, over entire galaxies. As a result, much of our empirical knowledge of star formation on these scales consists of scaling laws and other parametric descriptions. Fortunately, considerably work is underway to connect these efforts. In the coming decade, ALMA will be transformational for this purpose: it will reveal dense structures within molecular clouds in other galaxies and enable a direct comparison to dense clumps found within Milky Way clouds. In this talk I will discuss results from recent surveys of star formation in the Milky Way that are relevant for making the connection to understanding star formation on galaxy-wide scales. I will also showcase recent results from ALMA that provide the first empirical evidence that the current theoretical understanding of molecular cloud structure derived from clouds in the solar neighbourhood also holds in extreme, high-pressure environments. As such, these theories may be relevant for understanding rapidly star-forming galaxies, like those in the early Universe.

NASSP

Title: Young massive star clusters and superwinds in strongly star-forming galaxies
Speaker: Dr. Petri Vaisanen, SAAO
Date: 19 April
Time: 16h15 – 17h00
Venue: RW James, Lecture theatre 2A (James 2A)

Abstract: I will present an overview of our ongoing research on luminous IR galaxies, investigating the histories of their stellar populations, their super star cluster populations formed during violent star-forming episodes, and gas outflows and inflows both triggering and quenching further star-formation and feeding central active nucleus growth. These processes are detailed essential pieces in trying to understand the trends in larger scale cosmological galaxy evolution coming from results of higher redshifts surveys. We use SALT, VLT, Gemini, and ALMA for the detailed work, along with smaller telescopes and archival data. In particular I will highlight recent SALT-based results on a rapidly disappearing population of

massive clusters, indicating that globular cluster progenitors may need galaxy interactions to survive, and show an example of star-formation quenching seen in action within a nearby luminous merger, and describe student theses connected to the project.

Title: A tale of two unusual novae
Speaker: Prof. Patrick Woudt, UCT
Date: 3 May
Time: 16h15 – 17h00
Venue: RW James, Lecture theatre 2A (James 2A)

Abstract: In this talk I will present two unusual novae: one was a nova in the year 2000 in the constellation of Puppis and the other a nova in the year 483 in the constellation of Orion. Both objects stand out for their remarkable nova shells. I will present our observations of these two novae and will put them into context in terms of the long-term evolution of cataclysmic variable stars. At the end of this talk I will look forward to observations of novae with MeerKAT as part of the ThunderKAT legacy project.

Title: Space Science and Astronomy at South Pole
Speaker: Prof. Michael Kosch, SANSA
Date: 10 May
Time: 16h15 – 17h00
Venue: RW James, Lecture theatre 2A (James 2A)

Abstract: Prof. Kosch recently visited South Pole station to install his Scanning Doppler Imager. This unique instrument, only 1 of 7 in the world, can measure the wind and temperature of the upper atmosphere between 100 and 300 km altitude. He will describe his travel experience to this remote location, the astronomy facilities there as well as the functionality and science performed with the Scanning Doppler Imager.

Title: (Non Given)
Speaker: Zolile Mguda, UCT/UNISA
Date: 17 May
Time: 16h15 – 17h00
Venue: RW James, Lecture theatre 2A (James 2A)

Abstract: Supermassive Blackhole (SMB) masses have been found to correlate well several key characteristics of early type galaxies (ETGs) and bulges of spiral galaxies. These correlation have led to the widely held conclusion that the galaxy and it's SMB co-evolve. This co-evolution is a subject of active theoretical research through simulations.

Key to the understanding of this co-evolution is the reliable measurement of SMB masses. These have been indirectly measured since the early 80's and with bigger telescopes and better instrumentation the constraints on the mass measurements have been improved. The techniques for blackhole mass measurements are now being revised to take advantage of the new telescope like ALMA and future 30m class telescopes such as European Extremely Large Telescope (E-ELT), Thirty Meter Telescope (TMT) and Overwhelmingly Large Telescope.

I will discuss one of these methods whose use will be extended to E-ELT and TMT telescopes and what we have found out about the method through our use of SINFONI VLT data.

Astro-Coffee

Title: Machine Learning in Astronomy: lessons learned from learning machines
Speaker: Dr Kai Lars Polsterer, Heidelberg Institute for Theoretical Studies
Date: 10 May
Time: 13h00

Venue: 2nd floor auditorium SKA office, Pinelands

Abstract: The amount and size of astronomical data-sets was growing rapidly in the last decades. Now, with new technologies and dedicated survey telescopes, the databases are growing even faster. VO-standards provide an uniform access to this data. What is still required is a new way to analyze and tools to deal with these large data resources. E.g., common diagnostic diagrams have proven to be good tools to solve questions in the past, but they fail for millions of objects in high dimensional features spaces. Besides dealing with poly-structed and complex data, the time domain has become a new field of scientific interest. The next generation of radio telescopes, the SKA, will generate data sets with yet unseen resolution, sensitivity and completeness. By applying technologies from the field of computer sciences astronomical data can be accessed more efficiently. Machine learning is a key tool to make use of the nowadays freely available datasets. This talk presents some approaches to analyze and deal with those data sets.

UWC

Title: Galaxy Clusters from Inside to Out: Thermal Instability and Non-thermal Pressure Support

Speaker: Ian Parrish (Canadian Institute for Theoretical Astrophysics - CITA, University of Toronto)

Date**:** 6 May

Time**:** 14h00

Venue: Rm 1.35 New Physics Building, UWC

Abstract: Clusters of galaxies are the largest gravitationally-bound objects in the universe, and as such are useful as probes of both cosmology and astrophysics. To understand these objects as well as related problems in galaxy formation and black hole growth, we must understand the hot, dilute intracluster medium (ICM) that dominates the baryonic mass. In the cores of cool-core galaxy clusters, I will explore the balance between heating and cooling processes and explain when and how thermal

instability occurs. The resulting cool gas can form filaments or feed a central black hole. Our results are in good agreement with recent observations and have broad implications for feedback across many scales. I will describe a degree of thermal self-regulation of clusters and hot halos that can be achieved from this process and its consequences. Finally, I will move to the cluster outskirts and highlight the role of conduction-driven convection in the outskirts of galaxy clusters. This convection is driven by a unique plasma physics instability, the magnetothermal instability (MTI). The non-thermal pressure support from this vigorous convection has implications for our interpretation of ongoing SZ surveys.

Title: The Energy Balance of the ISM in M31. [CII] 158um as a SFR tracer and caveats

Speaker: Maria Kapala (UCT)
Date: 3 June
Time: 14h00
Venue: Rm 1.35 New Physics Building, UWC

Abstract: The energy balance dictates the multiphase structure of the interstellar medium (ISM), which in turn control the processes of star-formation (SF). Understanding the energy balance of the ISM is an essential step towards understanding the processes which shape the evolution of galaxies across the cosmic time. This work focuses on M31, an ideal laboratory to study the ISM due to its proximity, external perspective, and as it is a representative of the large, star-forming, metal-rich galaxies where most of the SF in the local Universe occurs. I will present the Survey of Lines in M31 (SLIM) with IFS Herschel [CII] and Calar Alto Halpha data, which allow us to study the dominant neutral gas coolant and typically one of the brightest emission lines from SF galaxies - [CII] 158um. On the small (~50pc) scales [CII] emission and SFR surface densities correlate well. The relation is sub-linear in most of the fields, but it approaches a 1-1 relation when averaged over whole fields (~700pc scales), which is in agreement with other extragalactic studies on similar

scales. I will show that we can predict [CII] emission in the SLIM fields in the disk based on the estimates from integrated SED fitting fraction of the stellar energy that contributes to gas heating (PEeff x UVatt) with a constant photoelectric heating efficiency (PEeff). We also found that the attenuated UV energy relative to the total attenuated energy (UVatt/TOTatt) correlates well with the observed [CII]/TIR ratio, suggesting that it is the soft photon heating of dust that is driving the observed variation in the [CII]/TIR ratio across the disk, and not an indication of changing PEeff. We propose that a better method to approximate the PE heating efficiency (than [CII]/TIR) is to use a SED fitting technique: [CII]/UVatt.

Title: Pulsar science with the SKA
Speaker: Aris Karastergiou (Oxford University)
Date: 10 June
Time: 14h00
Venue: Rm 1.35 New Physics Building, UWC

Abstract: Pulsar science will go through an exciting phase of new discovery with the SKA. I will describe in this talk what pulsars are, how we observe them now, and how we want to observe them in the future, while providing examples of some recent pulsar results that illustrate how pulsars allow us to study a broad range of physical phenomena.

Title: Cosmology with HI intensity mapping
Speaker: Dr Alkistis Pourtsidou (ICG, Portsmouth)
Date: 15 June
Time: 10h45
Venue: Rm 1.35 New Physics Building, UWC

No abstract

Title: Mapping Diffuse HI around Galaxies with the Green Bank Telescope
Speaker: Prof D.J. Pisano (West Virginia University)
Date: 17 June
Time: 10h45
Venue: Rm 1.35 New Physics Building, UWC

Abstract: In order to better understand how galaxies accrete gas from their surroundings, it is necessary to map neutral hydrogen emission down to the log N(HI)~17-18 level. While MeerKAT and SKA should be able to detect such gas, this sensitivity is currently achievable with the Green Bank Telescope. I will discuss the latest results from our ongoing surveys of nearby galaxies and their implications for the local accretion rate of galaxies.

ACGC

Title: Roulettes: A weak lensing formalism for strong gravitational lensing
Speaker: Prof. Chris Clarkson
Date: 24 May
Time: 12h00
Venue: MAM-111

Abstract: I will present a new perspective on gravitational lensing. I will discuss a new extension of the weak lensing formalism capable of describing strongly lensed images. By integrating the non-linear geodesic deviation equation, the amplification matrix of weak lensing is generalised to a sum over independent amplification tensors of increasing rank. An image distorted by a generic lens may be constructed as a sum over `roulettes', which are the natural curves associated with the independent spin modes of the amplification tensors. Highly distorted images can be constructed even for large sources observed near or within the Einstein radius of a lens where the shear and convergence are large. The amplitude of each roulette is formed from a sum over appropriate derivatives of the

lensing potential. Consequently, measuring these individual roulettes for images around a lens gives a new way to reconstruct a strong lens mass distribution without requiring a lens model. This formalism generalises the convergence, shear and flexion of weak lensing to arbitrary order, and provides a unified bridge between the strong and weak lensing regimes.

Title: Gravitational entropy: beyond the black hole
Speaker: Prof. Paul Davies (Arizona State University)
Date: 31 May
Time: 12h00
Venue: James LR 2A, UCT

No abstract.

Title: Dark energy interactions and the CMB - LSS tension
Speaker: Dr. Alkistis Pourtsidou (ICG Portsmouth)
Date: 16 June
Time: 12h00
Venue: MAM-111

Abstract: In the last few years we have entered the "golden era" of observational cosmology. The standard cosmological model, LCDM, is a very good fit to the data. However, low redshift large scale structure probes seem to point towards a slower growth of density perturbations than Planck + LCDM would prefer. If this tension is an indication of new physics, it can be alleviated by a dark energy - dark matter interaction with pure momentum exchange. In my talk I will first summarise the current state of the CMB-LSS tension, and then move on to introduce interacting dark energy models. I will present a comprehensive statistical analysis of a pure momentum exchange model using the wealth of available data and show that such models are prime candidates for reconciling the CMB and LSS measurements

Sky Delights: The Sky's Strong Man

Magda Streicher

Hercules was one of the oldest constellations to be named and portrays the mythology of the past in a very special way. The "strong man" was seen as a hero crouching on one knee, bow and arrow in hand. The constellation Sagita was probably seen as the arrow shot off by him. Before the Common Era the constellation was simply called The Kneeler, but the real name ascribed to the strong man in antiquity was Ninurta, the War God. The constellation is the fifth largest of the 88 constellations inhabiting the starry skies.

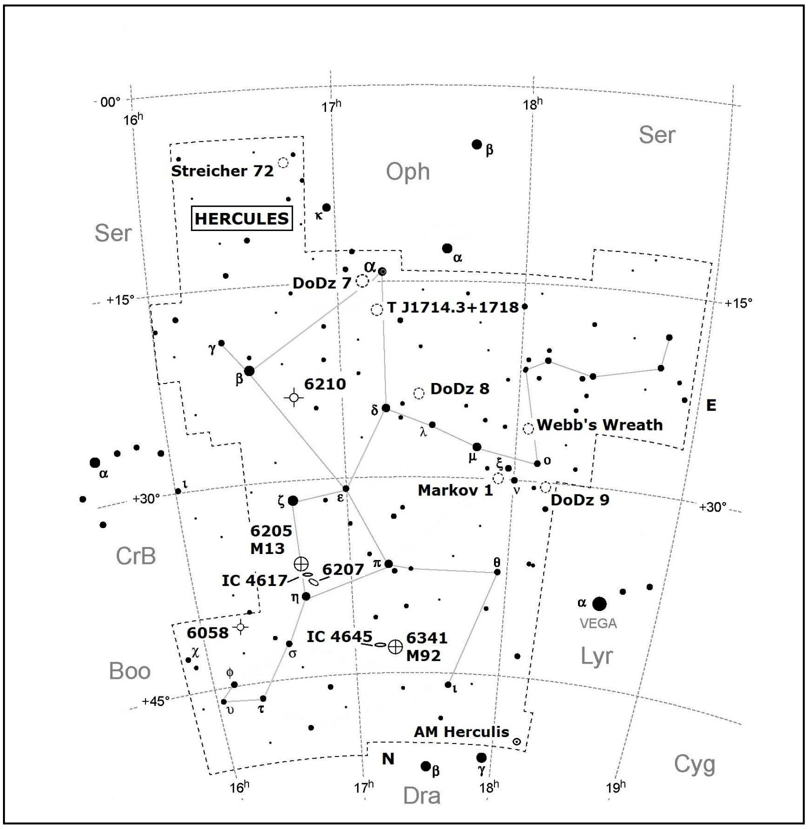

Fig 1. The constellation Hercules.

This hero lifted his head looking south-east with the star alpha (Rasalhague) Herculis in the direction of the constellation Ophiuchus. This red giant star is 400 light years away and is also a variable ranging between magnitude 2.7 and 4 during a six-year period.

The constellation offers a good variety of objects. The first one to discuss is **Dolidze-Dzimselejsvili 7** (DoDz 7), which is situated only 1.5 degrees north-west of alpha Herculis. The beauty of open clusters, and especially the ones with fewer stars, always tells a story of one kind or another. DoDz 7 shows itself off as a little boat drifting on a black sea, with the starry night sky to accompany it.

Three reddish magnitude 10 stars situated in a north-west to south-east direction can be seen as the base of the sailboat with a slightly brighter yellow star south-west at the top to mark the mask. Faint stars fill in the gaps and outline the impression. The Finnish observer Jere Kahanpää was the first to mention the resemblance and since then the grouping has been known for it.

Asterisms are decidedly among the most exciting star groupings for launching a celestial search. To observe deep sky objects is one thing, but there may be a gem in the area just waiting to be discovered in exceptionally small star groupings. I sniffed out **Streicher 72** by using a star program, followed by a search through the 16-inch telescope, which was extremely difficult. The very faint magnitude 12.5 grouping is in the southern corner of the constellation in a fairly densely packed faint star field. The impression, however, is amazing in that in a handful of similar magnitude stars one can see the image of a man sitting comfortably in a starry chair. A question mark shape of similar stars can be seen just to the north.

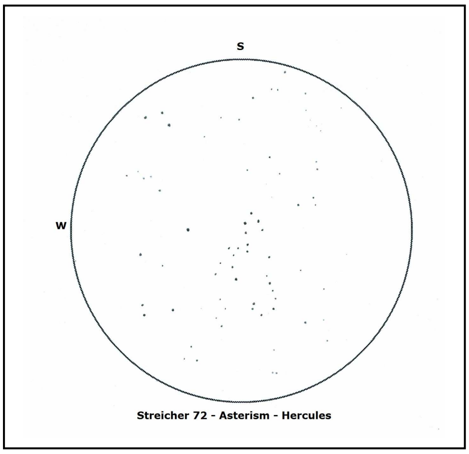

Fig 2. Streicher 72 (Asterism in Hercules).

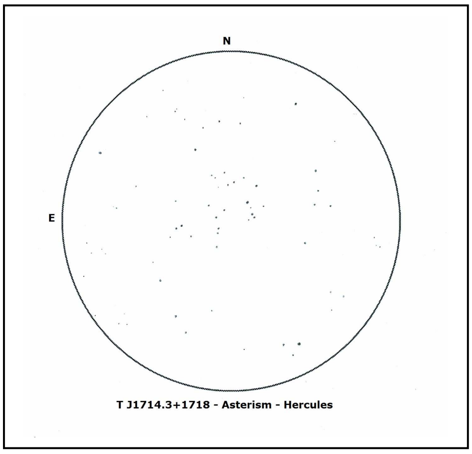

Fig 3. TJ1713 (Asterism in Hercules)

About 2 degrees north of alpha Herculis is the asterism **T J1714.3+1718**, which was discovered by the observer Philipp Teutsch from America. The dainty tight grouping contains a short string in a north-east to south-west direction just 1.5’ long with magnitude 12 stars. A few stars on the northern side seem to be holding this grouping in its hand.

The backbone of this constellation is beta Herculis, with a spectrum similar to that of our Sun, which approaching us at a speed of a few kilometres per second. One of the sky's most perfect planetary nebulae, **NGC 6210**, can be found 4 degrees north-east of the star beta Herculis. The planetary is situated 10' north-west from a magnitude 7 light orange coloured star. The planetary displays a near perfect round glow with a hazy edge and if I'm not mistaken, with a hint of green and light blue colour flowing into each other. The magnitude 12 central star is covered in its misty blanket. The well-known Steve O'Meara found "some crisp edges to an inner bubble and the core appeared as an amorphous knot in a speckled mist with high magnification 495X". Its nickname is the Turtle Nebula, although it can most definitely be described as one of the most delicate nebulae.

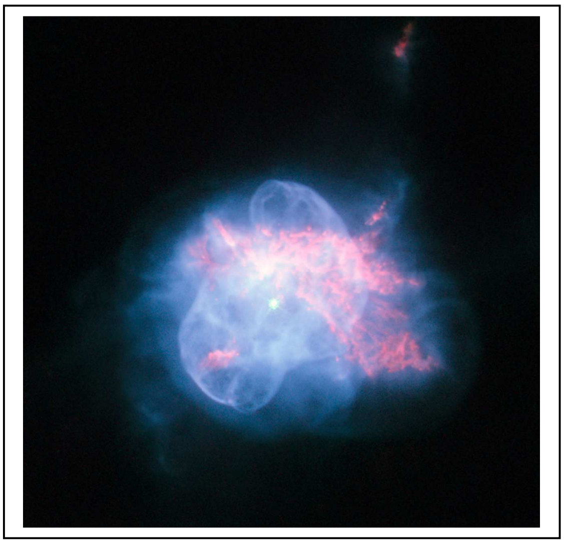

Fig 4. NGC6210, also known as the Turtle Nebula.

The open cluster **Dolidze-Dzimselejsvili 8** (DoDz8), is situated 1.5 degrees east from its host star, delta Herculis towards the eastern part of the constellation. Two pairs of double stars, north and south, framed a few faint stars. The grouping displays a zigzag shape in a way. It can be seen in the shape of a hat, or perhaps an insect of sorts.

The strong man's arm stretching from the star delta Herculis towards his finger points east, where a few star groupings possess a lot of character. The grouping **Markov 1** displays an altogether lovely half-moon shape open towards the west with 5 yellow and orange magnitude 10 stars. Up towards the north is the yellow-coloured magnitude 6.7 xi Herculis. Canadian amateur Paul Markov documented this grouping as an asterism in 2000. The grouping reminded him of a teapot shape.

In his arm he appears to be holding the grouping **Webb's Wreath**, which has been catalogued in the Thomas William Webb observing guide *Celestial Objects for Common Telescopes*. If an observer is looking for a colourful widespread grouping, then this is it, although rather faint. A lovely yellow magnitude 7 star (HD 165241) tops the grouping towards the south.

A colourful splash of stars quite outstanding against a faint star field is **Dolidze-Dzimselejsvili 9** (DoDZ 9), situated 2.5 degrees north-east of nu Herculis in a field sprinkled with faint stars. Madona Dolidze was a Georgian astronomer who worked from the late 1950s until at least 1975 using objective-prism plates with the Abastumani 70 cm Maksutov telescope, surveying for emission-line stars, red stars, and other objects. The star groups were reported incidentally from these surveys, and are regions where there seemed to be either groups of stars with early spectral types or where there seemed to be a main-sequence-like run from brighter early-type stars toward fainter/redder stars. The entire latter sort of "clusters" is non-physical, simply from the fact that the range in magnitudes observed is very much less steep than what a real cluster would show. Madona worked with G Dzimselejsvili in 1966 to publish a list of 11 open clusters which has been catalogued with both of their names.

The Hercules constellation is easily recognisable with the four corners marked by the magnitude 3.9 epsilon, 2.8 zeta towards the south, and 3.4 eta and 3.1pi north towards the middle section of the constellation. Within this square is the most famous globular cluster in the northern hemisphere, none other than **Messier 13 (NGC 6205)** situated between eta and zeta, and against a dark night sky it is visible even with the naked eye. M13 was discovered in 1714 by Edmond Halley, who noticed it with the naked eye as he hunted for comets at the time. The globular cluster is 21 000 light years from us. It is large and bright because it is relatively close to us and has been called the Great Hercules Cluster. Also in Hercules is a cluster of galaxies called the Hercules Galaxy Cluster, but it is a difficult task to unravel. I always want to compare this globular with the beautiful ones back south, but I must admit that M13 is a stunning globular cluster and truly unique. Stars seem to blow out with star outliers randomly into the star field from its fringy edge and more so on the north-western side. The bright wide core covered in a mist of faint stars is extremely compressed. A few dark lanes can be seen cutting through the mass of stars, called the Propeller by amateurs. The most prominent dark wedge is cutting towards the south-eastern part of the cluster. Fewer stars are obvious in the southern and eastern parts of the clusters. M13 explodes into starlight with the use of a large and medium telescope. An extremely faint and small galaxy, IC4617, is situated less than 10' north, riding in the misty rain of M13 .

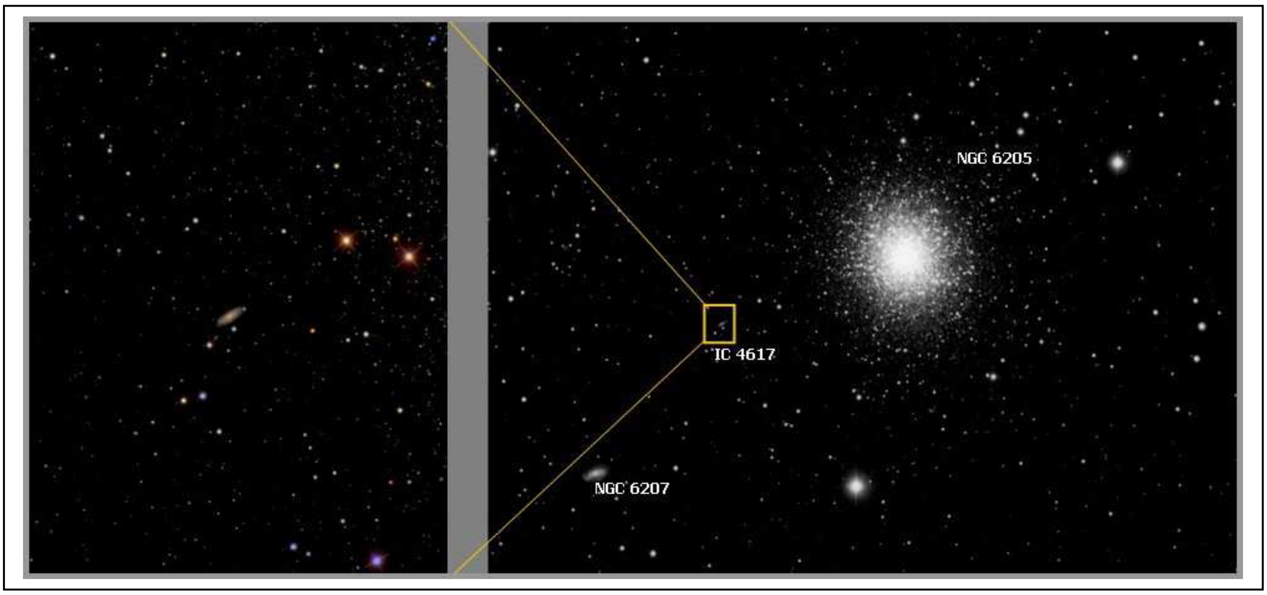

Fig 5. IC4617 (credit astroshark.wgz.cz)

However, less than a half a degree further north is a slightly brighter galaxy, **NGC 6207**. The galaxy displays a soft north-east to south-west oval haze which is somewhat brighter towards the middle. With higher power the nucleus grows in brightness. NGC 6207 was discovered in 1787 by William Herschel with an 18.7-inch f/13 speculum telescope. He called it "pB,pS, E sp-nf, vgmbM, which means pretty bright, pretty small, elongated in the direction south-west to north-east, the light becoming very gradually much brighter towards the middle".

Half the size of M13 and most of the time overlooked by the Great Hercules Cluster is the globular cluster **Messier 92** (**NGC 6341**). It is situated far to the north around 10 degrees from M13 or halfway between M13 and the Draco-head of the Draco constellation. M92 is beautiful with a core initially lightening slowly then suddenly growing brighter to a compressed middle. Scanty outliers gave it a more concentrated look with an unresolved core. A few dark spots settle among faint stars with a more notable string of faint stars flowing north-east. It is a very old globular, about 25 000 light years distant. J.E. Bode discovered M92 in 1777 and it was added as the 92nd entry in the 1781 Messier's catalogue. There is also a faint galaxy (IC 4645) half a degree west, to keep up the norm of competing with the famous M13. On top of that, M92 is accompanied by a chain of galaxies trailing behind, stretching for almost 3 degrees south.

Tucked into the most north-eastern corner, a degree east from the pair of galaxies IC 11970 is the variable star **AM Herculis**. In 1923 it was discovered by M. Wolf and was positively confirmed as the optical counterpart of 3U 1809+50, a weak X-ray source initially detected by the Uhuru satellite. AM Herculis with a spectral type M4.5, ranges between magnitude 12.3 and 14, lying just outside the rectangular Uhuru source. The X-ray telescope aboard the SAS-3 satellite was striving a better position for 3U 1809+50, and the accuracy of the measurements, the position of the X-ray source were the same. At the time the thought might have been that it was a quasar or related object. This unusual star has a very strong magnetic field surrounding the system. It has now been called an AM Her-type similar to AN Ursae Majoris, which are cataclysmic variables with extremely strong magnetic fields, also known as ***Polars***.

In the north-western corner of the constellation on the edge towards Corona Borealis a lone planetary nebula can be found. William Herschel discovered **NGC 6058** in 1787 and described it as a star with nebulosity. However, NGC 6058 displays a small and very faint disc with a hazy outer envelope. It has a washed-out whitish colour and seems to be slightly elongated north to south. The central star shines dimly at magnitude 13.8, making it not easy to spot. NGC 6058 is special because it is situated in a very strange position in relation to the surrounding stars. The planetary forms a very distinct Y shape with the surrounding magnitude 11–12 stars connecting the two bars of the Y. This feature is also known as the Mercedes-Benz logo.

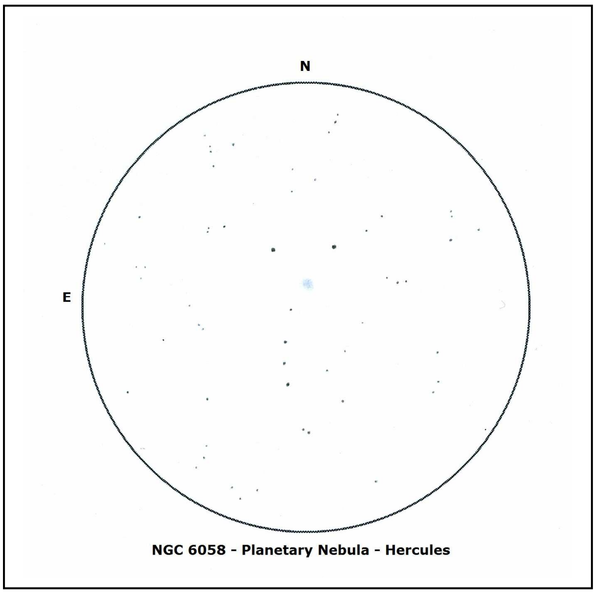

Fig 6. NGC6058, a Planetary Nebula.

You do not need to be strong to enjoy the various wonderful objects that the starry strong man has to offer – just do not try to take him on in a fight!

OBJECT	TYPE	RA	DEC	MAG	SIZE
NGC 6058	Planetary Nebula	16h04m.4	+40°41′.7	12.9	23″
NGC 6205 Messier 13	Globular Cluster	16h41m.7	+36°28′.2	5.7	16.6′
NGC 6207	Galaxy	16h43m.1	+36°50′.0	11.6	3.0′x1.1′
NGC 6210	Planetary Nebula	16h44m.5	+23°48′.5	8.8	14″
Streicher 72	Asterism	16h47m.3	+06°25′.4	12.5	5′
Dolidze-Dzimselejsvili 7	Open Cluster	17h11m.4	+15°28′.6	6	6′
Teutsch J 1714.3+1718	Asterism	17h14m.3	+17°18′.1	14	4′
NGC 6341 Messier 92	Globular Cluster	17h17m.1	+43°08′.2	6.4	11.2′
Dolidze-Dzimselejsvili 8	Open Cluster	17h26m.4	+24°11′.6	6.8	14′
Markov 1	Asterism	17h57m.2	+29°29′.2	6.8	15′
Webb's Wreath	Asterism	18h02m.3	+26°18′.0	10	5.5′
Dolidze-dzimselejsvili 9	Asterism	18h08m.8	+31°32′.2	10.5	28′
AM Herculis	*	18h16m.3	+49°52′.0	12.3	*

History of Astronomy in Africa Steering Meeting

Prof Nithaya Chetty of the NRF Astronomy Desk advises that a meeting to discuss historical projects that are in progress or proposed will take place at SAAO on 15 August. Short 15 minute presentations are proposed

Some suggested titles as follows:

1. Heritage status of our Astronomical sites, e.g. SAAO
2. Archiving of historical records
3. Digital archiving
4. Preservation of historical artefacts
5. Cultural roots of Astronomy in Africa
6. Recording of oral interviews, oral history
7. Modern history of the SKA project
8. Publishing of historical research papers – how can we have a more coordinated effort?
9. Publishing of academic books
10. Publishing in Wikipedia more effectively
11. Where have our telescopes come from?
12. Etc, etc, etc

This Steering Meeting is about taking a more coordinated approach to these matters of history. People are responsible for their own travel expenses. A Steering Committee will be established at this meeting.

(Postscript) Editorial

For the final issue of MNASSA of this year, December edition, I would like to get a record of all the small observatories in SA. The recent transit of Mercury indicated to me that there are a number, many of which I had never heard of before.

So this is an early request to anyone in SA, with their own little observatory that is in regular use, to start writing up a short article on your Observatory. There will be space for one or two images of about 250kB each, a brief write up, say 500 - 1 000 words, what the instrument(s) are and what principle observations are made: could be variable stars, astrophotography, deep sky objects, spectroscopy, solar studies comets etc.

Deadline for articles is 30 November, and you can start submitting at any time from now on! Let’s make this the first complete record of ALL the small, private observatories in SA.

Many thanks.

Case Rijsdijk
Editor MNASSA

Limerick solution

A dozen, a gross, and a score,
Plus three times the square root of four,
Divided by seven,
Plus five times eleven,
Equals nine squared and not a bit more.

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

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

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

Local Centres: Local Centres of the Society exist at Bloemfontein, Cape Town, Durban, Harare, Hermanus, Johannesburg, Pretoria and Sedgefield district (Garden Route Centre). Membership of any of these Centres automatically confers membership of the Society.

Sky & Telescope: Members may subscribe to Sky & Telescope at a significant discount (proof of membership is required). Please contact the Membership Secretary for details.

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ISSN 0024-8266
mnassa
monthly notes of the astronomical society of southern africa
Volume 75 Nos 5 & 6 June 2016

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