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monthly notes of the astronomical society of southern africa

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In this issue:

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RECOGNITION	Articles from *MNASSA* appear in the NASA/ADS data system.

Cover picture: Star Trails above Table Mountain. This amazing image was chosen as the winner in the "World at Night's 2015 International Earth and Sky Photo Contest". It was composed of over nine hundred 30 second exposures in June 2014. Image Credit: Eric Nathan

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ASSA News - Scholarships

ASSA Scholarship

The ASSA Scholarship for 2015 has been awarded to Brandon du Preez, who is a second year science student at the University of Cape Town. He plans to major in physics and astrophysics.

HartRAO-ASSA Scholarships

The new HartRAO-ASSA Scholarships are sponsored by the Hartebeesthoek Radio Astronomy Observatory. For 2015, they were awarded to the following students:

Michael Sarkis, a third year science student at the University of the Witwatersrand.
Jeremy Smith, a third year student studying electrical and computer engineering at the University of Cape Town.
Verlon Etsebeth, who is entering his third academic year in science at the University of South Africa. Verlon held a SAAO-ASSA Scholarship in 2014.

Three HartRAO-ASSA Scholarships with a financial value of R16 000 each will be available in 2016.

Scholarship winners: Left to right: Brandon du Preez, Michael Sarkis, Jeremy Smith and Verlon Etsebeth

SAAO-ASSA Scholarships

These scholarships were discontinued at the end of 2014. The three holders of these scholarships in 2014 made good progress with their studies and all advise that they are continuing with their undergraduate studies in 2015. They are Dean de Villiers, Francois Botha and Verlon Etsebeth.

News Notes - Darragh O'Donoghue

We regret to report that Darragh O'Donoghue of SAAO passed away on 25 June. He will be greatly missed and will be remembered, not only for his huge contribution to astronomy in South Africa and to SALT, but also as a kind, gentle friend and mentor to many. There will be a full obituary in the next edition.

News Notes - Sutherland high-speed optical camera (SHOC)

Edited from SAAO Press release by Nicola Loaring.

In with the new: Astronomers can now drive research telescopes using their smartphones!

The South African Astronomical Observatory (SAAO) has been a hive of activity lately with astronomers and engineers busily upgrading and improving the observatory's smaller telescopes. To keep these telescopes internationally competitive the SAAO has installed a new improved detector called the "Sutherland high-speed optical camera" (SHOC) used on its existing 1.9 m and 1 m telescopes and is installing two new telescopes to replace those which were donated to the University of KwaZulu-Natal and the University of the Free State in early 2015 (See *MNASSA* Vol. 74 Nos 1 & 2 February 2015). Along with the new telescopes and instruments, brand new software has been developed in house to support astronomers using the new facilities. The new software to drive the SHOC instrument has been designed to be used within a web-browser so that astronomers can control the camera from a remote computer, laptop, tablet or even their smartphone! In the coming months, the SAAO hopes to release the software into the Open Source community, thereby aiding other observatories around the world as well as amateur astronomers. It looks like the days, or rather nights, of astronomers freezing while observing up the mountain in Sutherland could soon be numbered!

An in-house SAAO team has recently released new software to drive the new SHOC instrument which is used on the SAAO's 1.9 m and 1 m telescopes. Originally, SHOC was controlled using software supplied by the camera manufacturer Andor. However, in order to fully customize the software and to allow for future extensions, the SAAO team collaborated to produce new Open Source software to drive SHOC via a web-based user interface. This new software also has the advantage of allowing users to control the SHOC instrument from any location, ushering in a new era of remote observing at the SAAO.

Software engineers Carel van Gend and Briehan Lombaard have developed a simple web-based user interface which astronomers use to control all aspects of data acquisition using SHOC. Astronomers can use the interface to select the camera exposure time they require and the colour filter they

wish to use, along with any other requirements for their observations. Once an astronomer has selected the appropriate configuration for their observation, all they have to do is hit the "start" button. The software then "drives" the instrument which automatically configures itself, takes the required picture and saves the data in a computer file for the astronomer to analyse later on.

Carel van Gend, a principal software engineer on the project said that they wanted to improve the functionality of the previous software, make it more convenient and intuitive for astronomers to use, and to move towards the long-term goal of making the instruments and telescopes remotely operable. They've done this, and along the way they've made the software more robust and easier to maintain and extend.

In addition to controlling the camera and instrument, astronomers also required a mechanism to view and analyse their data on the fly. Software engineer Briehan Lombaard was responsible for developing the user interface for viewing and analysing the data in real-time which is incorporated into the web-browser along with the instrument controls. Images output from the camera are automatically displayed in the web-browser and are updated every second.

The new software uses Linux, a widely used free and open source operating system as the underlying platform. The software comprises a number of free-standing but interacting modules, which allows the most suitable programming language to be used for each component. The back-end software which drives the hardware is written in C++ and Python. The front-end code, interacting with the user's web-browser, is written using Python, Flask, and JS9, a JavaScript library developed by the Smithsonian Astrophysical Observatory in the United States for astronomical applications.

The SHOC instrument is designed to take extremely short exposures in quick succession in order to look for rapid changes in the target object.

The camera can take up to 100 frames a second, which is four times faster than a normal motion picture! It is therefore crucial that the exact timing of the exposures is known to great accuracy. This is achieved using a GPS (Global Positioning System) receiver in the instrument. A familiar example of the use of GPS receivers is in car navigational aids; however, the space-based satellite navigation system also provides accurate time information for any position on Earth.

Dr Amanda Gulbis, Head of Instrumentation at the SAAO and SHOC designer said that the GPS settings can be controlled such that every image frame is triggered to better than micro-second accuracy. While the camera can take data up to hundreds of frames per second, the display only updates every one second or better, depending on the computer network connection.

One of the first astronomers to use the software, Dr Matt Burleigh of the University of Leicester, UK commented how impressed he was with the performance of SHOC, saying that the new operating software is also very easy to use.

As SHOC can now be driven from most modern web-browsers, including those on laptops, tablets and even smartphones, astronomers are no longer tied to the telescope dome in order to make their observations. To take data, the astronomer can be located in the telescope dome, or remotely from around the world. Van Gend and Lombaard are currently working on an extension to the software which will enable astronomers to pre-configure their observations in advance of a night's observing. Van Gend added that eventually they hope that astronomers will be able to configure their observations using only a web-browser, set them running, and download the data when they are ready without needing to travel to Sutherland, and to stay up all through the freezing night!

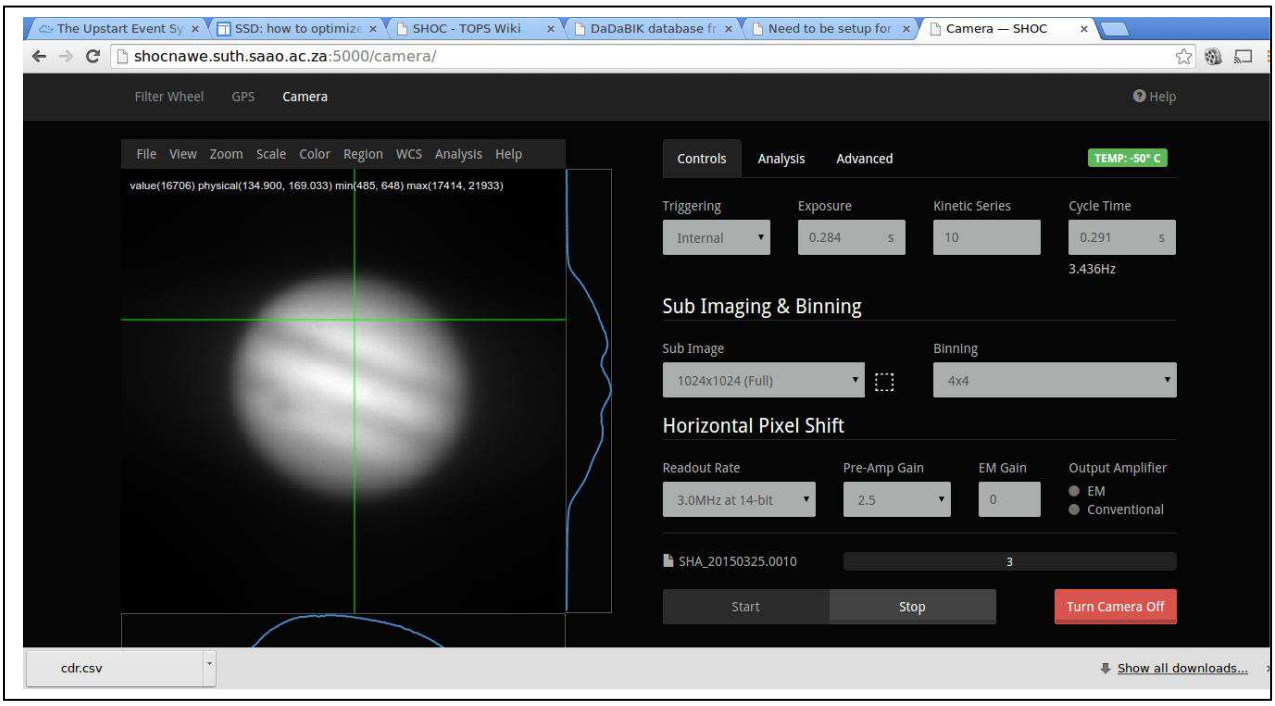
Dr Nicola Loaring, SAAO Outreach Officer mentioned that these new software developments have important implications, not only in terms of

efficiency and convenience, but also in terms of cost. The SAAO can expect significant savings in its operations budget by switching from traditional dome based observing to remote observing.

In the coming months, the SAAO hopes to release the software into the Open Source community, thereby aiding other observatories and amateurs in their endeavours when it comes to instrument building.

Hamish Whittal, SAAO's IT division manager and member of the project team, says:

“We've benefited from using open source at the SAAO, and we're excited to be giving something back.”



A view showing the new web-based SHOC software. In this example SHOC was observing the planet Jupiter during a test run. The image of the planet Jupiter taken using the camera is displayed on the left. This frame shows a picture captured using a blue (B) filter with an exposure time of only 0.284 seconds.

The astronomer can analyze the image further using the software. The cross-hairs over the image (green) have been positioned by the astronomer and the intensity of the image along the cross-hairs in both directions is displayed to the right and bottom of the image of Jupiter (blue lines). On the right hand side are the camera controls. Other instrument controls such as those for the GPS and the filter wheel are at the top of the user interface.

News Notes - The SALT Science Conference 2015

Edited from SAAO press release by Nicola Loaring

The Southern African Large Telescope (SALT) Foundation and South African Astronomical Observatory (SAAO) are delighted with the success of the SALT Science Conference 2015 held in Stellenbosch from 1 to 5 June. The programme was jam-packed with talks, poster presentations, practical workshops and discussions showcasing SALT's capabilities. Over ninety astronomers and education professionals attended the conference representing over twenty nationalities. Delegates from international astronomical institutes from seven countries attended the conference to foster scientific collaborations and enhance partnerships with the South African astronomical community. Education and outreach professionals also contributed to the conference programme in recognition of the pivotal role that SALT has played in the advancement of astronomy and science education and in skills development within South Africa.

The event was formally opened by the Minister of Science and Technology, Naledi Pandor. Her vision sees South Africa as a centre for research excellence in astronomy:

"Our aim is to position Africa as a global centre of research excellence for multi-wavelength astronomy, with optical, radio and gamma-ray telescopes working together to achieve common scientific goals."

She was keen to emphasize the importance of South Africa's experience in developing SALT in paving the way for South Africa's successful bid to host what will be the largest telescope ever built, the Square Kilometre Array (SKA) radio telescope, due for completion in 2024:

"South Africa pursued the SKA project by using the lessons learnt from SALT as the basis for our planning and partnerships. The links we developed through the SALT project allowed us to build on existing networks and partnerships to secure the iconic SKA, an extremely important strategic initiative that puts science and technology to work for the benefit of all Africans."

As well as acknowledging the key role that SALT has played for science and technology development in South Africa, educators at the conference stressed how the wonder and beauty of astronomy can be used to inspire and encourage young learners to take up science and mathematics (STEM)

subjects at school. Since its inception, the SALT project has placed a strong focus on education and public awareness programmes and Sivuyile Manxoyi, head of the SALT collateral benefits programme, summarised the work of the outreach department at the SAAO during his conference presentation:

“We have been very successful in training and supporting teachers and curriculum advisors in the teaching of Natural Science and particularly the theme ‘Earth and Beyond’. Through programmes such as the national astronomy quiz we have succeeded in using astronomy to inspire curiosity and critical thinking among learners. Through our exciting job shadowing programme, we are spreading career information pertaining to astronomy and related science.”

For the remainder of the conference the focus shifted to the practicalities of optimizing the use of the telescope and showcasing the recent exciting and varied science conducted using SALT observations.

Dr Steve Crawford, SALT Science Data Manager pointed out:

“Since the start of science operations, SALT has been producing exciting science at a comparable rate as similar telescopes at the same stage in their operations, but at a fraction of the cost. This is a huge compliment to the SALT staff and the astronomers working with the observatory. “

SALT operations staff also held several training workshops during the conference to help potential SALT users apply for telescope time and to aid them analyse SALT data products using software tools developed by the SALT team.

In terms of science, the areas covered ranged from planetary science, stellar astrophysics to studies of galaxies and the distant universe. A large portion of the conference focused on the variable universe, a niche area for SALT’s unique capabilities. SALT’s imaging instrumentation is tailored

towards achieving high time resolution observations of varying objects and transient (short-lived) objects.

Dr Petri Vaisanen, Head of SALT Astronomy Operations commented:

“Listening to the talks at the conference from an operational point of view, it was extremely gratifying to see so many scientists, from students to professors, getting results from SALT. People are finding out exciting things about the Universe from analysis of the data we have been dishing out to them under the Sutherland night skies for years, it makes the work worthwhile.”

Dr David Buckley, chair of the conference scientific organising committee and SALT Scientist added:

“SALT has really come of age. This is demonstrated by the breadth and quality of the science results presented. Over the past couple of years there has been a steady improvement in the efficiency and productivity and SALT’s community of users have learned how to best exploit it to their advantage. This has resulted in a ramping up of science publications showing that SALT is beginning to make a significant contribution in forefront astronomy, partly due to some of the competitive advantages that it has.”

Finally, the conference finished with considerations and prospects for future SALT science. Dr Marsha Wolf from the University of Wisconsin, US, detailed the proposed extension of SALT’s capabilities into the near-Infrared region of the electromagnetic spectrum. If implemented this will allow astronomers to observe even more distant objects than is presently possible with SALT. This is because the light from distant galaxies is “redshifted” into the near-Infrared as a consequence of the expansion of the Universe. Extending into the near-Infrared will also allow observations of objects that are enshrouded in gas and dust which are not possible using visible light alone.

Prof. Bruce Bassett, joint Professor at SAAO, UCT and AIMS in Cape Town introduced methods that he has developed employing computer algorithms to automate the classification of transient objects. The volume of data that astronomers will need to analyse will increase significantly once the SKA comes online and automating data analysis wherever possible will be crucial in order to fully exploit SALT and SKA in the future.

One of the key take home messages from the conference was the importance of using SALT together with other ground based and space based observatories such as the SKA radio telescope and the European Space Agency's Euclid satellite mission.

Dr David Buckley, commented:

"The meeting was well attended by SALT users, both within South Africa and abroad. Importantly many graduate students whose early careers are taking full advantage of SALT attended. The future for SALT looks assured, particularly with planned new developments and synergies with emerging facilities in South Africa and globally."

The prospects for SALT and astronomy in general within South Africa are brighter than they have ever been. Exciting times lie ahead, however, to fully understand the wonders of our Universe it is now clear that astronomers will have to adopt a multi-wavelength approach and peer at the skies with a combination of telescopes!

Further details of the conference, programme, attendees etc., can be found at http://ssc2015.salt.ac.za/

News note: Tracking Secret Satellite

By Greg Roberts

South African amateur astronomers recently played a pivotal role in tracking a secret satellite

The fourth flight of the secret US Air Force mini-shuttle, also known as the X-37B or OTV-4 (Orbital Test Vehicle) was launched by ULA (United Launch Alliance) atop an ATLAS V rocket from Cape Canaveral on the 20th May 2015 at 15.05UT. As per previous missions of this spacecraft only the first four and a half minutes of the launch were carried live on internet TV before a news blackout took place to conceal the orbit of the classified spacecraft.

However this did not present a problem to Ted Molczan who is a well - known Canadian amateur satellite tracker and one of the world's top orbit analysts, amateur or professional. Using information that is in the public domain he determined that the orbital inclination was likely to be 39 degrees, somewhat lower than that used by the three previous OTV launches. Working on the assumption that the orbiting altitude would be in the range of 350 to 390 km above the Earth's surface, Ted, as he traditionally does for all classified launches, posted pre-launch orbital elements on the SeeSat Group's web page that would hopefully assist amateur satellite trackers to locate the secret satellite once in orbit. For a satellite at about 350 km altitude the orbital period is around 91.5 minutes (15.73 revs/day) whilst for an altitude of 390 km it is around 92.3 minutes (15.60 revs/day). He also indicated that the first northern hemisphere visibility window would be in the morning and opening at about 29 May, whilst the first southern hemisphere visibility window would be in the evening opening about 25 May.

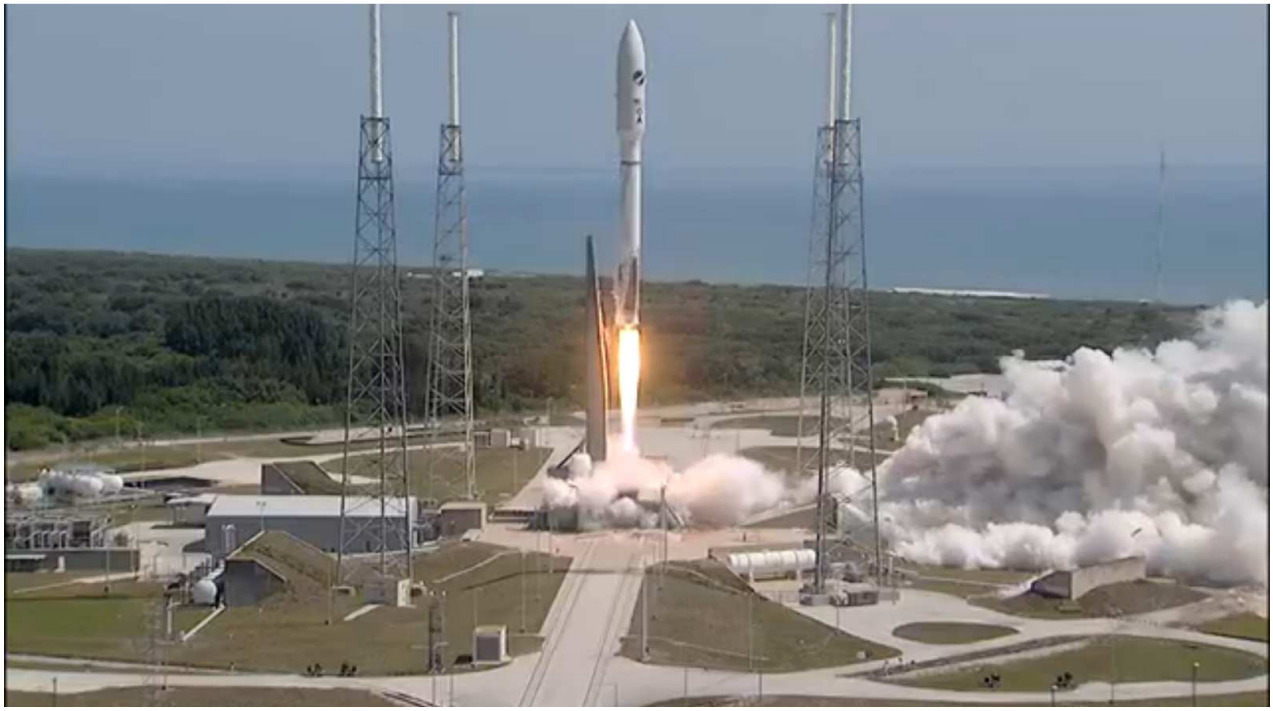
Ten ULTRASATS were also to be orbited in orbits somewhat different to that planned for OTV-4 - namely about 350 by 700 km altitude at an inclination of 57 degrees - including the LIGHTSAIL mission - but these

need not concern us here - suffice to say his pre-launch elements were within a minute when LightSail was tracked by means of its radio transmission when it passed over my Cape Town station, in the Earth's shadow, about 4 hours after launch. Ted had this to say about LightSail:

The most interesting secondary payload for observers is likely to be the Planetary Society's experimental solar sail, named LightSail, see

http://sail.planetary.org/

LightSail is a citizen-funded project by The Planetary Society, the world's largest non-profit space advocacy group who intend to send two small spacecraft into Earth orbit, carrying large, reflective sails measuring 32 square meters (344 square feet). Their first mission was a May 2015 test flight that will pave the way for a second, full-fledged solar sailing demonstration in 2016.



Launch of LightSail

In May 2015, their first LightSail spacecraft was to hitch a ride to orbit aboard an Atlas V rocket for a shakedown cruise. It would not be high enough above the Earth's atmosphere for solar sailing, but it would be able to test their sail deployment sequence and snap some pretty pictures.

According to the following timeline, the deployment of the sail was planned for 28 days after launch, see:

http://www.planetary.org/blogs/jason-davis/2015/20150330-your-first-timeline-of-events.html

By then, the orbit would be visible from the northern hemisphere during the middle of the night. The southern hemisphere may have marginal evening passes. Note that the high area to mass ratio with sail deployed, combined with the low perigee height, was expected to result in decay as soon as a couple of days after deployment.

It was successfully deployed at 21.51 SAST on 7 June 2015 and has been visually confirmed as working - so LightSail mission was a success. It was expected to re-enter the Earth's atmosphere in about two days' time. There was/is no optical visibility for us in South Africa.

The Centaur rocket should have been de-orbited into the southern Indian Ocean; with time of impact shortly after T+02:30. Ted offered the pre-launch search orbital elements in support of the search for OTV 4. It should be used with reasonable allowance for uncertainty in the mean motion and inclination.

Historically, the X-37B has tended to maintain a constant altitude for long periods, achieved by means of frequent small manoeuvres to counter the effects of drag. Large orbit manoeuvres have been infrequent; however, X-37B is highly manoeuvrable, which has the potential to complicate the search.

When visible passes were due to start over Southern Africa on 25 May, 2015, the author knew that the chances of seeing it from Cape Town were minimal due to almost continuous cloud during the Cape winter season. With most of the rest of South Africa relatively clear the idea of trying to encourage anyone interested to try and observe it came about, especially since the far northern parts of South Africa had visibility several days before Cape Town would have it and the earlier in the mission the better the chance of acquiring the satellite. Consequently the author posted predictions for several places scattered in South Africa on his Facebook page using the search elements generated by Ted Molczan which assumed a circular orbit at an altitude of 390 km, inclination 39.000 degrees and taking 92.30 minutes per orbit.

Kos Coronaios in Louis Trichardt volunteered his services and he had an excellent near zenith pass on the 24 May, 2015. He conducted a search and took several images of where the satellite was predicted to be. As it turns out the search was of too short a duration - not that it would have made any difference as the satellite was running a long way off time for reasons that will shortly be explained. So Kos unfortunately missed out on the chance to be the first person in the world to see OTV-4 in orbit – the author hopes he will have better luck next time he volunteers!

So nothing was observed during the first illuminated and hence naked-eye pass over Southern Africa. Knowing now that the satellite was NOT running close to the predicted time, potential observers for the 25 May were warned to look quite a lot earlier to quite a lot later to bracket the predicted time. Deon van Rooyen, who lives in Krugersdorp set up on the predicted pass at 18h24m SAST and managed to secure two images *(see left)* of a possible satellite running about 25 minutes late at

18h48m44s SAST, through thin cloud. The author was confident that it was OTV-4 and forwarded the two images and other details such as times taken and observer's location to the amateur network's orbit specialists Ted Molczan in Canada and Cees Bassa in the Netherlands. An orbit was computed but differed considerably from that expected so efforts were made to make the observations made by Deon fit what was expected, and a new set of search elements was generated and predictions posted on my Facebook page for the 26 May, again with the warning that the orbit was uncertain and observers should bracket the predicted time.

So on the 26 May, Hannes Pieterse, who lives in Bloemfontein, started setting up his equipment shortly after 19h SAST, before the expected pass time of around 19h21m SAST and was experimenting with finding the best exposure to use when he captured a satellite at the edge of the first image he took at 19h04m39s SAST. He continued taking images until well after the expected time and saw nothing. However he sent me the image secured with the comment that he thought it was travelling towards the horizon *(See image on left)*

The author initially dismissed this as a sighting of another satellite - the sky is full of them - and waited in anticipation of getting reports from other observers. Both Kos and Deon were unable to observe the satellite as it was too low down for them - a few degrees at Louis Trichardt, and behind buildings for Deon. Cape Town was cloudy.

No further reports were received so now the situation was getting serious – observers did not know where the satellite was, despite being 100%

confident in Deon's observation but needing a second observation to confirm it and thus "tie" down the orbit. More out of curiosity than anything else the author examined the image taken by Hannes and could not match the unidentified star field and flight trajectory of the satellite to the satellite being search for. The flight angle, if heading downwards, was at right angles to that expected and in addition the satellite trail was variable in brightness- contrary to what the satellite should have shown. For fun I submitted it to Astrometry.net for field determination and on receipt of the results realised that this was in the western part of the sky, and not in the eastern sky, where the vast majority of satellites would not have been heading downwards westwards so it had to be moving upwards.

Knowing this it did not take long to decide that this was in fact OTV-4 and he had captured it just as it started to enter the Earth's shadow which explained the variation in brightness. Hannes refers to his photograph as an almost accidental image and a "shot in the dark". Had he been a few seconds later we might still be looking for it! This information and image was passed onto Ted and an orbit derived that fitted the observations made by Deon and Hannes and the realization dawned that the satellite had to be in a lower orbit than ever used before, and explained why the satellite was running such different orbital periods from the search elements based on a higher anticipated orbit.

Ted produced the following orbit which we now felt was pretty close to reality and the author posted predictions for most of the major locations in South Africa on my Facebook page for 27 May, using elements which had the satellite in an orbit ranging from 312 to 325 km, orbital inclination 37.95 degrees and taking 90.84 minutes

to perform one orbit - quite a lot different from the original search elements using an orbital period of 92.30 minutes. As luck would have it the author was able to secure fourteen images through a rather cloudy sky which confirmed that the orbit was now virtually "spot-on". Unfortunately no other observers secured observations but the satellite was now "our captive!" (see image on previous page).

The following was posted by Ted on the SeeSat newsgroup where all serious satellite trackers, lurkers and government spies meet:

From: Ted Molczan via Seesat-l <seesat-l@satobs.org

Date: Thu, 28 May 2015 05:48:26 -0400

The following elements are based on observations by Hannes Pieterse, Deon van Rooyen and Greg Roberts (not repeated here but essentially giving the orbit as 312 by 325 kms at an inclination of 38.02 degrees to the equator and taking 90.85 minutes for one orbit)

Congratulations to Greg and his team on their successful effort to rapidly discover OTV 4 in orbit.

My personal thanks go to Deon and Hannes - and to the other observers who got negative results for one or other reason but tried. This is the first time any of them have done any "serious" satellite observing and maybe the sense of achievement, and the excitement of the chase, might encourage them to do some more! Thanks also to Ted Molzcan and Cees Bassa who put a lot of work into deriving orbits that fitted the data provided. Without their input this work would not be possible.

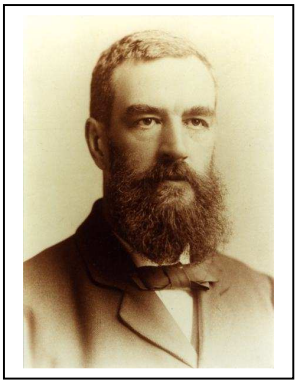
The satellite is now being regularly tracked in the northern hemisphere by other amateur observers and interested parties.

The Franklin-Adams Telescope

I.S. Glass (SAAO)

Introduction

John Franklin-Adams 1843-1912 was one of a small number of extraordinary (and wealthy!) 19th century British amateurs who made important contributions to astronomy, including Nasmyth, De La Rue, Carrington, Roberts and Huggins.



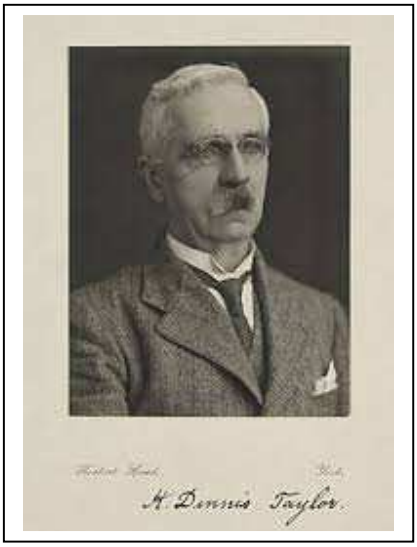
By profession he was a senior figure at Lloyds insurance. He became seriously interested in astronomy quite late in life, around 1890. In 1897 he established his first observatory at his holiday house in Scotland. This was well-equipped, housing a variety of instruments.

Left: John Franklin-Adams (1843-1912)

Following discussions with David Gill and other astronomers, he decided that the most useful contribution he could make to astronomy would be to undertake a photographic survey of the Milky Way. He later expanded the project to cover the whole sky, resulting in the *Franklin-Adams Sky Survey*, published in the end by the Royal Greenwich Observatory in 1914.

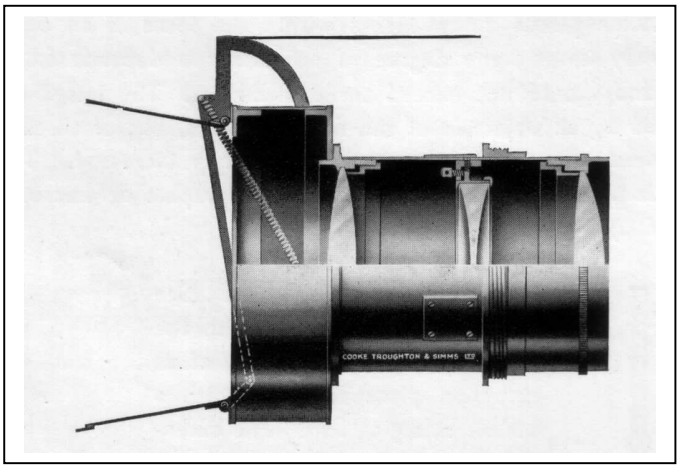
Interaction with H Dennis Taylor

Around 1898 he obtained a 6-inch f/4 wide-angle camera from the Thomas Cook and Sons Company. This was designed by the famous optician H. Dennis Taylor (1862-1943). He was soon, however, dissatisfied and had it reworked to f/4.5 to achieve better performance.



Left: H. Dennis Taylor (1862-1943)

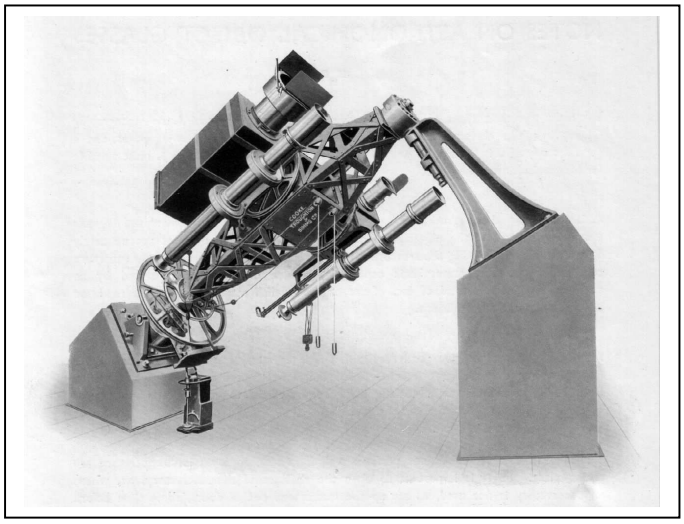
Shortly afterwards he got Taylor to design a 10-inch camera which gave good images over 12 x 12 inches, though capable of covering 18 x 18 inches with "fair" images. Its focal length was 44.2 inches. The design of this lens was described in detail by H.D. Taylor (1904) himself. It was delivered in 1903 and weighed 100 lbs (Franklin-Adams, 1904). Its design was highly innovative. No wide-angle lens of such high performance had been constructed before.



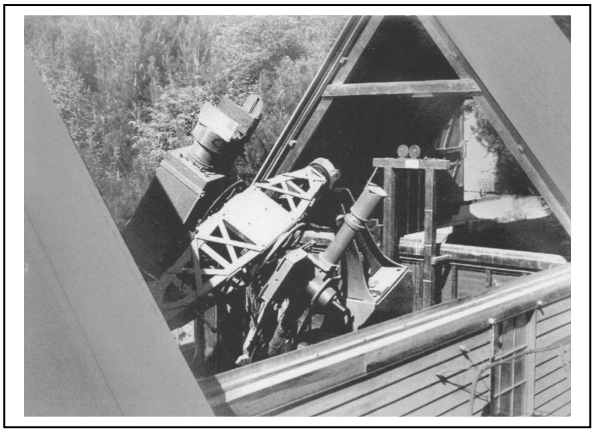
Left: The 10-inch photographic objective. The outer components were of barium silicate crown glass and the inner was a flint glass. (From a Cook, Troughton and Simms Catalogue of about 1930).

He commissioned a rigid English mount from the Thomas Cook company, capable of supporting his 6- and 10-inch lenses and having two 6-inch guide telescopes. It was designed by Alfred Taylor (1904). Unlike most telescopes of the time, this one avoided the use of sectors and had a continuous RA drive worm, 43 inches in diameter with 1080 teeth. The declination axis had a worm wheel 27 inches in diameter, also with 1080 teeth. The RA drive was constructed by Repsold. Another innovation was that ball bearings in swivelling frames were used to hold the RA axis. The mount and lens weighed 2¾ tons.

Right: Engraving of the telescope from a Cook, Troughton and Simms Catalogue of about 1930. This shows both the 10-inch and 6-inch cameras mounted.



A wooden building with internal dimensions 12’ 6” x 20’ 6” was constructed to house the telescope. The walls were erected on a low concrete foundation. A two-piece sliding roof with each piece supported by four rollers ran along rails on top of the walls and extending 10 feet beyond. The roofs could be opened symmetrically or both towards the same side so that all parts of the sky could be observed without hindrance.



Left: The telescope in its original wooden building, location unknown (from Vermeulen, 2006).

The telescope at the Cape

At Sir David Gill’s invitation, he sent the telescope and building to the Royal Observatory, Cape, in 1902. It was mounted in the NW part of the grounds (the location is shown on old maps of the Observatory). His assistant, Mr G. N. Kennedy came out in 1903. During the dark of Moon, they made 2-hr exposures on 12” x 10” and 15” x 15” plates. Franklin-

Adams, who suffered from rheumatic complaints, would spend the bright of Moon at the warm baths in Caledon.

The telescope back in England

In Spring 1904 the telescope and housing were shipped back to England and re-erected at Franklin-Adams's new observatory, called Marvel Hill, in Hambleton. Here the northern part of the sky survey was completed during the next few years. The 6-inch lens was sent to the Royal Greenwich Observatory, where it seems to have remained.

By 1909 Franklin-Adams had become seriously ill. Further, it was found that the Cape photographs had not been up to standard. The telescope as it had then stood was insufficiently stable and lacked proper means for adjusting the lens and plateholder to make it give its best performance. Thus it was decided that the southern plates would have to be repeated.

The telescope in Johannesburg

In 1909 the telescope was sent to the Transvaal Observatory (later known as the Union Observatory and after that as the Republic Observatory) under the care of an assistant, Mr R.J. Mitchell. Its site is indicated on a photograph in Vermeulen (2006, p. 113). However, Mitchell did not stay very long and Mr H.E. Wood of the Transvaal Observatory took over the task under the direction of R.T.A. Innes. This work started in April 1910.

Wood also took 50 fine photographs of Halley's Comet during its 1910 appearance (Hers, 1987).

The Atlas programme was completed successfully in short order.

Franklin-Adams died in 1912 (Gill, 1912). The plates to be used for the Franklin-Adams Sky Atlas were sent to the Royal Greenwich Observatory and a limited edition of the Atlas was issued in 1914. A copy of this exists

at the SAAO in Cape Town. The Atlas comprises 206 photographic prints. The original plates were 15 x 15 inches square on a scale of approximately 20mms per degree. The reproductions were on a "slightly reduced scale", and were 10½ x 10½ inches, covering about 17° x 17°. The scale was about 4 arcmin/mm and the stellar images were several arcsec wide.

Wide-angle astrographic lenses such as this one were rendered obsolete by the cameras invented by Bernhard Schmidt (1879-1935) in 1930. The large post-WWII Schmidt cameras such as that at Palomar had fields of 6° x 6° and plate scales of around 66"/mm.

Innes's discovery of Proxima

The most celebrated result from the Franklin-Adams telescope was the discovery of the nearest star, now called Proxima Centauri, by RTA Innes in 1915 (see Innes, 1915).

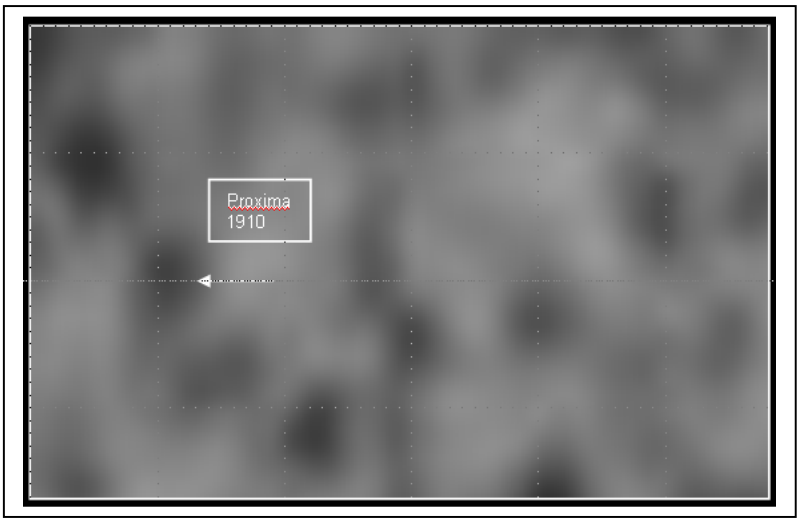
For his first epoch, Innes made use of plate no 20 from the Atlas, taken on 10 April 1910. However, he did not have the original and had to work from a positive print. He remarked that the images of the stars were a bit elongated and swollen, so that that of the star now known as Proxima and another nearby star of similar magnitude all but coalesced.

The second plate of the region was taken on 9 July 1915. By this time, Proxima had moved about 19 seconds of arc. This second plate was blinked against the first one and the change would have been conspicuous. Nevertheless, without the use of the blink technique it is doubtful if he could have found this star. Innes wrote in his paper dated October 5 1915:

"The area swept over was about 60 square degrees and, although the search was not exhaustive, because the character of the images would not justify the investigation of every unusual object, it took about 40 hours. …

The strain on the eye is pretty severe; actually the 40 hours were spread over a fortnight”

Looking at the Atlas image of the Proxima Cen region one cannot help admiring Innes’s patience! Though the telescope has a very large field, the stellar images are quite large compared with those seen in modern sky atlases made with Schmidt telescopes.

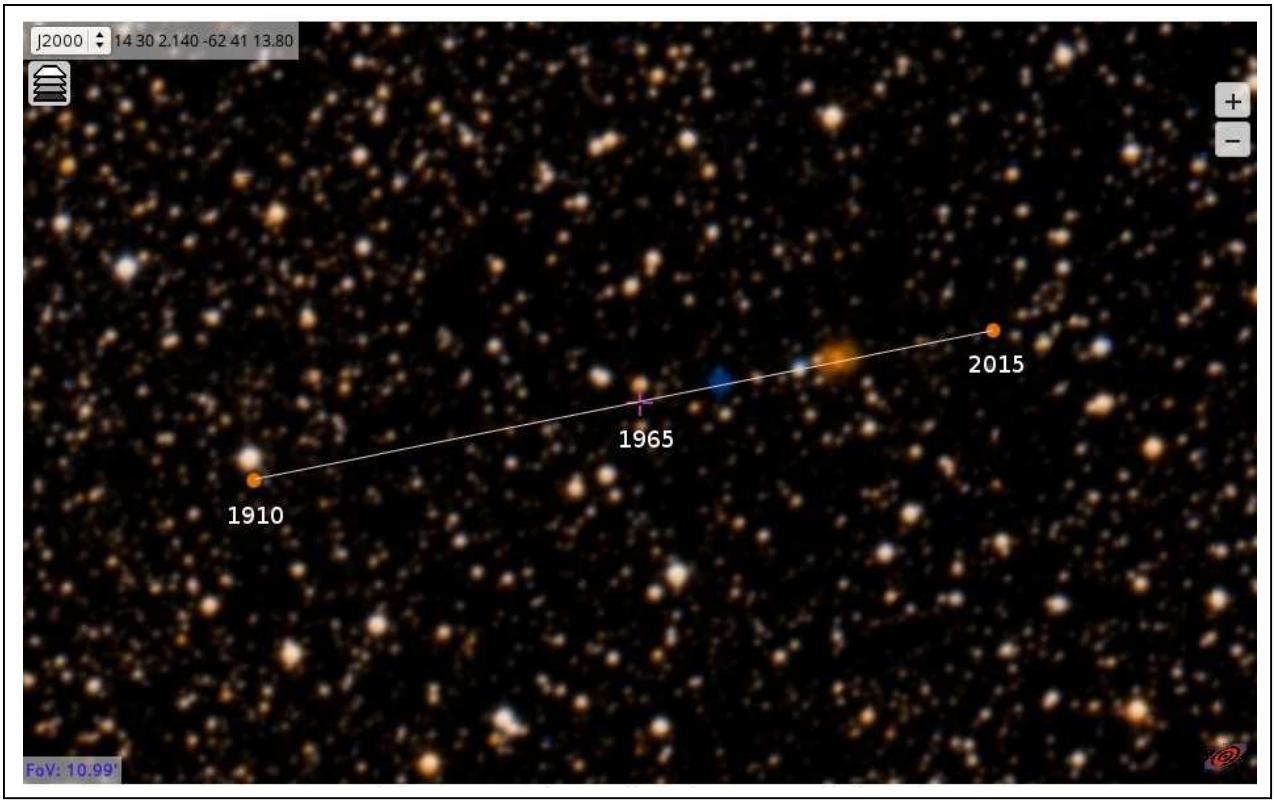


Left: Approx 120x enlargement of the 1910 Franlklin-Adams Atlas image containing Proxima Cen. The area covered is about 10 x 7 arcmin. The size of the stellar image is about 20-30 arcsec across and at this time Proxima was almost on top of another star.

At this time of discovery, Innes referred to the star as “A faint star of large proper motion”. He did not actually name it “Proxima” until 1917 (see Innes, 1917).

Subsequent history of the telescope

From 1919 to 1938 a new series of 559 charts of the sky south of -19° was prepared by Innes and Wood and published as half-tones. These are known as the “Union Observatory Charts” and, together with the Franklin-Adams Atlas, were the main source of finding charts used by southern hemisphere astronomers before the ESO Schmidt charts became available in the 1980s.



Above: A composite Schmidt-based colour image of the region of Proxima, showing how it has moved between April 1910 and January 2015. This image (based on CDS Aladin) covers approximately the same area of sky as the previous one but has much higher resolution. The coloured images of Proxima around 1975-1985 show where it was during the ESO and SRC sky surveys. On account of its low temperature, its blue mag is about 13. It is most conspicuous in the red with R mag about 9.5.

In 1923, Leiden Observatory entered into a cooperative agreement with the Union Observatory. By 1957 they had acquired 12,000 plates with the Franklin-Adams telescope according to van Herk & Kleibrink, (1983).

Vermeulen (2006) mentions that a 10-inch photographic telescope of 92 inches focal length was at one time mounted on the Franklin-Adams mount. This instrument was later in Sutherland, attached to the 30-inch telescope, though little used.

The annual report of the Union Observatory for 1950 (van den Bos, 1950) mentions that the original drive motor was replaced with a synchronous one in 1946.

In August 1954 the Franklin-Adams was moved to its present site in a brick building at Broederstroom, close to the Hartebeespoort Dam. This was an annexe of the Leiden and Union/Republic Observatories. Photographic plateholders were made for 8" x 8" plates (Vermeulen, 2006). A second camera was attached at the time to the mount, with a 3 1/2-inch diameter lens and a focal length of 20 inches. This is no longer on the telescope.

In 1971, the Republic Observatory was merged with SAAO but J.A. Bruwer continued to take plates of minor planets and comets with the Franklin-Adams telescope until he retired about 1978. Subsequently, in 1978, the Broederstroom site was transferred to the Pretoria Technikon, now part of Tshwane University of Technology. It now used for team-building exercises.

David Blane recollects "the last time telescope was used was when a team of us, working with the late Prof. Wargau from UNISA, took a series of plates of SN1987a".

Left: Group visit to the telescope at Toppieshoek on 17 April 2015 (photo: Chris Stewart).

On 17 April 2015 a group of ASSA members – David Blane, Lerika Cross, Chris Stewart and myself, with Hubert Mathebula from SAASTA, visited the Broederstroom site, now called Toppieshoek. We noted that the

Franklin-Adams telescope and the Rockefeller twin 16-inch telescope (formerly owned by Leiden Observatory) appear to be in surprisingly good order in spite of being quasi-abandoned for several decades, thanks to the interest of the Facility Manager, Mr François de Jager.

Note that in 1912, Franklin-Adams also donated a 6/7-inch photovisual telescope to the Union Observatory.

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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: Proxima Centauri – 100 years since its discovery
Speaker: Dr Ian Glass
Date: 7 May
Time 11h00
Venue: SAAO Auditorium

Abstract: Proxima Cen, the current nearest star, was discovered as a high proper motion object 100 years ago by Robert Innes, working from the then Union Observatory in Johannesburg. In 1917 he announced that it is the nearest star and gave it its name. The first star to have its distance measured was the double, Alpha Cen. This was done by Thomas Henderson from the Royal Observatory in Cape Town. My talk will describe the circumstances leading up to the two events and some of the science about these stars, the nearest of their types and thus prime candidates for planet searches and other investigations.

Title: Using Remote Telescopes to Expand Astronomy Access in Universities
Speaker: Ram Venuogopal
Date: 14 May
Time: 11h00
Venue: SAAO Auditorium

Abstract: More than a decade has passed since telescopes were first used over the internet for the purposes of teaching and education. Yet, the concept has never managed to 'break out'. The explosion of robotic and remote telescopes has contributed immensely to research but with not enough examples in education at universities & schools. This talk will share what has been done and how the OAD plans to leverage these telescopes in the field of education.

The OAD is currently hosting the Ultrascope team who have built a 3D printed, open design, robotic telescope. They will be present with their telescope during the talk.

Title: Galaxies at Cosmic Dawn
Speaker: Michele Trenti (University of Melbourne, Australia)
Date: 28 May
Time: 11h00
Venue: 1896 Building

Abstract: In the last five years, Hubble Space Telescope observations taken with the new infrared camera transformed our view of early galaxy formation by building reliable samples of galaxies out to redshift z~8 (~700 Myr after the Big Bang, more than 13 Gyr ago), and by hinting at a dramatic evolution in properties at yet earlier times. I will present our existing data and combine them with spectroscopic follow up observations to discuss the connection between dark-matter halos, assembly of galaxies, and reionization of hydrogen in the intergalactic medium. Finally, I will preview the first observations from a new campaign of Hubble

imaging that I am leading with the goal of finding the most luminous galaxies present 500 Myr after the Big Bang.

Title: Resolving stellar populations with MUSE
Speaker: Tim-Oliver Husser
Date: 11 June
Time: 11h00
Venue: SAAO Auditorium

Abstract: In my talk I will present the first results from a large observing campaign focused on the stellar populations in globular clusters using the recently commissioned integral field spectrograph MUSE. We are going to target about 30 clusters in the Milky Way, of which some have already been observed during commissioning and in GTO time. Using the technique of crowded field spectroscopy that we developed, we can resolve several thousand stellar spectra in a single data cube of the highly crowded cluster centres – as an example, about 90 minutes of observations on NGC 6397 yielded
~24 000 spectra of >12,000 stars, with a large fraction well below the main-sequence turnoff. Dedicated analysis tools allow us to determine radial velocities and stellar parameters for most stars in this sample. This will help us to better understand kinematics in globular clusters as well as their chemical compositions. In addition, multi-epoch observations will provide us for the first time with constraints on the distribution of binary periods inside the clusters.

Astro-Coffee

Title: From data to theory at the cosmic dawn
Speaker: Paul Matthew Sutter (SISSA, INFN-Trieste and OSU CCAPP)
Date: 30 April
Time: 13h00
Venue: SKA office - 2nd Floor Auditorium (CT)

Abstract: Understanding the epoch of reionization is extremely difficult due to significant observational challenges and only a vague theoretical picture of the underlying physical processes. Fortunately, in the past year there have been many developments that address these difficulties. As examples I will discuss HERA, a proposed radio interferometer designed specifically to observe this epoch, and a new semi-blind Bayesian method for foreground removal and signal recovery. Finally, I will present some ideas for extracting physically meaningful quantities from the upcoming measurements.

Title: NGC 1097 with ALMA
Speaker: Dr. Kartik Sheth (Associate Astronomer, NAASC, NRAO, Director Office of Diversity and Inclusion (ODI), NAC/NINE Program Director)
Date: 28 May
Time: 13h00
Venue: SKA office - 2nd Floor Auditorium (CT)

Abstract: I will show the latest results on the molecular gas activity in the barred spiral galaxy NGC 1097 with the ALMA array exploring the star formation activity in the galaxy's bar, nuclear ring and bar ends, and the measurement of the black hole mass in its centre.

UWC

Title: Theoretical challenges in Massive Gravity
Speaker: Dr Lavinia Heisenberg (NORDITA,Stockholm)
Date**:** 13 May
Time**:** 14h00
Venue: Room 1.35, Physics Department

Abstract: There has been a successful non-linear covariant ghost-free generalization of Fierz-Pauli massive gravity, the dRGT theory. I will explore the recent developments within the framework of the dRGT theory. I will quickly discuss the decoupling limit of this theory and its

practicality. I will review the works on the cosmological aspects of this theory. Furthermore, I will address the question whether or not the theory is stable under quantum corrections. The aforementioned theory requires the coexistence of two metrics and therefore it is a natural question of how the matter fields couple to these two metrics. I will present the latest developments in this direction as well

Title: Macro Dark Matter
Speaker: David Jacobs UCT
Date**:** 22 May
Time**:** 14h00
Venue: Room 1.35, Physics Department

Abstract: Dark matter is a vital component of the current best model of our universe, Lambda-CDM. There are leading candidates for what the dark matter could be (e.g. weakly-interacting massive particles, or axions), but no compelling observational or experimental evidence exists to support these particular candidates, nor any beyond-the-Standard-Model physics that might produce such candidates. This suggests that other dark matter candidates, including ones that might arise in the Standard Model, should receive increased attention. I will discuss the general class of dark matter candidates with characteristic masses and interaction cross-sections characterized in units of grams and square centimeters, respectively -- we refer to these macroscopic candidates as Macros. Such dark matter objects could potentially be assembled out of Standard Model particles (quarks and leptons) in the early universe. I will discuss the earth-based, astrophysical, and cosmological observations used to constrain part of the Macro parameter space. Large regions remain unconstrained, however, most notably for nuclear-dense objects with masses in the range between about 50 - 10^17 and 10^20 - 10^24 grams

Title: Galaxy Evolution over Cosmic Time
Speakers: Kartik Sheth (NRAO) and Sabrina Stierwalt (University of Virginia)
Date**:** 27 May
Time**:** 14h00
Venue: Room 1.35, Physics Department

Abstract: We will present some highlights from our latest results from ALMA, HST and Spitzer exploring the evolution and assembly of galaxies at low and high redshift. K. Sheth will discuss new results from ALMA shedding light on the evolution of the cosmic star formation and AGN activity to z~2. S. Stierwalt will discuss the role played by galaxy mergers in the assembly history of galaxies and the overall production of stars in the universe. They will also discuss the NRAO International Exchange Program (NINE) and its growing partnership with South Africa / Africa and hope to discuss how we can increase our collaborations with the UWC group.

Title: The search for extragalactic black hole binaries in globular clusters
Speaker: Tana Joseph (UCT)
Date: 29 May
Time: 14h00
Venue: Room 1.35, Physics Department

Abstract: Until quite recently it was thought that black holes formed in globular clusters would very quickly be ejected or would cause the cluster to evaporate. In 2002 it was then put forward that globular clusters might host intermediate mass black holes and the search for black holes in globular clusters began. The first (stellar mass) black hole binary in a globular cluster was found serendipitously in 2007. Since then, four more serendipitous discoveries of such sources have been made. These sources are of interest because they black holes in dense stellar environments are thought to sources of detectable gravitational waves. My research is focused on a dedicated search for

extragalactic black hole binaries in globular clusters using X-ray and optical data. I have identified a list of 12 candidate sources in the Virgo Cluster. I will present the results of the timing and spectral analysis of these sources. I will also discuss future work, including carrying out a similar search in the Fornax Cluster as well as possible radio follow up of the candidate black hole sources with VLBI networks, such as the African VLBI Network**.**

Title: Redshifted 21-cm signal from the epoch of reionization: What is so special about its line of sight anisotropies?
Speaker: Suman Majumdar (SU)
Date: 8 June
Time: 14h00
Venue: Room 1.35, Physics Department

Abstract: Observations of the redshifted 21-cm signal from neutral hydrogen are a very promising probe of the Epoch of Reionization (EoR), and there is a considerable observational effort underway to detect the this signal using the present (GMRT, LOFAR, PAPER, MWA) and the upcoming (HERA and SKA) radio interferometric arrays. It is currently expected that the probable first detection of this signal would be via the variance or the power spectrum statistic. The two main line of sight anisotropies (namely the finite light travel time effect and the effect of redshift space distortions) of this signal presents some unique possibilities to answer many long standing puzzles about the reionization epoch.

My past and present research effort is mostly concentrated towards the understanding of the effect of these anisotropies in the global statistical signal of EoR as well as the local signature of EoR around strong individual sources (e.g. quasars). In this talk I will briefly describe the different ways by which we can use these anisotropies to constrain global parameters of EoR.

NASSP

Title: Sprites - Gas discharges into Space
Speaker: Prof. Mike Kosch, SANSA.
Date**:** 22 April
Time**:** 16h00
Venue**:** RW James, Lecture theatre D (James D)

Abstract: Sprites are optical gas discharges from the top of convective thunderstorm clouds into space within the mesosphere (~50-90 km altitude). This mysterious yet common phenomenon, first observed by airline pilots, remains poorly understood. However, it is clear that sprites form part of the global electric circuit and that they involve accelerating electrons to relativistic velocities. Despite the fact that they are easily visible, nobody has ever reported seeing one over South Africa, something that will hopefully change soon

Title: The 21cm line as a probe of the early Universe
Speaker: Dr Gianni Bernardi SKA
Date**:** 28 April
Time**:** 16h00
Venue**:** RW James, Lecture theatre D (James D)

Abstract: I will review the physics of the 21cm emission from neutral Hydrogen at high redshift, describing what we expect to learn from its observations. I will conclude presenting the current observational state of the art as well the upcoming HERA and SKA instruments.

Title: Keep Calm and Find a Mentor
Speaker: Dr Michelle Cluver UWC
Date**:** 6 May
Time**:** 16h00
Venue**:** RW James, Lecture theatre D (James D)

Abstract: From growing positive networks to navigating collaborations, the aim of this talk is to provide tips and strategies for dealing with the challenges of becoming a researcher. Are you mindful of professionalism and cognisant of your online digital tattoo? To illustrate some of these principles, I'll highlight some science results from collaborations I'm involved with.

Title: Keep Calm and Find a Mentor
Speaker: Prof. Pieter Meintjes, University of Free State
Date: 13 May
Time: 16h00
Venue: RW James, Lecture theatre D (James D)

Abstract: A non-technical presentation to introduce students to Very High Energy (VHE) gamma-ray astronomy in general, as well as the state of the art facilities in Southern Africa like the Stereoscopic Air Cerenkov Telescope Array HESS in Namibia, as well as the Cerenkov Telescope Array (CTA) that could possibly be established in the Southern parts of Namibia in 2016.

ACGC

Title: Born-Infeld inspired extensions of gravity and dust inflation
Speaker: Jose Beltrán Jiménez (Université d'Aix-Marseille)
Date**:** 21 April
Time**:** 13h00
Venue**:** M111 Maths Building, UCT

Abstract: In order to regularize the energy of point-like charged particles, Born and Infeld introduced a modification of the Maxwell Lagrangian that naturally imposes an upper bound on electromagnetic fields. This approach was later taken by Deser and Gibbons to propose an analogous modification for gravity. I will review some of these ideas as well as some extensions for the gravitational sector. Finally, a scenario where inflation

could be supported by a set of massive particles within the context of these theories will be discussed.

Title: Graviton non-masslessness
Speaker: Lavinia Heisenberg (Nordita, KTH Royal Institute of Technology and Stockholm University)
Date**:** 24 April
Time**:** 13h00
Venue**:** M111 Maths Building, UCT

Abstract: If the particle carrier of the gravitational force had a mass, gravity could behave differently from GR on cosmological scales thereby potentially tackling the dark energy and cosmological constant problems. In this context the dRGT theory will be introduced. After discussing the cosmological consequences, I will concentrate on the radiative corrections to the potential interactions. This will play an important role for the naturalness of the theory. Furthermore, I will address the question of how the matter fields can be consistently coupled in massive (bi-)gravity.

Title: All-sky galaxy surveys: recent results and future prospects
Speaker: Maciej Bilicki (UCT)
Date**: 2**8 April
Time**:** 13h00
Venue**:** Seminar Room, Astronomy Dept. UCT

Abstract: Wide-angle galaxy redshift surveys such as the Sloan Digital Sky Survey have revolutionized our knowledge of the Universe. A trade-off between depth and sky coverage of such spectroscopic surveys limits however a systematic three-dimensional account of the entire sky beyond the Local Volume, while various aspects of cosmology require comprehensive mapping of the cosmic web to considerable depths. In order to probe the whole extragalactic sky beyond 100 megaparsecs, one must draw on multiwavelength datasets and state-of-the-art photometric redshift techniques. I will summarise the current status of our dedicated

programme to employ the largest photometric all-sky surveys – 2MASS, WISE and SuperCOSMOS – to obtain accurate redshift estimates of millions of galaxies. The first outcome of these efforts – the 2MASS Photometric Redshift catalogue (2MPZ) – was publicly released in 2013 and includes almost 1 million galaxies with a median depth over 300 Mpc. I will detail how this catalogue was constructed and how it is being used for various cosmological tests. I will also present how combining the WISE mid-infrared survey with SuperCOSMOS optical data allows us to push to depths over 1 gigaparsec on unprecedented angular scales. These photometric redshift samples, with about 20 million sources in total, provide access to volumes large enough to study observationally the Copernican Principle of universal homogeneity and isotropy, as well as to probe various aspects of dark energy and dark matter through cross-correlations with other data such as the cosmic microwave or gamma-ray background. Last but not least, they constitute a test-bed for forthcoming wide-angle multi-million galaxy samples expected from such instruments as SKA, Euclid or LSST.

AIMS

Title: Can the graviton be massive?
Speaker: Dr Lavinia Heisenberg (Nordita, Stockholm)
Venue: AIMS research centre
Date: 11 May
Time: 12h00.
Venue: AIMS upstairs Hall

Abstract: If the particle carrier of the gravitational force had a mass, gravity could behave differently as GR on cosmological scales thereby potentially tackling the dark energy and cosmological constant problems. In this context the dRGT theory will be introduced. After discussing the cosmological consequences, I will concentrate on the radiative corrections to the potential interactions. This will play an important role for the

naturalness of the theory. Furthermore, I will address the question of how the matter fields can be consistently coupled in massive (bi-)gravity.

Title: Numerically reconstructing the "Lambda" LTB metric from observations

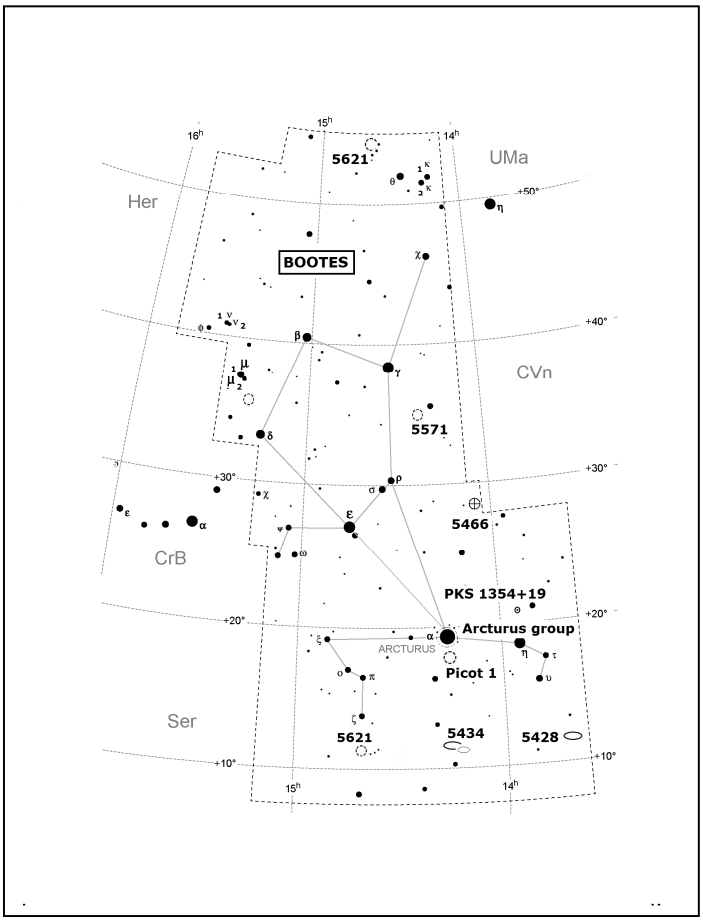
Speaker: Landman Bester (Rhodes)
Venue: AIMS research centre
Date: 8 June
Time: 12h00.
Venue: AIMS upstairs Hall

Abstract: The problem of reconstructing the background cosmological metric directly from observations is known as the inverse problem in cosmology. This talk will be on the inverse problem in spherically symmetric dust universes that may include a cosmological constant. Such models of the universe, otherwise known as "Lambda" LTB models, can be used to test the validity of the Copernican principle. I will begin by introducing the Lambda LTB model in observational coordinates and specify the data required to find its general relativistic solution. The focus of the talk will then shift to how Gaussian process priors can be used to smooth the data in a way that doesn't violate any physical constraints. These smoothed functions can then be used to set the initial conditions of a numerical integration scheme that solves the Einstein field equations in observational coordinates. To finish I present an algorithm that utilises a Monte-Carlo experiment to find the full distributions of metric components inside the past lightcone.

Sky delights: The Slave Driver

Magda Streicher

Various amateurs have referred to Boötes as the constellation that does not in any way reflect its name. The constellation is supposed to represent a herdsman (a worker) who is pushing the Great Bear (Ursa Major) through the heaven lies by the tail, or chasing it with his hunting dogs Canis Venatici. He was also seen as the son of Jupiter and Callisto.



Homer and Hesiod mentioned the starry figures because this is one of those constellations that they simply do not have another name or explanation for. The constellation stretches from Draco to Virgo.

(Left) The constellation Boötes

Well, what is so special about the constellation? you may ask.

Its brightest star, magnitude 0.1 is none other than Arcturus or alpha Boötis and one of the first stars to be named. In ancient times the star was most probably the first indication that there might be a pole in question. The Chinese called Arcturus “Ta Kio”, or more to the point, the star is the emperor’s palace with the group of three fainter stars on its western side, magnitude 2.6 eta, 4.4 tau and 4 upsilon, the leaders. The herdsman has his feet (stars) pressing firmly against the northern skies

with eta Boötesis to be seen in the tail end of the Boötes kite-shape, so to speak.

Early drawings show Arcturus as the sword or dagger simply because it is so prominent. The star was probably the first star to be seen in daytime through a telescope. It is particularly special to the author is that it is surely one of the most exceptional stars. What makes it special is that Arcturus can show off various colours – when it glitters against the northern horizon in a display of soft, rosy to metallic blue colours. In her view this is the loveliest star to grace the starry skies by far.

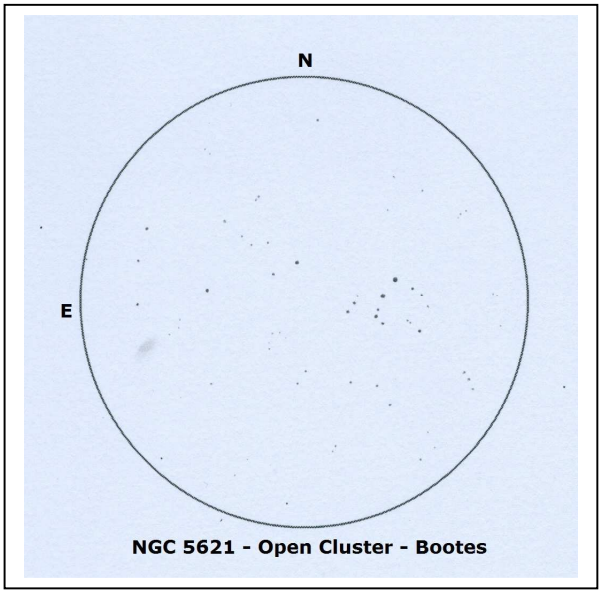
The constellation is home to a number of galaxies as well as galaxy clusters. It is not easy to observe these galaxy clusters, but with a little effort and transparent dark skies it is possible. One of the more accessible to search out is the galaxy cluster **NGC 5434** (not that it is easy). This group consists of 10 galaxies in a mere 40' field of view 2 degrees north of the border with Virgo. Most of them are in the range of magnitude 13 plus, with the largest galaxy, NGC 5434, interacting with NGC 5434B on its north-eastern edge. The group's members are NGC 5423, 5434B, 5424, 5431, 5423, 5416, 5409, 5437, 5436, 5438. Towards the north of the group a yellow-coloured magnitude 6.2 star shows the way.

To search out this group it is essential to have a good star map, and then a good dash of guesswork as the author has proved on an excellent night of observating conditions. At most only one or two of the members can be glimpsed.

But one should never give up hope – on the western edge of the constellation Boötis is another galaxy which might be an easier task to observe. **NGC 5248** comes to light as a soft oval in a north-western to south-eastern direction. The edge of this galaxy seems to be very hazy. However, it has a pretty bright nucleus and with higher power a few darker spots can be glimpsed on its surface, the most prominent of which is perhaps towards the brighter southern part, which could indicate spiral

structure. “Lord Ross notes a large pretty bright, maybe lower, branch joins the nucleus or continuation of the upper curve.”

The indicated number **NGC 5621** is somewhat of a mystery. It is situated towards the southern edge of the constellation, and the catalogue *Star Clusters* (Brent A. Archinal and Steve J. Hynes) indicates a string of three faint stars. However, several strings of three close stars can be seen in the surroundings, of which the brightest is a magnitude 5 star, followed by 5.9 and 6 towards the west of the indicated position. Another string of three stars with magnitudes 8.3, 9.8 and 9.9 is situated east of the indicated position. The galaxies NGC 5665 and 5665A are just 10’ towards south of the fainter string, but it is most probably the brighter outstanding three stars prominent that is in play here.



(Left) The Open Cluster NGC5621.

Getting back to the bright shiny star Arcturus: Julio F. Navarro of the University of Victoria in Canada believes that Arcturus seems to have come from another galaxy born 5–8 billion years ago, speeding through our stellar neighbourhood at 120 km per second. Because of the high speed it is also estimated to be the flattest star and therefore perhaps distorted. The star indicates the knee of this strange man carved out of stars.

However, the star field around Arcturus is sprinkled with both faint and brighter stars. The stars accompanying this famous star are now known as the **Arcturus group** with around 9 stars of magnitude 7. **Picot 1,** a nice little asterism 35’ towards the south, can be seen in an east-west direction. Seven stars ranging from magnitude 9 to 10.5 are nicely spaced and can also be seen as a question mark shape. Fulbert Picot, the French

astronomer, called it Napoleon's Hat, while Ken Hewitt-White sees the 7 stars as a cosmic caterpillar humped up in mid-crawl – I agree with him on this one.

Boötis lacks known open clusters and nebulae, but does not disappoint us, with a quasar, **PKS 1354+19**, situated about a degree north-west of eta Boötis. This quasar, nearly 10 billion light years away harbours a monstrous black hole in its centre. It is believed to be one of the most massive, distant galaxies with an enormous output of energy.

Nearly hanging on to the constellation Canis Venatici border is a lone globular cluster, **NGC 5466**, at first seen as a soft glow. Faint star points come to light during my observation through a medium-sized telescope, but the core seems to be an unresolved haze. The shape is somewhat uneven, not quite round, with a short string of very faint stars curling its way out towards the west on the south-eastern side. The south-western side of the globular seems denser. Here and there the edge seems slightly rough, which indicates faint stars.

Halfway between magnitude 3.5 rho and magnitude 3 gamma Boötis is another proclaimed asterism, but this one has a name, **NGC 5571**. This asterism is close to the galaxy NGC 5579, which is only a faint roundish haze. Among galaxies a few double stars stand out; so, not quite sure about what to look for, the author spotted a rather lovely east-west "Y" shape of six stars of more or less magnitude 9, a degree further north at position 14h22m.8 and +36o16'.

The star Nekkar, perhaps better known as beta Boötis, could be hidden from us being situated too far north for some of us down south. However, this star marks the head of this figure with magnitude 3 gamma the left shoulder and delta the right. Together the stars truly do have the shape of a kite, flying off to many more galaxies in the area.

Although it is a northern constellation, its shape is outstanding, so take the Herdsman by its arm and search out the soft cotton balls in the area close to the most beautiful star, Arcturus.

Object	**Type**	**RA**	**DEC**	**MAG**	**SIZE**
NGC 5248	Galaxy	13h37m.5	+08°53’	10.3	6.2’x4.6’
PKS1354+19	Quasar	13h54.0	+19°44’	16	10”
NGC 5434	Galaxy group	14h04m.4	+09°27’	13	1.6’x1.6’
NGC 5466	Globular Cluster	14h05’.5	+28°32’	9	11’
Picot 1	Asterism	14h15’	+18°35’	9.8	20’
Arcturus Group	Asterism	14h19’.5	+19°04’	5	2-3deg
NGC 5571	Asterism	14h19’.6	+35°09’.4	9	26’
NGC 5621	Open Cluster	14.27’	+o8°15’	7	8’

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