SOUTHERN AFRICAN
LARGE TELESCOPE

ANNUAL REPORT 2014

SOUTHERN AFRICAN LARGE TELESCOPE

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ABOUT SALT

The Board of the Southern African Large Telescope (SALT) is proud to present its Annual Performance Report for the period 1st January 2014 to 31st December 2014. This report offers an overview of the activities and performance of SALT, and highlights the impact of a selection of SALT research projects.

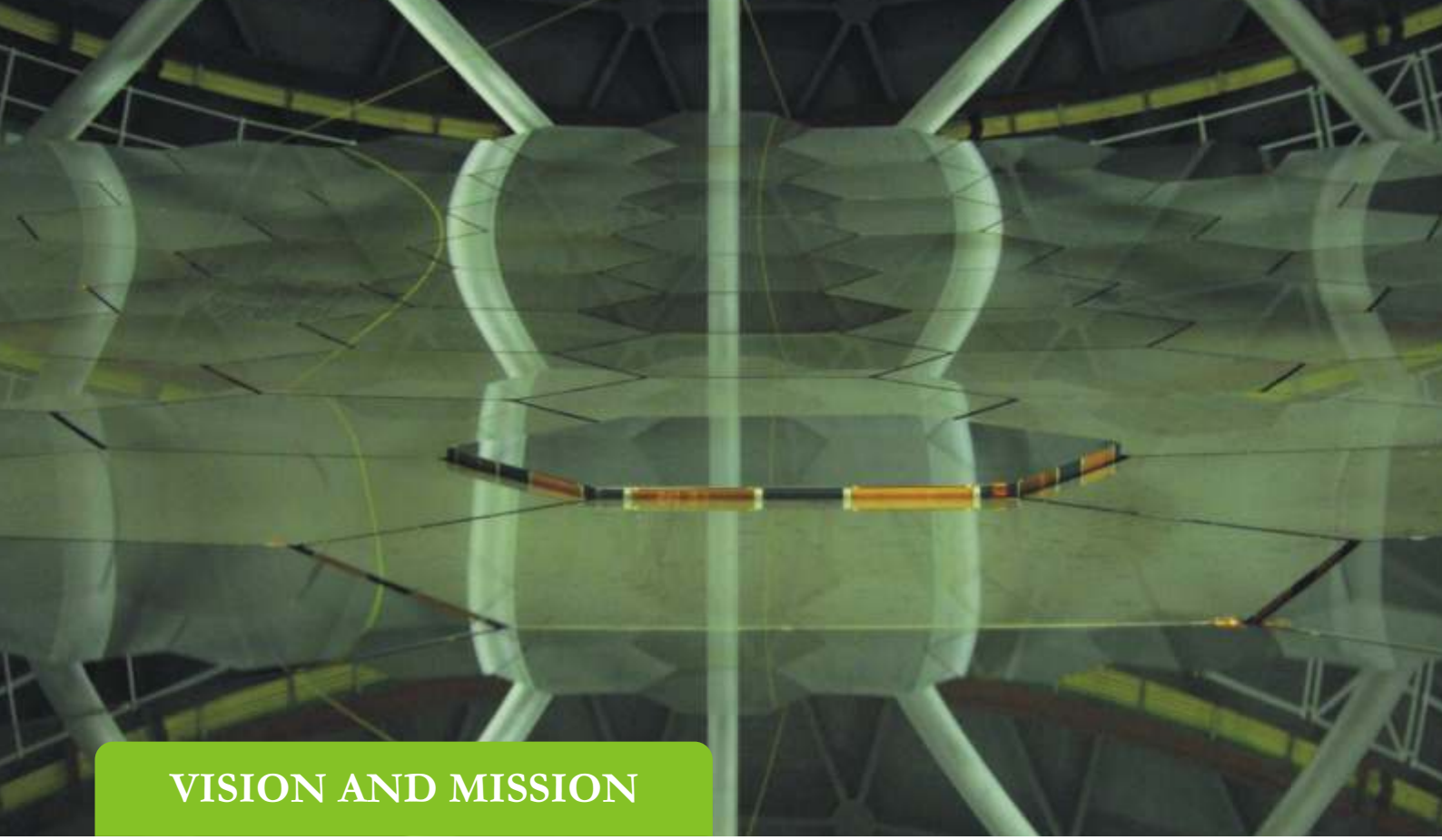
The Southern African Large Telescope (SALT) is the largest single optical telescope in the southern hemisphere and amongst the largest in the world. It has a hexagonal primary mirror array 11 meters across, comprising 91 individual 1m hexagonal mirrors. It is the non-identical twin of the Hobby-Eberly Telescope (HET) located at McDonald Observatory, Texas, USA. HET and SALT representa completely new paradigm in the design of optical telescopes. The light gathered by its huge mirror is fed into a suite of instruments (an imager and two spectrographs) from which astronomers infer the properties of planets, stars and galaxies, as well as the structure of the Universe itself.

SALT is owned by the SALT Foundation, a private company registered in South Africa. The shareholders of this company include universities, institutions and science funding agencies from Africa, India, Europe, New Zealand and North America. The South African National Research Foundation is the major shareholder with a ~1/3 stake. Other large shareholders are Dartmouth College, the University of Wisconsin-Madison, Nicolaus Copernicus Astronomical Centre of the Polish Academy of Sciences and Rutgers University. Smaller shareholders include the American Museum of Natural History, the Indian Inter-University Centre for Astronomy and Astrophysics in India, the University of Canterbury (New Zealand), the University of North Carolina,

Gottingen University and the UK SALT Consortium, the latter representing the Universities of Central Lancashire, Keele, Nottingham and Southampton, the Open University and the Armagh Observatory. The size of the shareholding of each partner determines the access to the telescope which they enjoy. The HET Consortium, although not a shareholder, received ten percent of the telescope time for the first10 years of operation, in return for providing all the designs and plans of the HET as well as assistance during the construction of SALT.

SALT is located at the observing site of the South African Astronomical Observatory, near the small town of Sutherland, about 380 km north-east of Cape Town in the Karoo. This site has been host to a number of other smaller telescopes since the early 1970s, and benefits from location in a semi-desert region with clear, dark skies. The quality of this site for optical astronomy is preserved by South African legislation.

CONTENT



VISION AND MISSION

VISION

Africa's Giant Eye on the Sky: Inspiring society by exploring the Universe.

MISSION

Provide a world-class large telescope research facility cost-effectively to astronomers in an international community.

Lead the advancement and development of optical astronomy on the African continent and inspire and educate new generations of scientists and engineers worldwide.

STRATEGIC OBJECTIVES OF SALT

Enable world leading astrophysical research: To provide high quality data that result in highly cited published papers in front rank journals;

Optimize science operations: To maximize science efficiency and productivity while minimizing technical downtime;

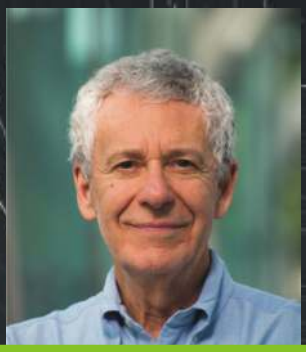
Continuous improvement: To find and focus on science and operational areas of best performance; to enable and strengthen a creative staff; to secure financial support for operations and new developments;

Instrumentation development: To develop the skills and capacity needed for designing and building instrumentation and telescope functionality to keep SALT competitive in the future;

Human Capital Development: To use SALT for graduate student training, outreach to undergraduates, schools and the general public; to have a special focus on developing professional astronomy on the African continent;

To promote SALT as global flagship optical telescope;

To increase SALT visibility and positive image in the international community and national and international media.



CHAIRPERSON'S OVERVIEW

SALT and its partners' scientific productivity rose significantly in 2014, with 32 peer-reviewed papers published, in comparison with 16 in 2013. The annual operating costs of running SALT are less than 30% of those of other 8-10 meter class telescopes. Rapid and impressive improvements to SALT and its instrumentation also took place throughout 2014. The Robert Stobie Spectrograph (RSS) was removed from the telescope in September-October for its first-ever cleaning and servicing. This was highly successful, with subsequent tests showing significant improvement in optical throughput and mechanical reliability. RSS was returned to SALT and recommissioned during November-December.

The High Resolution Spectrograph was delivered by Durham University. An intensive commissioning phase has identified and corrected some initial problems, and determined that most of the instrument's specifications are being met or exceeded.

The National Research Foundation established a new Astronomy sub-agency, appointing Professor Nithaya Chetty as Deputy CEO: Astronomy. The SALT Board is delighted to be able to continue to work closely with Professor Chetty.

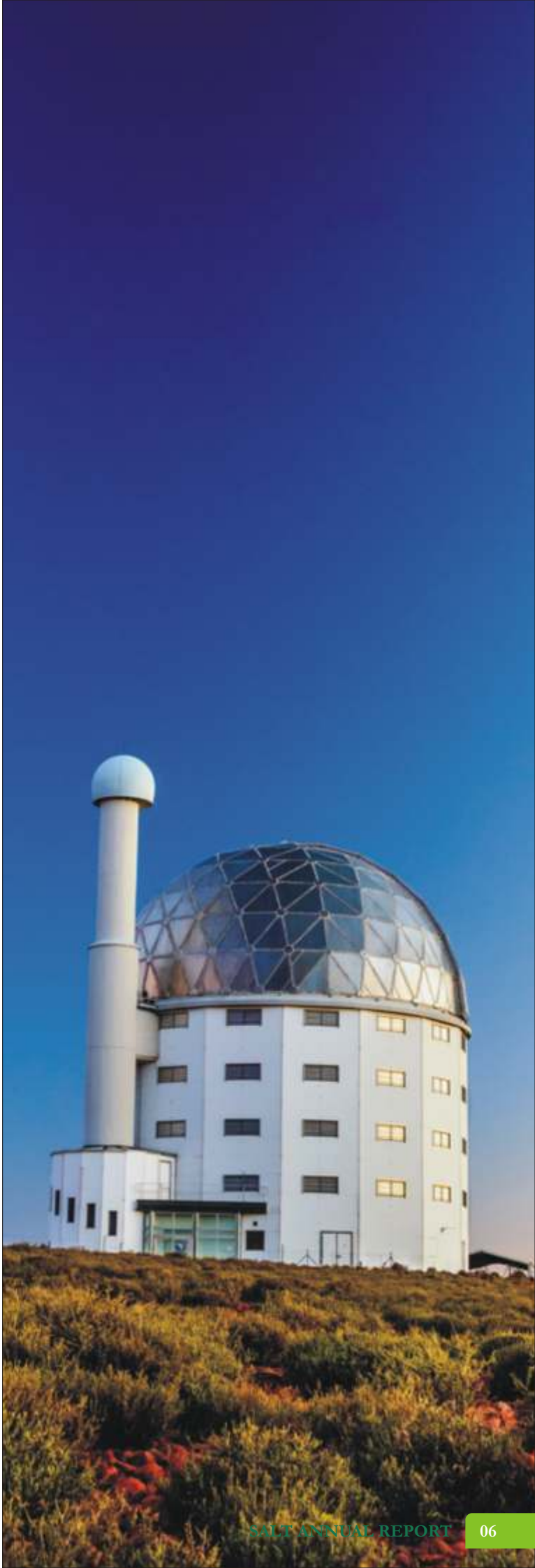
A new SAAO-SALT operations contract was successfully negotiated for the 10-year period 2015-2025. Important provisions in this contract allow for easier and more equitable sharing of manpower and resources between SAAO and SALT.

The technical operation and astronomy operations divisions were merged into a single SALT Operations Division under the leadership of Chris Coetzee at the end of 2014. Chris Coetzee also took the lead of the SAMS edge-sensors project as it moved into its technical implementation phase. Petri Vaisanen became head of astronomy operations, assisting Chris on the scientific side of telescope operations.

Two new SALT Astronomers, Brent Miszalski and Éric Depagne were appointed. Both are actively continuing research in addition to their other SALT duties.

This year scheduling opportunities prompted both semi-annual Board meetings to be held outside South Africa, at the University of North Carolina (in May) and at IUCAA in India in November. The Board expresses deep thanks to both institutions for their gracious support in hosting these meetings.

Prof. Michael Shara
Chairperson, SALT board



SALT OPERATIONS

One of the highlights of the year was a joint Astro Ops/Tech Ops meeting held in Sutherland over 22-23 May. The gathering brought most of the SALT team together, which led to extensive discussions and the development of a list of issues to be tackled in order to improve the performance of the telescope.

A joint-operations meeting was held in Sutherland, providing an opportunity for presentations and discussions about the various on-going SALT projects and their relative priorities.

TECHNICAL OPERATIONS

The Technical Operations team was characteristically busy throughout the year, tackling a number of projects/tasks (see below), in addition to seeing to the daily operations and maintenance of the telescope and instruments.

Power supply:

The SALT primary mirror array fogged over during a prolonged Eskom power outage that prevented active conditioning of the dome - fortunately no damage was done to the mirror.

Tracker:

The tracker lower X and right hand Y-rails and linear bearings were successfully replaced.

CCAS Instrument:

The software for the Centre of Curvature Alignment System Instrument has been updated and is operating reliably.

Testing before hand-over:

Tech Ops now work through a standardized test procedure before handing over the telescope in the afternoons. This has had a positive effect on night operations, particularly during the start up phase when technical issues related to daytime work would typically surface.

The Failure Mode Effect and Criticality Analysis (FMECA):

There are currently 17 red items on the FMECA, 4 of which cannot be mitigated further by Tech Ops. The remaining 13 will all be mitigated in time.

Maintenance:

Maintenance planning is getting priority attention. In order to lay a solid foundation for this work, the SALT Systems Engineer has made significant progress by documenting all of the planned maintenance requirements from the supplier documents. Such maintenance falls into four categories: 'Inspect before every use', 'Predictive Maintenance', 'Preventative Maintenance' and 'Corrective Maintenance'. The maintenance frequencies are also recorded. The aim is to input the planning into a maintenance software program that will issue Maintenance Tickets to the appropriate people at the respective dates or times.

Fraction of Time Lost Due to Technical Issues:

The average for this metric during the reporting period has been 10%, compared to the 3% specification, but this is steadily decreasing. The relatively high figure was mainly due to the many changes and additions done to complex telescope sub-systems and instrumentation during the year.

Health and Safety:

No safety incidents occurred during this year. All required certifications (such as First Aid, fire fighting, working at heights etc) for staff have been renewed.

ASTRONOMY OPERATIONS

Two SALT observing semesters were completed during the 2014 calendar year, the periods 2013-2(1 Nov 2013 - 30 April 2014) and 2014-1 (1 May 2014 - 31 October 2014). Altogether, these two science semesters saw approximately 200 accepted observing programs in the queue, including HRS science programs for the first time.

The final fraction of night-time used for science was lower than usual (37%), however, due to the continued HRS commissioning and the scheduled and crucial RSS optical service during the year. Overall, 1450 accepted individual observations ("blocks") were completed over the semesters. As far as science observations go, the 2013-2 period was the more efficient of the two, and in particular, saw a healthy 72% of all high priority P0 and P1 time completed. The good news is that the highest priority (P0 + P1) programs had higher relative completion rates during 2014, with a 95% block completion success rate based on the available science time, which was only 32% compared to an expected 55% due mostly to poorer than expected weather conditions.

SALT science output during 2014 reached a record level, as the number of refereed publications based on SALT data doubled from 2013, hitting 32 in 2014. As described in the Crawford et al. (2014) SPIE publication, it is noteworthy that when counted from the beginning of science operations in late 2011, the rate per telescope is at the same level as for other major international 8-10m class observatories. Since the papers published during a given year are typically based on data taken 1-2 years earlier, the trend of slowly but steadily increasing data-gathering efficiency bodes well for publications rates over the coming years.

Night time SALT operations are well established with 3 SALT Operators (SO) and 6 SALT Astronomers (SA) running a variety of software packages written in-house to control the telescope and instruments, and using continually developing scheduling and planning software. Together with 3 more people on the management, software and data handling side, the Astronomy Operations team, in addition to being the Observations team as well as the Software Development group, also constitutes what could be called a User Support Division in other larger observatory organizations.

During 2014, two new SAs joined the ranks, Éric Depagne from AIP, Potsdam and Brent Miszalski who already was at SALT as a post-doctoral fellow. While being an observer short during the year, the team also received much appreciated help from SAAO staff Lisa Crause and Hannah Worters, and Luke Tyas, the HRS post-doc working on the commissioning of the instrument.

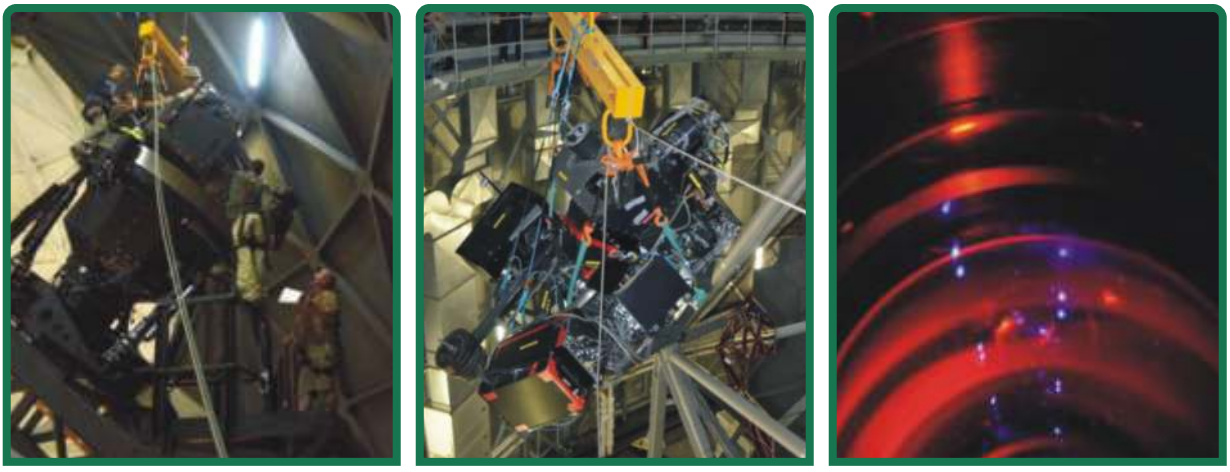
INSTRUMENTATION NEWS

Optical Serving of the Robert Stobie Spectrograph

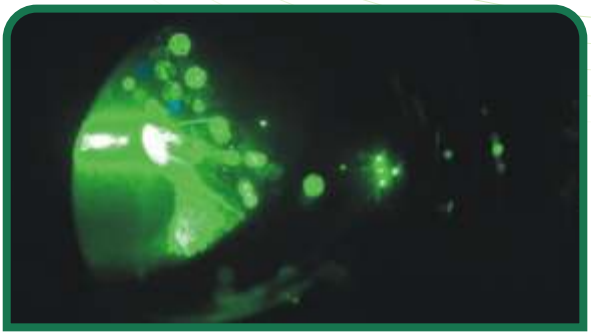
The RSS was removed from the telescope on 9 September to undergo a comprehensive service. The primary goal was to characterize and improve the throughput of the instrument, by cleaning the collimator optics and also replacing the lens fluid within the three collimator multiplets. Furthermore, reflectance tests were carried out to check the condition of the anti-reflection coatings on the outer surfaces of these lens-groups.

Having the RSS on the ground also provided the SALT Tech Ops team with the opportunity to attend to a variety of long-standing mechanical and electrical issues, without the usual restrictions associated with working up on the tracker. The slitmask mechanism, etalon mounts, wave-plates and grating holder all received attention, and the entire instrument was meticulously baffled to eliminate light-leaks that produce stray light on the detector and thus degrade the data quality. Having easy access to the various mechanisms also allowed draughtsmen to generate as-built detailed CAD drawings that were not available previously. These interventions have significantly increased the reliability, performance and maintainability of this major SALT instrument.

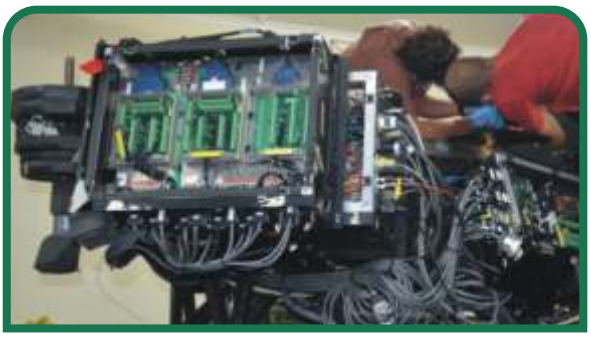
The largest overall gains with RSS servicing came from the cleaning of the optics, while the replacement of the lens fluid contributed more dramatically to improving the throughput in the blue. In summary, the optical servicing work doubled the effective throughput at the bluest wavelengths (shortward of 400nm) and yielded a ~40% increase over the rest of the wavelength range. This is a truly impressive result that greatly enhanced the performance of SALT's workhorse instrument! The spectrograph when re-installed on the telescope on 13 November.

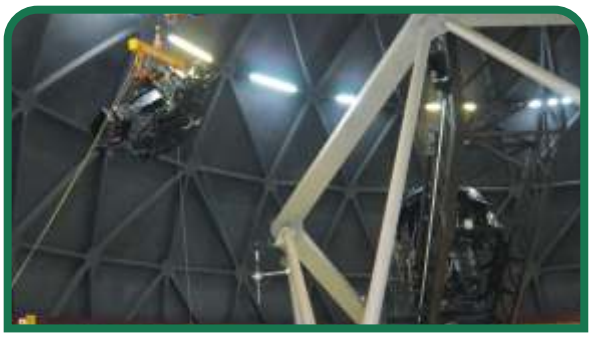


RSS being removed from the tracker (left), and lowered to the ground with the dome crane (centre). Red light illuminating the collimator lenses while a blue laser was set up to measure the throughput of the optics (right).

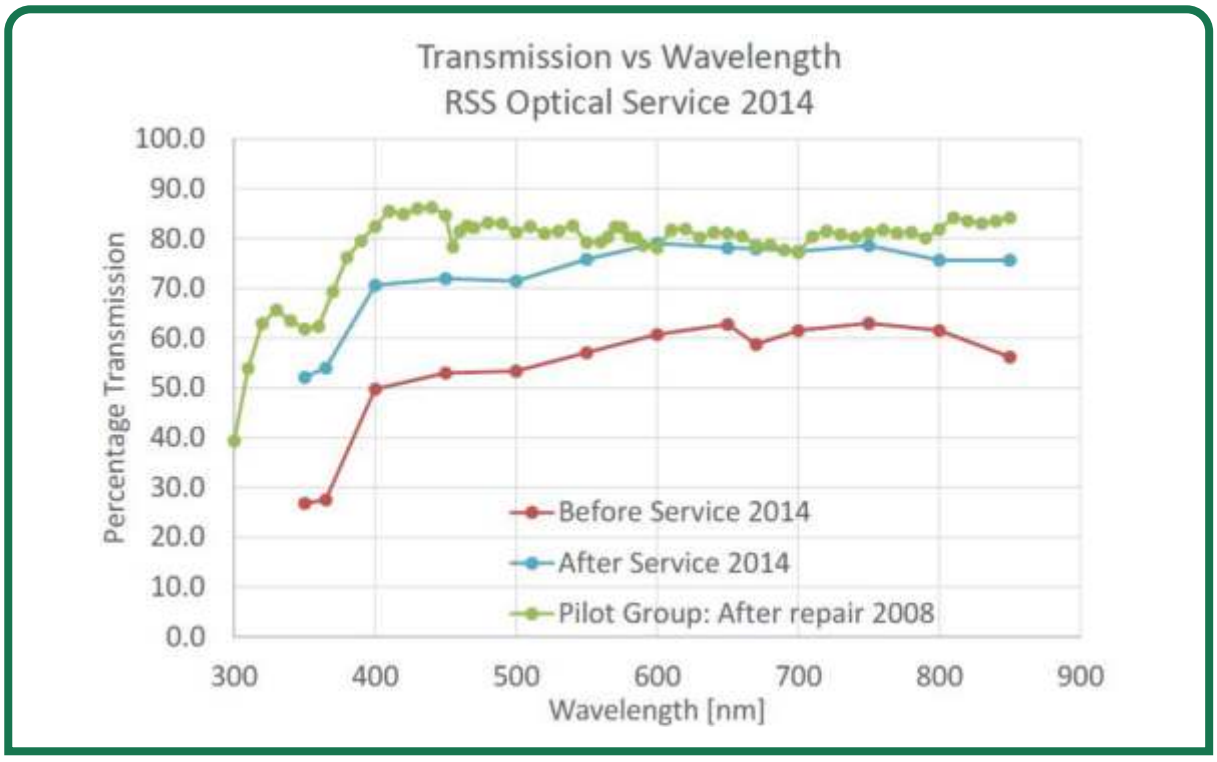


Green laser light illuminating the RSS collimator optics (left). Members of the Tech Ops team working on the RSS grating holder and the wave-plate mechanism (right).





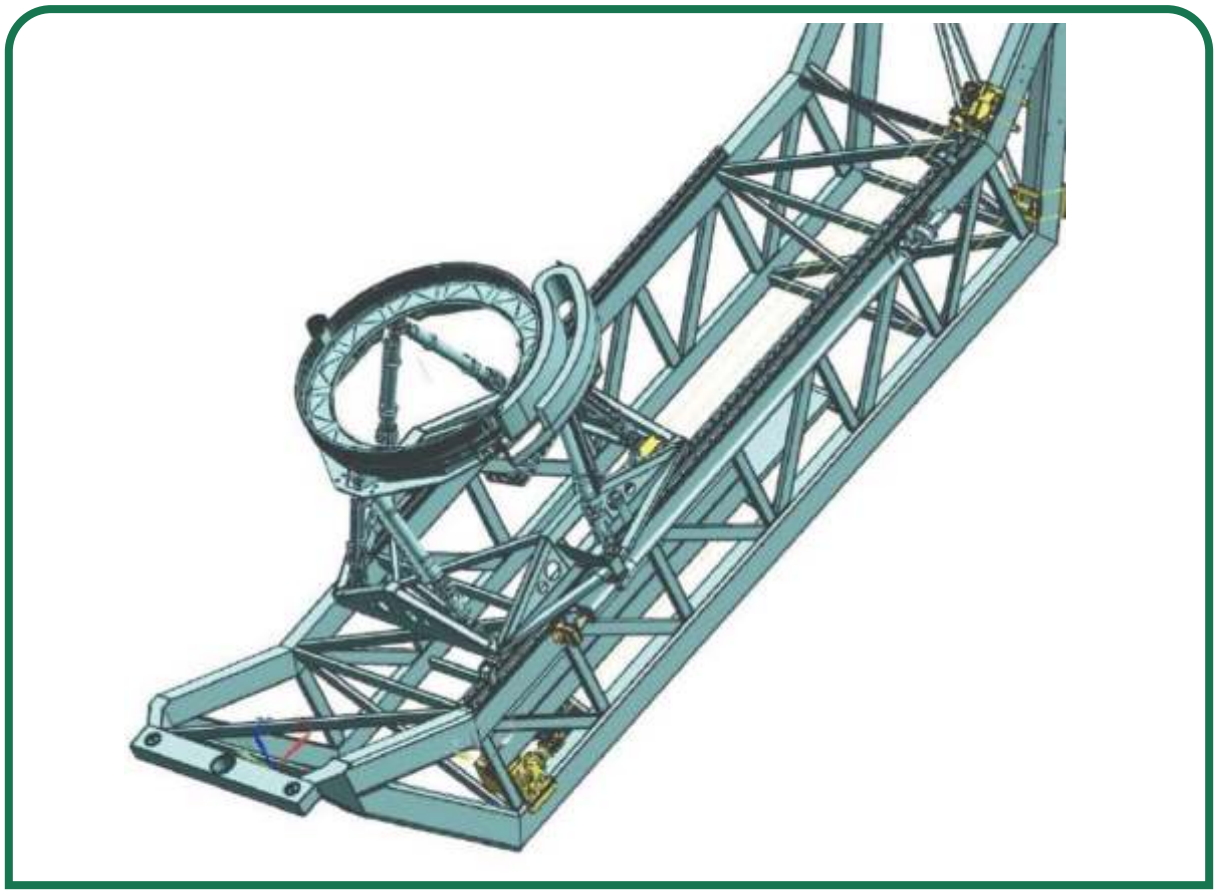
Open electronics boxes reveal the complexity of the instrument (left). The RSS being returned to the tracker on 13 November (right).



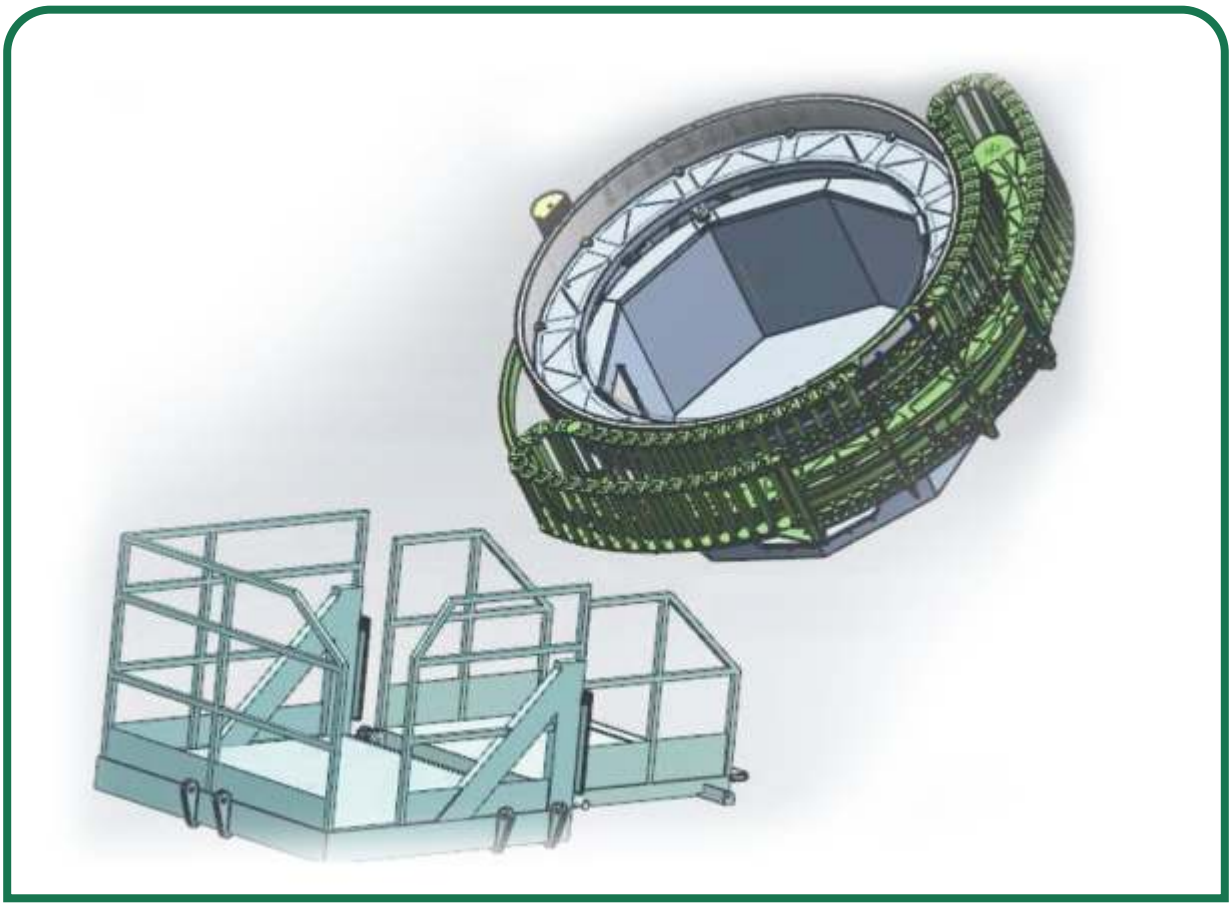
Comparative RSS throughput measurements before (red) and after (blue) the 2014 optical service.

TRACKER UPGRADE

Stage 1 of the Tracker Upgrade project, namely Y- drive upgrade - was successfully completed early in the year, when the Final Design Review was passed and the complete installation kit was delivered to SALT. The kit contains all of the completed subassemblies, as well as the documentation required to carry out the installation at SALT. Stage 2 of the project, the rho-drive upgrade, commenced at the end of February. The Concept Evaluation Review was passed in the middle of April and the detailed design phase ended in early August when the Critical Design Review was passed. The rho upgrade design solution is similar to the existing rho-drive system, except that newer technology (in the form of a harmonic drive motor) has been selected. The new motor is much lighter and stronger, and also requires less current, cooling and maintenance. The new cable handler contains two cable wraps, effectively doubling the volume available for cables, pipes and services. Manufacturing for Stage 2 is currently underway.



Stage 1: the Y-drive upgrade

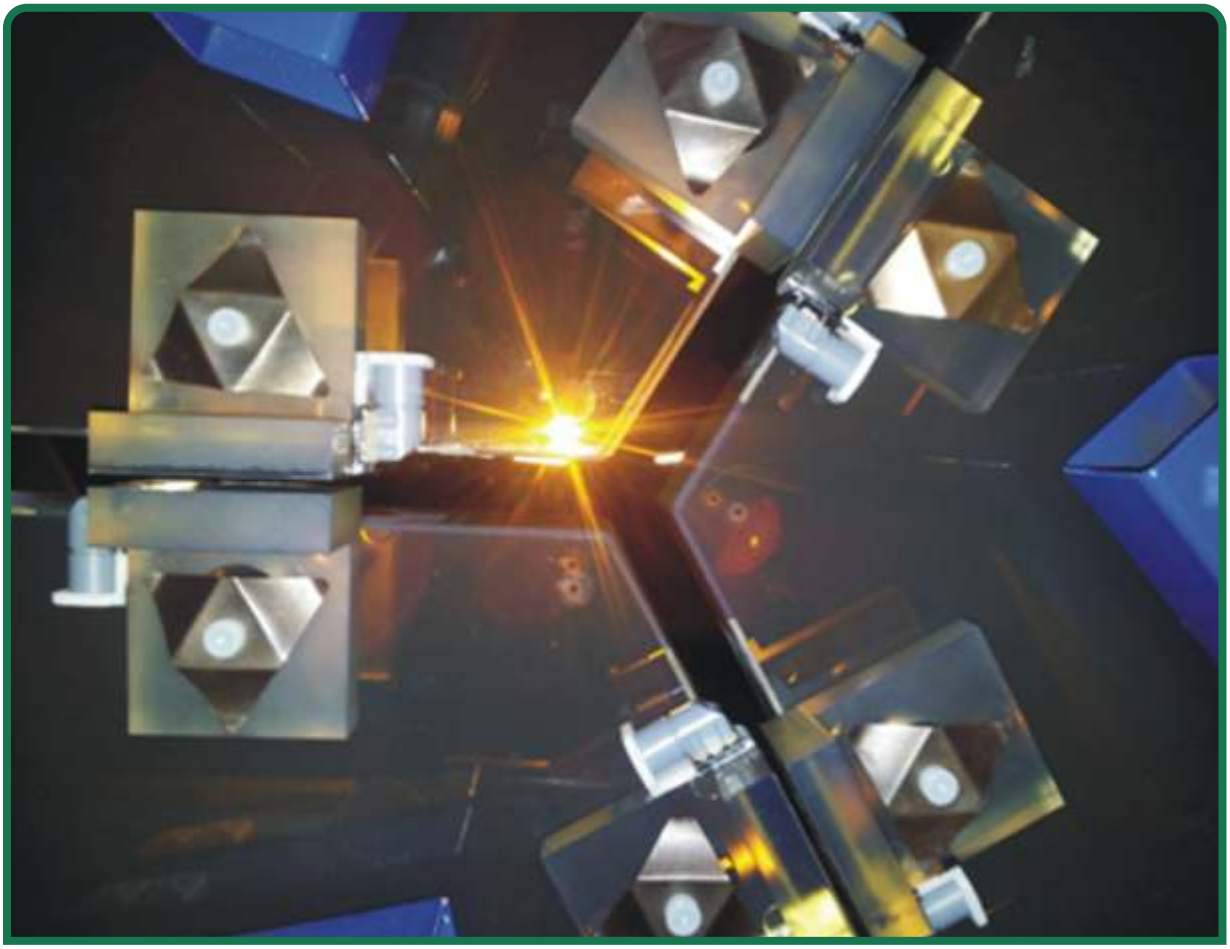


Stage 2: the rho-drive upgrade, shown in relation to the tracker access platform

SAMS

A preliminary Factory Acceptance Test was held at Fogale Nanotech in Nîmes, France, in March. The results gave the SAMS team confidence that most of the technical issues with the edge sensors had either been overcome, or were likely to be solved before delivery to SALT. The first batch of 26 sensors and their associated electronics were delivered in September, and 24 were fitted to the central seven segments of the array. The sensors are bonded to Sitall L-brackets, which are then mounted on invar buttons attached to the backs of the segments.

Early tests were promising and closed loop control was demonstrated by the end of September. Unfortunately, good weather was required to allow the CCAS instrument (used to align the primary mirror segments) to verify closed-loop operation. By the end of the year, the team had achieved full control (within specification) of the central seven segments, but only over a temperature change of 2.6 °C, while the specification is over a 15 °C variation. Further testing was planned to continue into 2015. Given the existing results, there is good reason for optimism regarding the final success of the project.



A subset of the 12 pairs of edge sensors attached to the central seven segments of the primary mirror array.

RSS Near Infrared Arm

The Near Infrared (NIR) arm of the Robert Stobie Spectrograph is being built by the University of Wisconsin-Madison. The 2014 highlights in the development of this instrument included achieving first light with the camera system in the lab, and characterization and optimization of the engineering grade detector. Performance of the detector system in a faster readout mode was significantly improved and the well depth of the CCD was measured. The camera-focus and filter wheel mechanisms are now under software control and work on the other mechanisms continues. The dewar system has successfully undergone vacuum and thermal control tests at lab and operational temperatures and a Request for Bid was released for the CO_2 cooling system required to maintain the instrument's pre-dewar enclosure at -40 C. The instrument team remains in regular contact with SALT Operations to ensure control of the various interfaces.

The new RSS-NIR camera test configuration with a fibre inspection camera

SALT's High Resolution Spectrograph (HRS)

As was to be expected, a brand new, complex instrument like the HRS, kept the SALT team busy during the spectrograph's first full year of science operation on the telescope. In addition to carrying out a range of on-sky commissioning tests and science verification observations, we also had to contend with the inevitable growing pains.

In March we were forced to dismantle the thermal enclosure's interlocking Styrostone bricks before breaking vacuum on the three metre long stainless steel tank that houses the optical bench. The fault was quickly traced to a slightly-loose screw on a micro-switch that controls the mode selector, one of the instrument's four moving mechanisms inside the tank.

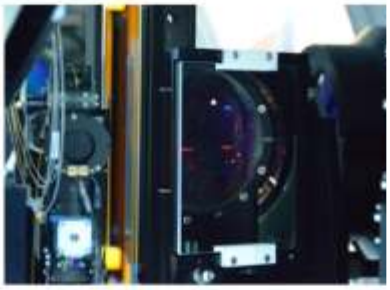
Preparing to open the HRS vacuum tank, after dismantling the grey Styrostone thermal enclosure (left), and the HRS mode selector assembly that needed attention, seen here after being removed from the optical bench (right).

Although opening the tank was disruptive for the instrument and carried certain risks, it did provide a great opportunity to acquaint members of the instrument team with the inner workings of the system, and of course to admire the spectrograph's magnificent optics once more!

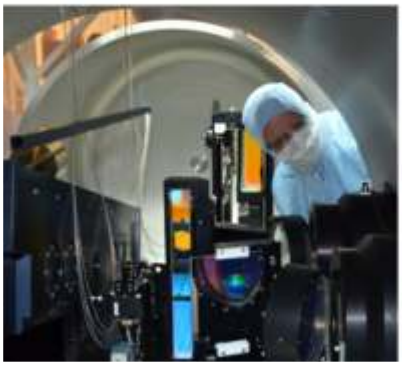
The SALT High Resolution Spectrograph

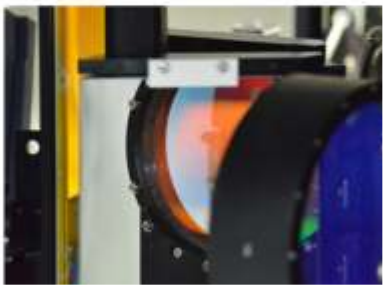


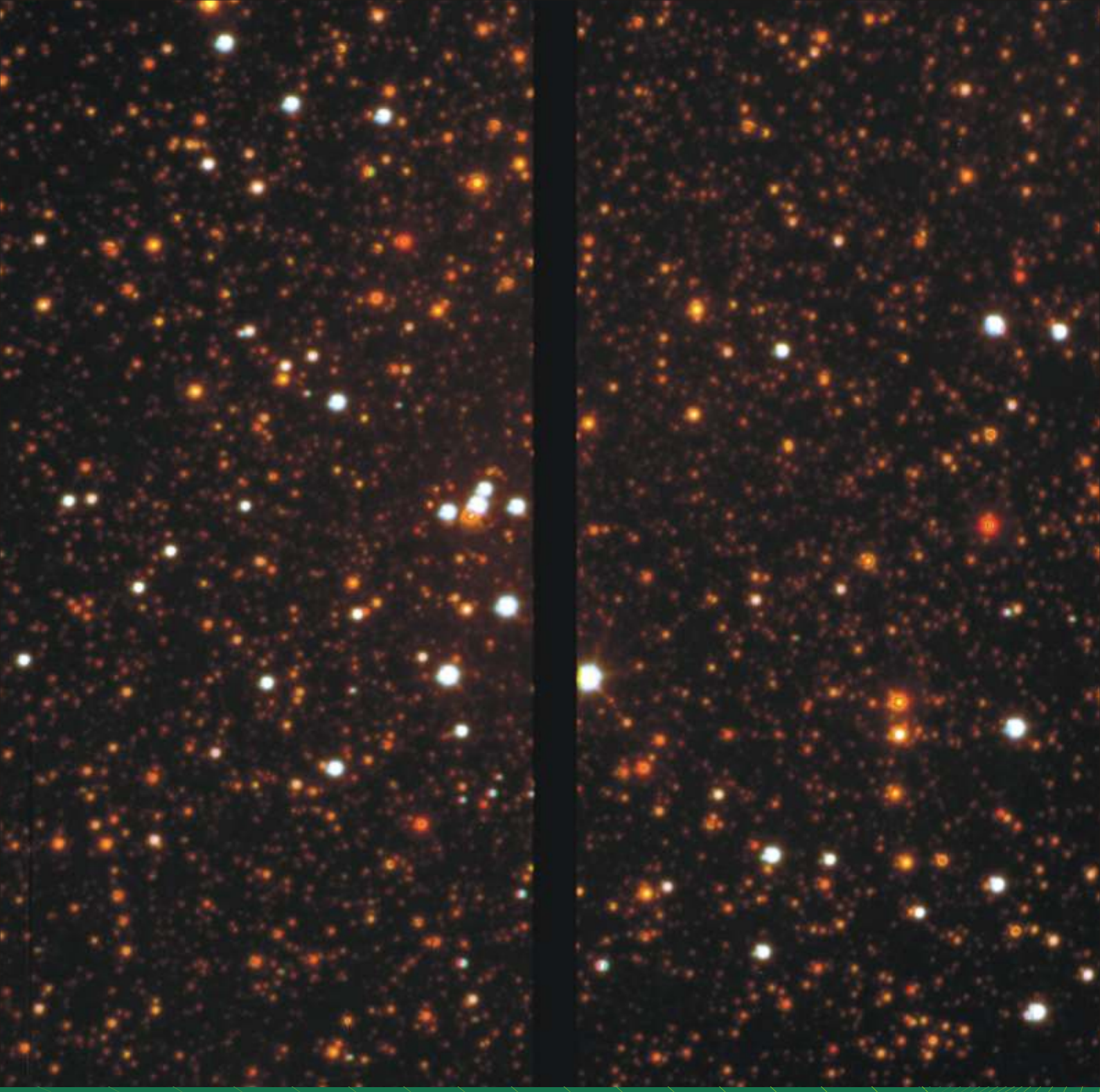












RESEARCH HIGHLIGHTS

In this section a number of research highlights for the year which followed from a variety of SALT observing programs are reported.

Non-Detection of Nova Shells Around Asynchronous Polars

Polars are mass-transferring white dwarf (WD)- main sequence (MS) binaries, known as Cataclysmic Variable, in which the WD has a strong magnetic field (~ 10 - 102 MG). This prevents the formation of an accretion disk around the accreting star, and instead channels the accreted material, along the magnetic field lines, directly onto the magnetic pole regions of the WD. In most polars, orbital and spin periods are synchronized. For a handful of systems, however, the WD rotates asynchronously, so that orbital and spin angular velocities differ significantly. One hypothesis for the cause of this asynchronism is nova eruptions in the past few centuries. Accreted hydrogen builds up on the surface of the WD until it reaches a critical temperature/pressure, thereby igniting a thermonuclear runaway in the accreted, hydrogen-rich layer - a nova eruption. The ejection of this layer during a nova event causes the WD to spin with a higher angular velocity than before the nova. If this hypothesis is correct then nova shells should be observed around asynchronous polars. No evidence was found of nova shells in any of the SALTICAM images obtained from a program of deep imaging of asynchronous polars (Fig. 1), challenging the hypothesis that asynchronism is due to a recent nova event. As reported by Ashley Pagnotta and Dave Zurek of AMNH.

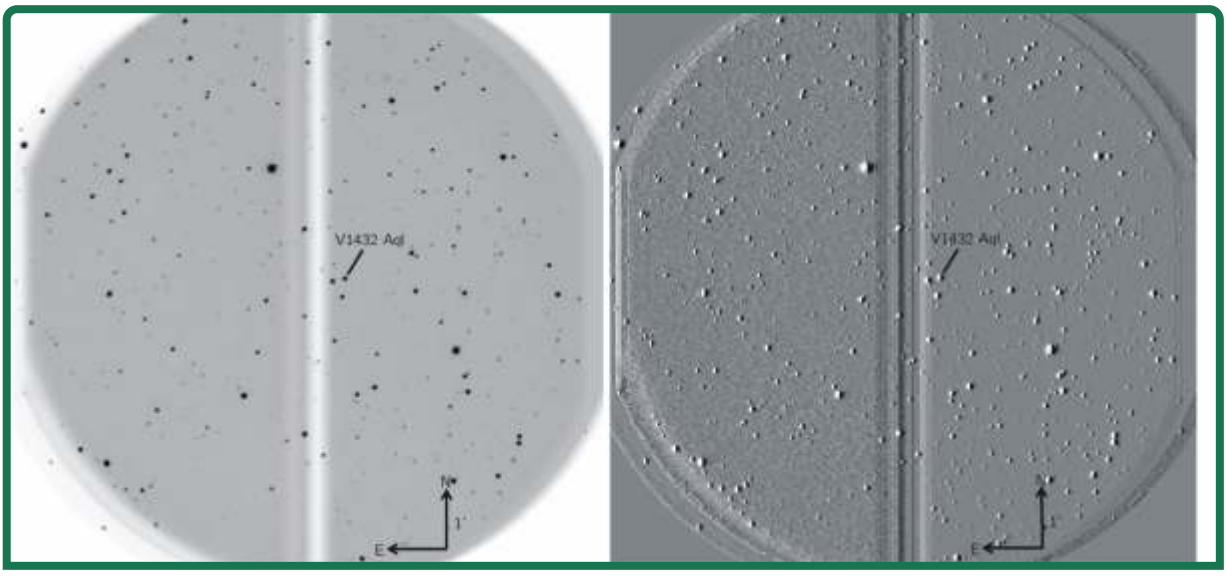


Fig. 1: Left: SALTICAM Ha image of the asynchronous polar V1432 Aql, made from a combination of 26 separate SALTICAM exposures for a total exposure time of 3120s. North is up, East is to the left, and the length of the directional arrows corresponds to 1' on the figure. The full unvignetted field of view of the image is 8' in diameter, and the lighter stripes in the middle of the image are due to the gap between the two SALTICAM chips. The position of V1432 Aql is marked, and no shells or shell fragments are visible. Right: This figure shows the same V1432 Aql field seen on the left after it has been processed using an unsharp masking technique that involves subtracting a duplicate of the image from the original, after the duplicate has been shifted by 0.5 pixels in the x-direction. This method increases the local contrast of the different areas of the image and highlights edge features, such as those seen in nova shells. With this, one can be confident that if there were a detectable shell in this image, one would see it here.

Symbiotic Stars And Other Emission Line Objects

Symbiotic stars (SySt) are interacting binaries with very long orbital periods (from a few years to dozens and even hundreds of years) composed of an evolved giant transferring mass to a compact companion, usually a white dwarf, although in some SySt a neutron star is also found. The binary is embedded in an ionized nebula. These systems are very important tracers of late phases of stellar evolution, as well as promising "factories" of Supernovae Type Ia progenitors. There are major unresolved puzzles concerning their formation and evolution. The composition of SySt makes them strong Hα emitters associated with very red objects. Miszalski and Mikolajewska have identified a few hundreds of SySt candidates in our Galaxy and a few dozen in the Magellanic Clouds, and since late 2012 have been using SALT with RSS to get spectroscopic confirmation of their symbiotic nature. So far, over 20 new galactic SySt have been found, and 2 in MCs. In 2014, first results of this continued search were published in two referred papers. In particular, the SALT spectra and basic characteristics of 12 new SySt and 3 possible SySt, as well as many other interesting emission-line objects were published by Miszalski & Mikołajewska (2014). The most remarkable among these is the very rare carbon-rich SySt that displays coronal [FeX] and may host a massive white dwarf (Fig. 2). This publication, based solely on SALT RSS spectra (~40 spectra presented and discussed), in many cases obtained in mediocre weather conditions, was prepared, submitted and accepted in MNRAS within only 1 year since the observations began. Miszalski et al. (2014) also discovered that OGLE-SMC-LPV-00861 (LIN 9) is a SySt, and that its OGLE light curves revealed the first proven Z And-type outburst in a Magellanic symbiotic star. As reported by Brent Miszalski of SALT/SAAO and Joanna Mikolajewska of CAMK, Poland.

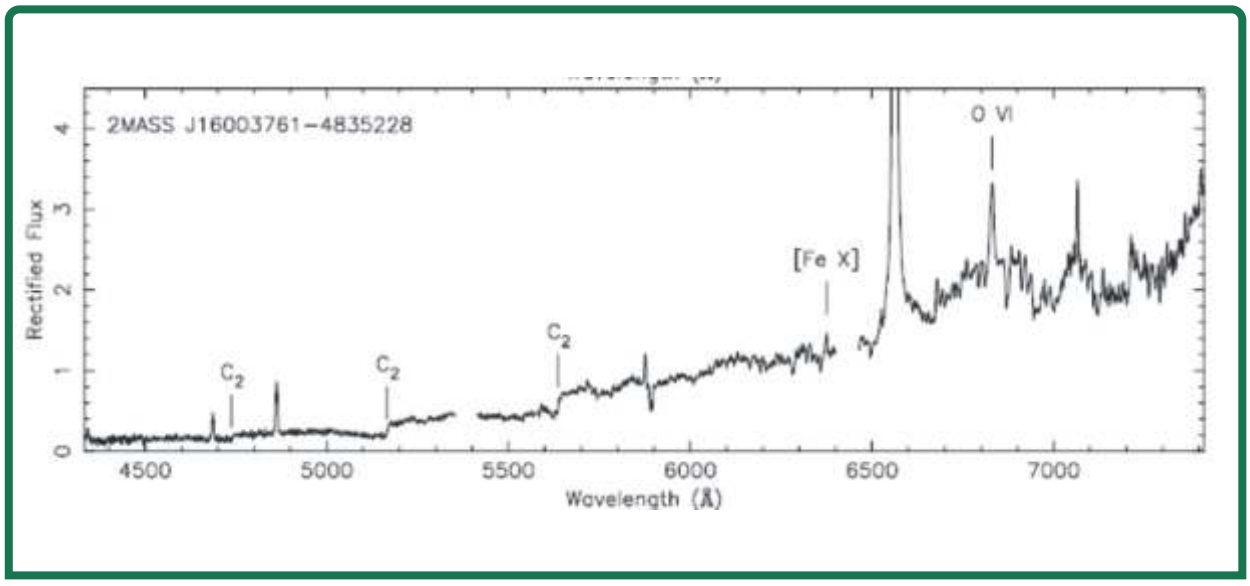


Fig. 2: SALT spectrum of the new C-rich SySt (from Miszalski & Mikołajewska 2014).

Searching for Evidence of Planetary Differentiation

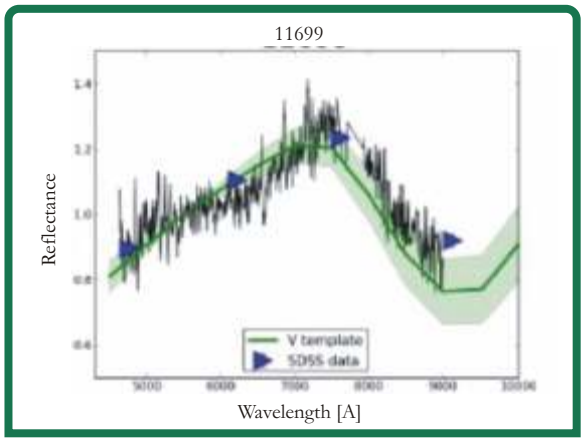


Fig. 3: SALT spectra of asteroid (11699) FL105 with the overlaid reflectance values computed from the SDSS photometry. The thick line represents the taxonomical template for the V-type and the shaded area is the standard deviation of the template (from Oszkiewicz et al. 2014).

Meteoric evidence suggests 50-100 differentiated parent bodies in the solar system, yet we know only one fully differentiated asteroid (Vesta). Low resolution spectra obtained with SALT RSS helped determine the taxonomical (a proxy for mineralogical) type of a sample of asteroids and predict the distribution of basaltic material in the Main Asteroid Belt (Oszkiewicz et al. 2014, Fig.3). As reported by D. A. Oszkiewicz of Mickiewicz University, Poland.

Spectroscopic followup of variable stars discovered in SuperWASP search

As part of a long-term programme to investigate variable stars discovered as a by-product of the SuperWASP exoplanet transit search project, a SALT spectrum of the object 1SWASP J050634 was obtained. From the SuperWASP data, this object showed a complex light curve, exhibiting two independent periodic variations. First, there is a roughly sinusoidal 1.78 hour pulsation, but this is superimposed on a 5.1 day modulation, which is characteristic of an eclipsing binary star. This system consists of a so-called δ Scuti star (a pulsating variable star which has just left the core hydrogen-burning main sequence) in a semi-detached eclipsing binary configuration with another, normal star.

A series of 15 spectra obtained with the RSS on SALT during Dec 2014 - February 2015 were used to derive the radial velocities of the two component stars from the Doppler shifts of their spectral lines. In turn, by modelling the resulting radial velocity curves in conjunction with the eclipsing binary light curve, the masses and radii of the two component stars, as well as other parameters of the orbit, were determined. As a result, 1SWASP J050634 is confirmed as a relatively rare, long period, semi-detached eclipsing binary containing a δ Scuti star with a first overtone radial pulsation of high amplitude. A paper reporting the results has been submitted to the journal Astronomy & Astrophysics. As reported by Andrew Norton & Marcus Lohr, The Open University, UK.

Central Stars of Planetary Nebulae

Low resolution spectra from various telescopes, including SALT RSS data, were used to search for variability of planetary nebulae suspected to host binary systems (Hajduk et al. 2014), and to trace evolution of the [OIII]/Hβ emission line ratio of planetary nebulae hosting central stars (CS) of different type, very likely reflecting their different evolutionary status. This line ratio provides a good proxy for temperature of the central star. The temperature evolution of CS in Hen 2-260, spanning almost a decade, allowed to precisely determine the stellar mass, since the pace of the temperature evolution depends critically on the core mass. As reported by M. Hajduk of CAMK.

The Post-Common-Envelope, Binary Central Star of the Planetary Nebula Hen 2-11

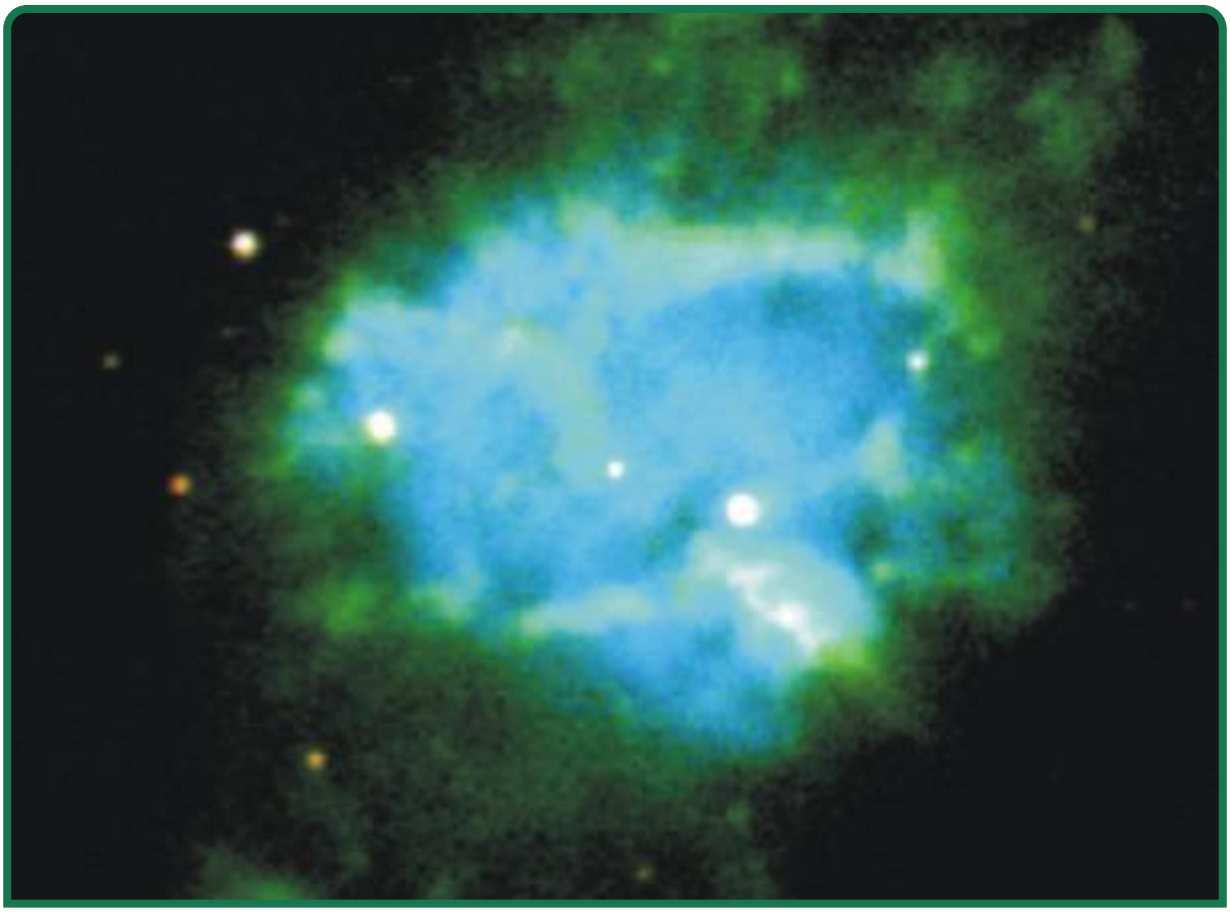


Fig. 4: ESO NTT-EFOSC2 colour-composite image of Hen 2-11 made from [S II] (red), Hα+[N II] (green) and [O III] (blue). North is up and east to the left in this image of approximately 2 × 3 arcmin.

At the end of their lives stars like the sun will eject most of their atmosphere to create spectacular cosmic butterflies called Planetary Nebulae (PNe). At their heart lies a very hot central star that ionizes leftover gas to reveal an amazing variety of shapes. A glance at images from the Hubble Space Telescope show that the shapes range from perfectly spherical bubbles, to butterfly-like shapes with multiple ejected lobes, to double-lobed nebulae with highly collimated jet-like outflows. In recent years much attention has been directed towards finding PNe with binary central stars in which we know the nebula has been shaped by the binary. Jones et al. used SALT RSS observations of Hen 2-11 (see Fig. 4) to confirm the binary detected via photometry was the hot central star (not just an unrelated star). Furthermore, the nebular emission lines recorded in the spectrum were used to derive the radial velocity of the nebula and the chemical abundances of the nebula. Constraints on the temperature of the white dwarf component of the binary were also made. Relatively few of the known sample of around 50 close binary central stars of PNe have abundance measurements that are useful to inform what possible progenitor stars could have produced the nebula. As reported by Brent Miszalski.

New Galactic Bona Fide Luminous Blue Variable

Some massive stars during their life undergo a stage of drastic changes in spectral appearance and brightness, which are accompanied by episodes of enhanced mass loss. In this stage such massive stars are called luminous blue variables (LBV) and change their visual brightness by one or more magnitudes on time-scales of years and their spectral types vary between late O/early B and A/F supergiants. The nature of the LBV-type activity remains unclear also because the number of bona fide and candidate LBVs (cLBVs) has remained quite sparse until recently.

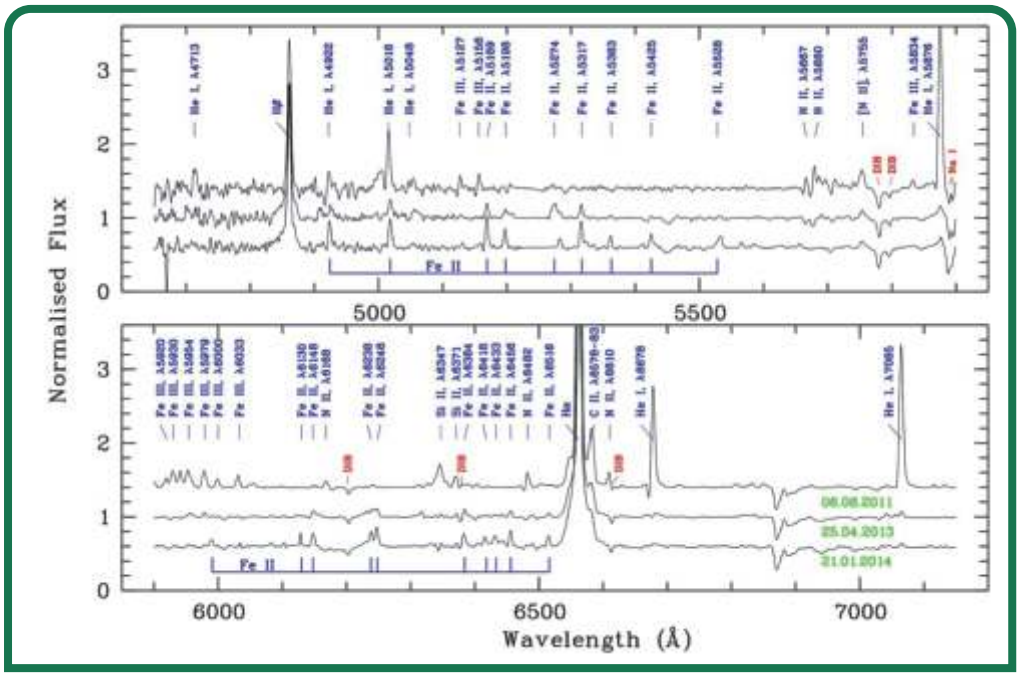


Fig 5: The evolution of the normalized spectrum of Wray 16-137 between 2011 August and 2014 January. The principal lines and most prominent DIBs are indicated.

The number of known cLBVs in the Milky Way has greatly increased with the advent of modern infrared telescopes, which resulted in the discovery of numerous compact infrared shells - the distinctive characteristic of LBV and some other evolved massive stars. Follow-up spectroscopy of central stars of these shells have nearly doubled the number of Galactic cLBVs. However, none of the newly discovered cLBVs have reported spectral and photometric variability strong enough to call them bona fide LBVs.

Kniazev and collaborators reported the discovery of a circular mid-infrared shell around the emission-line star Wray 16-137 using archival data of the Spitzer space telescope. Follow-up optical spectroscopy of Wray 16-137 with the SALT revealed a rich emission spectrum typical of the classical luminous blue variables (LBVs) like P Cygni. Subsequent spectroscopic and photometric observations showed drastic changes in the spectrum and brightness during the last three years (see Fig 5). Taken together, these observations unambiguously show that Wray 16-137 is a new member of the family of Galactic bona fide LBVs. As reported by Alexei Kniazev of SALT/SAAO.

A search for p-mode pulsations in white dwarf stars using the Berkeley Visible Imaging Tube detector

Pulsating white dwarf stars fall into well-defined temperature regions on the white dwarf cooling tracks and include the DAV (or ZZ Ceti stars), DBV (V777 Her) and DOV (GW Vir) variable types. These stars exhibit multiple variations with periods usually in the range 100 to 1000 seconds, which are well-understood as non-radial g-mode pulsations where gravity (actually buoyancy) is the restoring force. Theory predicts that if such stars should show p-modes - where pressure is the restoring force - these would have periods around 1 second or at least in the range 0.1 to 10 seconds. Most white dwarf stars are intrinsically very faint so that attempting to find p-mode pulsations is very difficult - it requires very good light-gathering power and the ability to obtain measurements at a cadence of 0.1 second or better. Very few such attempts have been made - none successfully.

Dave Kilkenny and collaborators took advantage of commissioning time with the Berkely Visible Image Tube detector (BVIT) on SALT to examine several white dwarf stars for p-mode pulsation. Three known ZZ Ceti variables (DAV stars) were observed as well as one white dwarf not known to vary and one AM CVn variable. Even in quite short runs with BVIT (< 1 hour) they were able to achieve mean noise levels ~0.2 millimag and retrieve many of the known g-mode pulsation periods, though they did not detect any p-modes (Fig. 6). As reported by Dave Kilkenny of the University of Western Cape, South Africa.

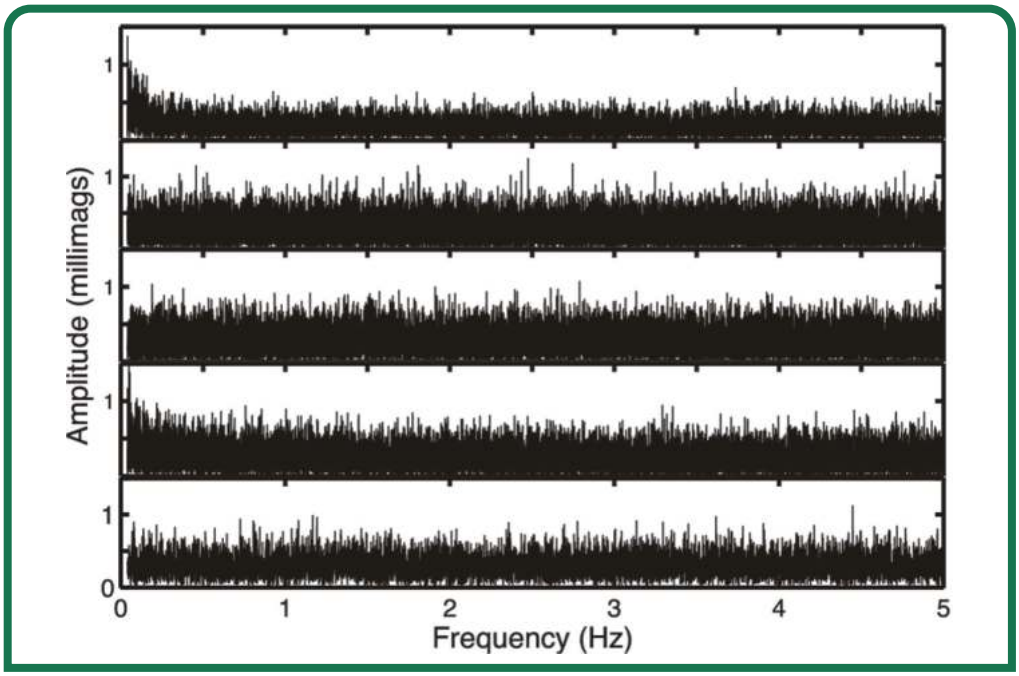


Fig 6: High-frequency amplitude spectra of the detrended data from BVIT/SALT. From top to bottom: ZZ Ceti, HK Ceti, AF Pic, HP Lib and WD 1056-384.

Probing Accretion Flows in Magnetic Cvs

Various SALT programmes probing high frequency variability of magnetic cataclysmic variable (mCV) stars involving David Buckley, Stephen Potter and collaborators have continued to produce new results and publications (3 to date). The most recent results (Semena et al. 2014), came from a combined study of fast timing variability in magnetic cataclysmic variables (mCVs) utilizing both SALT (SALTICAM and BVIT) and the EM-CCD based SHOC camera on the SAAO 1.9-m telescope. It was previously shown that one may expect the rapid flux variability of mCVs to be smeared out on time-scales shorter than the cooling time of the hot plasma in the post-shock region of the accretion curtain, near the white dwarf (WD) surface. Estimates of the cooling time and the mass accretion rate can provide a tool to measure the density of the post-shock plasma and the cross-sectional area of the accretion funnel at the WD surface.

This study probed the high frequencies in the aperiodic fluctuations of one of the brightest mCVs, EX Hya, and placed upper limits on the plasma cooling time-scale, $\tau < 0.3$ s, the fractional area of the accretion curtain footprint, $f < 1.6 \times 10^{-4}$, and a lower limit on the specific mass accretion rate, $\dot{M}/A > 3$ g s^{-1} cm^{-2}. Previous measurements of accretion column footprints, via eclipse mapping, can highly overestimate the size of the accretion regions, whereas for these recent results a value of $\Delta r/r \sim 10^{-3}$ was derived as an upper limit to the penetration depth of the accretion disc plasma at the boundary of the magnetosphere. This could have interesting implications for the analogous LMXBs, with neutron stars accretors, which have a similar magnetosphere-disk geometry. In these cases, the fractional area of the neutron star accretion column, $A/4\pi r^2_{NS}$, is $< 10^{-5}$, resulting in a very high mass flux, strongly influencing the accretion column structure. As reported by David A. H. Buckley of SALT/SAAO.

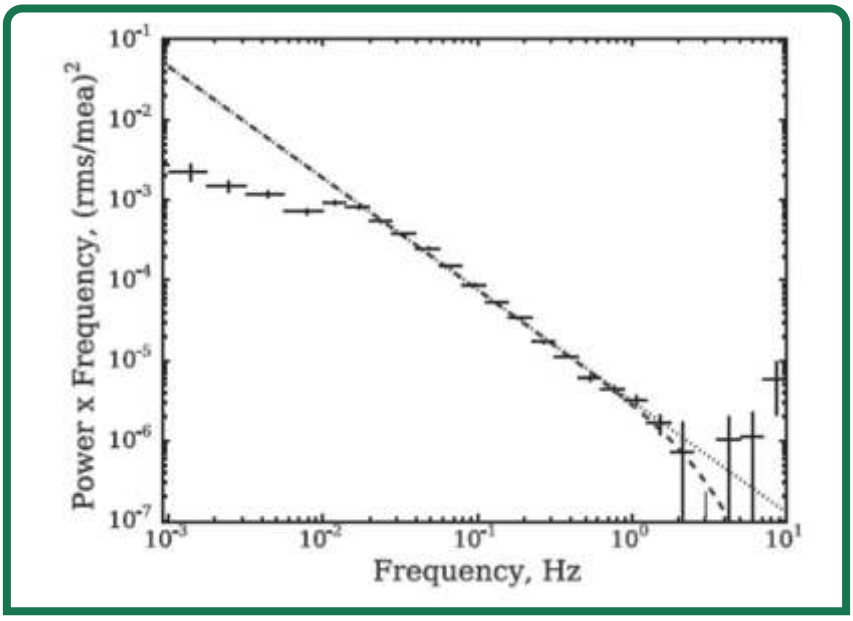


Fig 7: The combined Power Density Spectrum of EX Hya from SALT (SALTICAM and BVIT) and SHOC high speed photometry, after subtraction of shot noise, with a power law fit (dotted line) $\alpha = 2.4$. These observations have placed an upper limit on the plasma cooling timescale of ~0.3 - 0.5 sec, leading to an estimate of the accretion area, $A < 10^{15}$ cm^2, and a lower limit on the mass flux of $\dot{M}/A > 3$ g s^{-1} cm^{-2}.

SALT observation of X-ray pulse reprocessing in 4U 1626-67

Dipankar Bhattacharya and collaborators investigated the optical reprocessing of X-rays in the LMXB pulsar 4U1626-67 in its current spin-up phase from high speed photometry with SALTCAM. Near simultaneous observations were also obtained with Swift-XRT and nonsimultaneous observations with RXTE-PCA and results used in a timing analysis. Using SALT observations carried out on 5th and 6th March, 2014, they also detected some interesting reprocessing signatures. They detected a weak optical Quasi Periodic Oscillation (QPO) feature in the power density spectrum on March 5th at 48 mHz with a fractional rms amplitude of 3.3% in spite of the fact that the source shows no corresponding X-ray QPO in the spin-up phase. In the light curve obtained on March 5th, they detected a coherent pulsation at the spin period of › 7.677 s. A previously known, slightly down-shifted side-band feature is also detected at 129.92 MHz. The frequency spacing between the main pulse and this side-band is different from the earlier observation, though the statistical significance of the difference is limited. The light curve of 6th March displays short time-scale variability in the form of flares on timescales of a few minutes. The folded pulse profiles resulting from the data of this night show an interesting trend of the pulse peak drifting with time. The drift of the pulse phase in short time scale could be due to i) short time scale changes in the reprocessing agent, like orbital motion of an accretion disk warp around the neutron star or ii) intrinsic pulse phase changes in the X-rays. They also examined some X-ray light curves and power density spectra, obtained with RXTE−PCA during 2008-2010 for pulse shape changes in short time scales during the X-ray flares. As reported by Dipankar Bhattacharya of IUCAA, India.

Characterising a new "Redback" X-ray binary

A Coordinated spectroscopy, optical photometry and infrared photometry were conducted by David Buckley, Marissa Kotze and collaborators on the enigmatic X-ray binary system XSS J1227.0-4859, discovered as a persistent *Fermi*/LAT γ-ray source, which has subsequently been found to harbour a millisecond pulsar. This campaign was conducted using SALT, the ESO NTT 3.5-m and REM telescopes and several smaller SAAO telescopes and has been published in de Martino et al. 2014. The 2012 campaign was conducted during an accretion state, manifested by high speed optical flickering and a variable emission from the accretion disk. A Doppler tomography analysis of the combined SALT/NTT spectra has led to the discovery of a 6.9 h orbital period, where absorption line radial velocity variations are clearly seen from the mass donating secondary star. In addition, emission lines reveal the presence of an accretion disc, which tend to vanish at superior conjunction of the secondary, where flares and random dips are also seen. Its spectral type changes from G5 V to F5 V between inferior and superior conjunctions, a signature of strong irradiation effects. This is also supported by the strong ellipsoidal photometric variation seen in the REM light curves. Modelling the SALT/NTT spectroscopy has resulted in the determination of an orbital inclination in the range 45° - 60° and the conclusion that the donor star is highly under-massive, at $M_2 \sim 0.06 - 0.12 M_\odot$, for a neutron star mass in the range 1.4 -3 $M_\odot$. Thus, this system is the seventh member of the group of so-called redback low mass X-ray binaries. The observational characteristics, and particularly more recent (2013) high speed photometry, indicated that the system has transitioned between an accretion state (2012) and propeller, or rotation-powered phase (2013). This was confirmed in 2014 with the discovery that the neutron star is a 1.69 ms radio pulsar. As reported by David A. H. Buckley of SALT/SAAO.

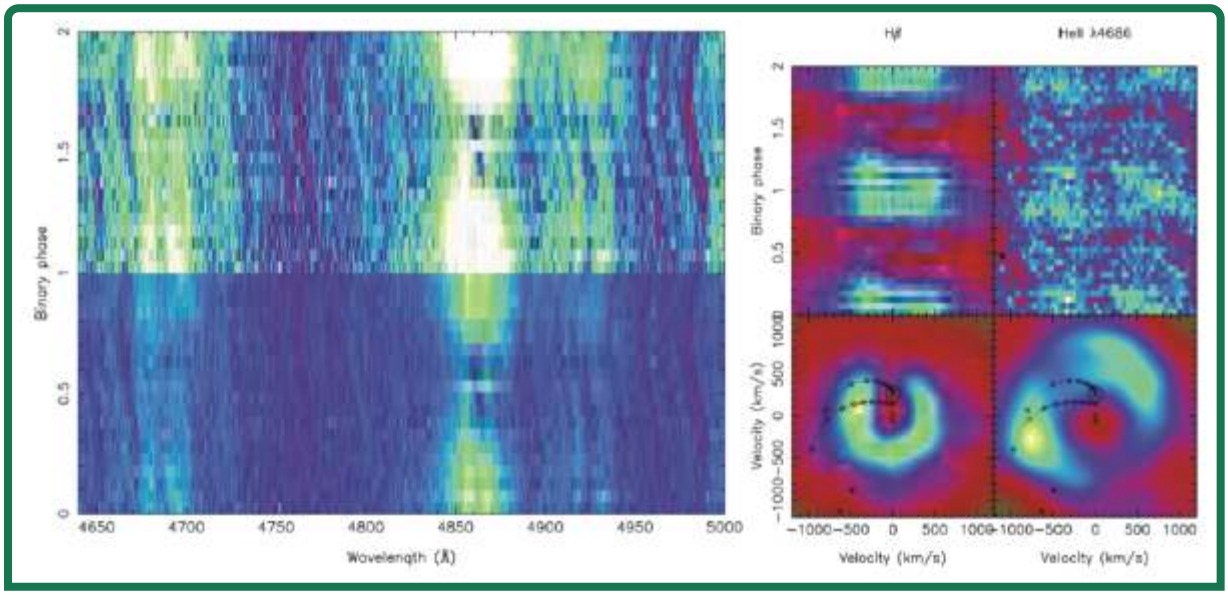


Fig. 8: Left - Phase folded (at 6.9 h orbital period) spectra of XSS J1227.0−4859, with the highly variable Hβ and HeII 4686Å emission lines from the accretion disk plus the metallic (Fe) absorption lines from the secondary star. Right - Doppler tomogram of the disk emission lines showing the double-peaked shape (top). Doppler maps in velocity coordinates are shown together with the theoretical Keplerian trajectory along the gas stream and the stream trajectory. The secondary Roche lobe is also indicated for q = 0.25.

Search for Higgs Shifts in White Dwarfs

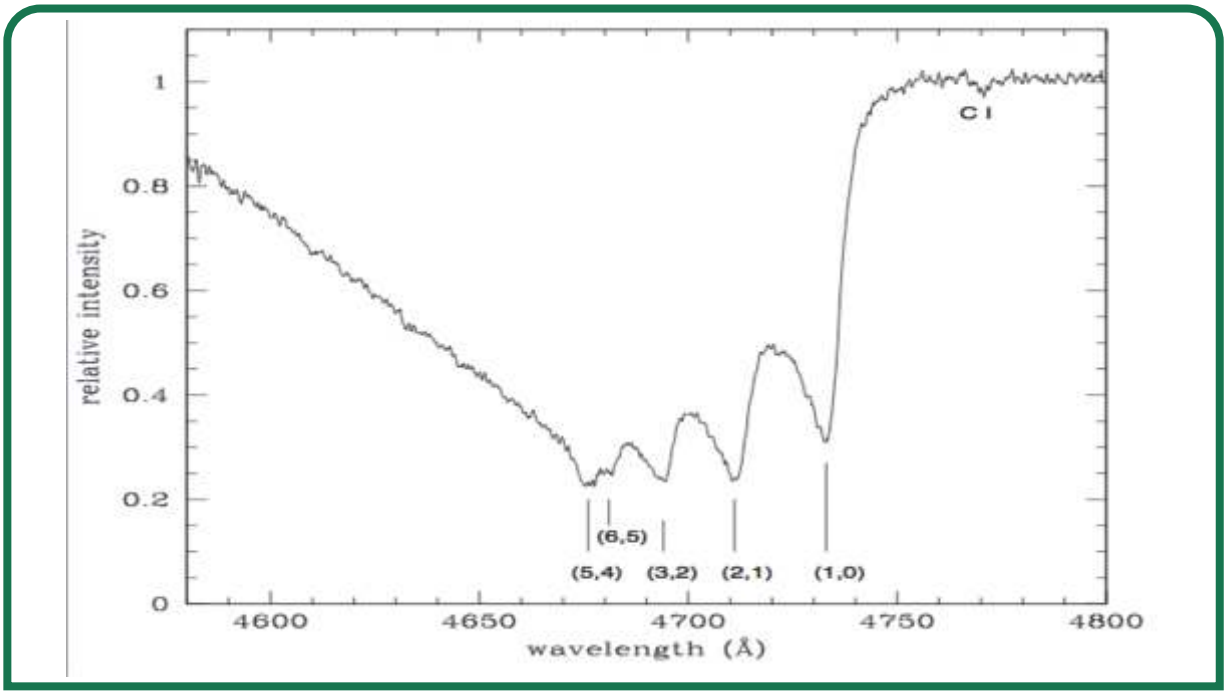


Fig. 9: A portion of the spectrum of the white dwarf BPM 27606 observed with SALT showing the C2 carbon bands and atomic line of carbon.

Roberto Onofrio (Univ. Padova and Harvard-Smithsonian Center for Astrophysics) and Gary A. Wegner (Dartmouth) have used SALT RSS spectra of the DQ white dwarf BPM 27606 to set limits on the space-time curvature coupling of the Higgs field with gravity. Mass is important in understanding the nature of gravity and the Higgs curvature coupling would shift the wavelengths of molecular bands and atoms differently. This is because nucleons (protons and neutrons) are affected differently than electrons by the Higgs field resulting in the wavelength shift. Observations with the SALT (see Fig. 9 for an example) using spectra of BPM27606 which has both atomic and molecular lines place an upper limit on the coupling between the Higgs field and the space-time curvature that is 10 orders of magnitude better than results available from table-top experiments. This has implications for various extensions of the standard model which play roles in inflation and dark energy. A more detailed commentary on this work my be found at *http://phys.org/news/2014-09-higgs-gravity-white-dwarfs.html*. As reported by Gary A. Wegner of Datmouth College, USA.

Exoplanetary Debris Disks Around White Dwarfs

An exciting science program which researchers at UNC are pursuing with HRS is the discovery and characterization of southern hemisphere white dwarfs hosting exoplanetary debris disks. These systems offer insight into planetary dynamics and sensitively probe exoplanet composition as material accretes onto the white dwarf surface. They have drawn targets from the Edinburgh-Cape Blue Object survey and have used catalogue photometry to establish the targets that exhibit the infrared excess characteristics of dusty debris disks. Using HRS in low resolution mode they will be able to collect high signal to noise spectra across the entire visible range to search for atmospheric metal pollution, the hallmark of recent accretion. A pilot study conducted during the 2014-1 semester studied a set of known debris disk hosting white dwarfs. Although the signal-to-noise of the pilot study was too low for feature detection, the spectra offered training in reduction and scaling for planned future observations. As reported by Gerald Cecil of University of North Carolina, USA.

Stellar populations in central cluster galaxies: the infuence of cooling fows

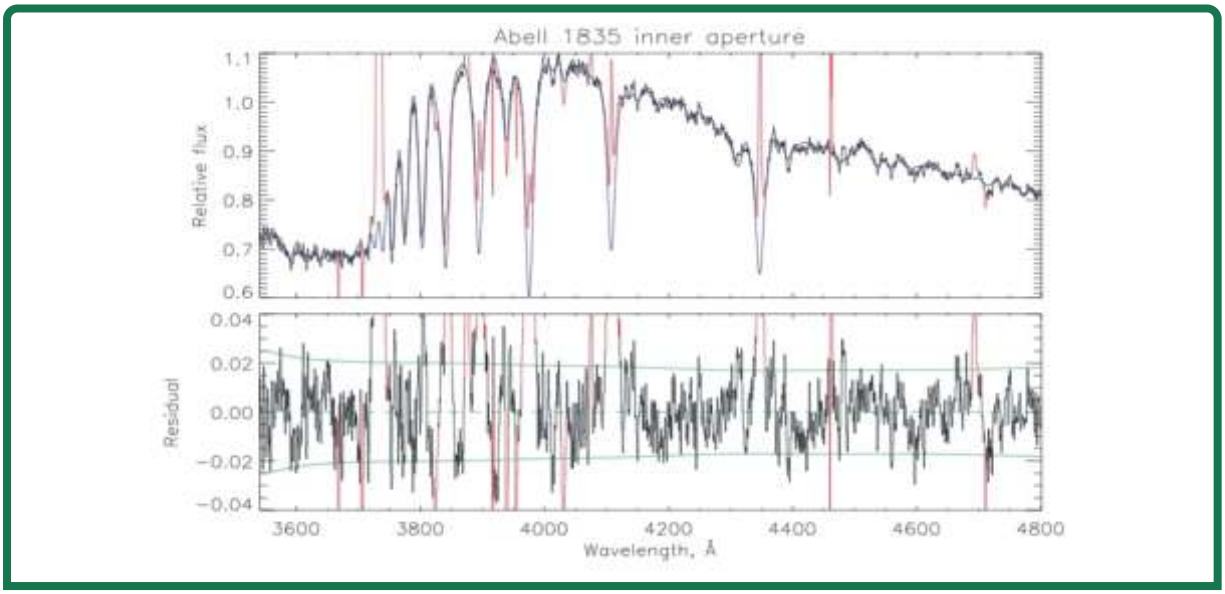


Fig 10: The image shows an optical spectrum of a well-known star forming BCG, consisting of a 7% mass fraction of a 100 Myr young stellar population providing the dominant luminosity contribution to the blue part of the optical spectrum.

A fraction of the brightest cluster galaxies (BCGs) exhibit evolutionary histories that are in stark contrast with the conventional expectation that giant elliptical galaxies in clusters are all quiescent, "red and dead" systems. BCGs, particularly those residing at the centers of cool-core clusters exhibit "blue cores" corresponding to the presence of a small fraction of young stars, and reveal activity in their radio emission, have optical emission-line nebulae, excess UV light, far-infrared emission from warm dust, and molecular hydrogen. BCGs in the nearby Universe exhibit diverse star formation histories, despite the fact that most are located in a similar, privileged environment in the centers of X-ray luminous clusters. Nearly half of galaxy clusters in X-ray selected samples have central gas cooling times < 1 Gyr, predicting star formation rates at least an order of magnitude higher (100 - 1000 $M_{\odot}$ yr^{-1}) than observed. The BCGs often host radio-loud AGN, and theoretical and X-ray studies have long suggested that the heating of the intracluster gas by these AGNs plays a key role in counteracting radiative cooling. There is now a broad consensus that in order to make sense of the full range of BCG properties, it is crucial to understand the role of cooling, feedback and gas accretion in cluster cores. However, the details of how this coupling operates and of the precise mechanism(s) linking the different phenomena remain a puzzle.

Loubser 2014 is part of a much larger, ongoing study focused on analysing various aspects (stellar populations, kinematics and dynamics, morphology and ionisation of the hot outflowing gas) of these active massive galaxies using optical spectroscopy. The authors have obtained, analysed andinterpreted detailed, high spatial and spectral resolution, long-slit observations of four BCGs obtained on SALT (Fig 10), to probe the spatially-resolved kinematics and stellar populations of the stars.

They identified plausible star formation histories of the galaxies by fitting Simple Stellar Populations (SSPs) as well as composite populations, consisting of a young stellar component superimposed on an intermediate/old stellar component, to accurately constrain their star formation histories. They also explored the relationship between the star formation history and the local environment of the BCGs (as observed in the X-ray regime). As reported by Ilani Loubser of North West University, in South Africa.

Dark Energy Tests with Quasar Monitoring

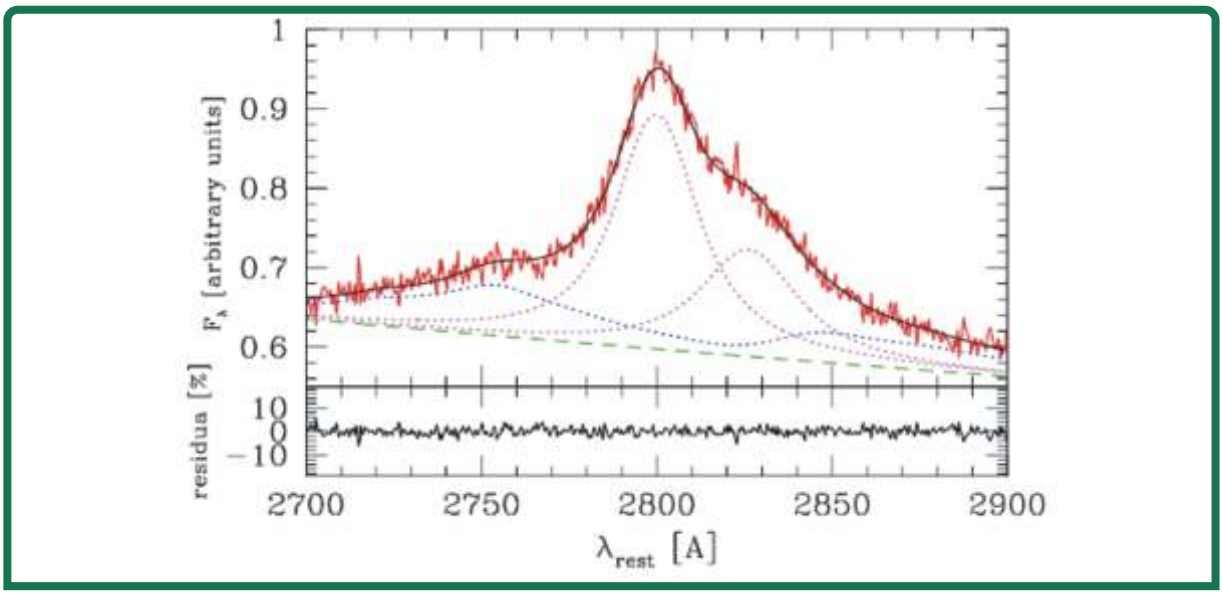


Fig 11: Decomposition of the SALT-RSS spectrum of quasar CTS C30.10 (z =0.900) into two-component MgII line(pink dotted line), Fe II pseudo-continuum (blue dotted line) and underlying continuum (dashed green line).

Quasars can be used to measure the expansion rate of the Universe. The method is based on the theory of the formation of Broad Emission Lines (Czerny & Hryniewicz, 2011). This theory implies the connection between the time delay of the lines with respect to the continuum and the intrinsic absolute monochromatic luminosity in a given source. Observationally, the project requires the measurement of this time delay, which is of order of a few hundred days for quasars at redshift 1.

Monitoring of a small sample of quasars with SALT started in late 2012. While the monitoring interval is not yet long enough to measure the time delay some important results have already been obtained, and resulted in 2 refereed papers published in 2014. In particular, Modzelewska et al. (2014) show that the Mg II line (2800 Å rest frame) in CTS C30.10, consists of two kinematic components, but only the blue component is accompanied by the Fe II pseudo-continuum (Fig. 11). This may be a general property of type B quasars but it could be noticed only due to the exceptionally high quality of the SALT data. They also confirm the absence of a separate Narrow Line Region in distant quasars, previously shown in type A quasar LBQS 2113-4538 (Hryniewicz et al. 2014) also observed with SALT. More results and papers are coming in 2015-2016. As reported by J. Modzelewska of CAMK, Poland.

Discovery of a new transition dwarf galaxy KK 258 neighbouring the Local Group:

The sport of hunting for nearby dwarfs is invigorated by the challenge to resolve the known contradiction between the few observed companions around local massive galaxies and the great amount of them from theoretical expectations that exceed by tenfold the observed numbers. Over the past 5 years, in the spherical layer within D = 1–3 Mpc, only two new dwarf galaxies were found. The interest in such solitary objects is due to an appreciation that they have not forgotten their "initial conditions" unlike virialized members of groups. Discovering even one isolated dwarf with a high peculiar velocity could disprove the coldness of the local Hubble flow with important cosmological implications.

The low surface brightness dwarf galaxy KK 258 (= ESO468-020) was expected to have a distance of 3.9 Mpc, but HST observations showed that its distance is 2.23 ± 0.05 Mpc (see Fig. 12). This fact has established KK 258 as a new dwarf galaxy near the Local Group. Spectroscopic observations with the SALT telescope identified KK 258 as possessing a heliocentric radial velocity V = 92 ±5 km/s. Thus, KK 258 has a low peculiar velocity (V_{pec} ~ 3 km/s) with respect to the local Hubble flow using H_0 = 73 km/s/Mpc (see Fig. 13).

According to its basic parameters, KK 258 looks like a typical representative of the sample of transition type dwarfs. However, unlike other dTr-galaxies, KK 258 is sufficiently isolated that tidal interactions are not likely to have affected its evolution in any way. From its spatial location KK 258 can be described as an outlier of the dwarf galaxy group around NGC 55, which contains 5 members and resides in the scattered Sculptor filament. The status of the dwarf system KK 258 in the category of isolated transition dwarfs seems difficult to explain by usual gas stripping mechanisms. As reported by Alexei Kniazev of SALT/SAAO.

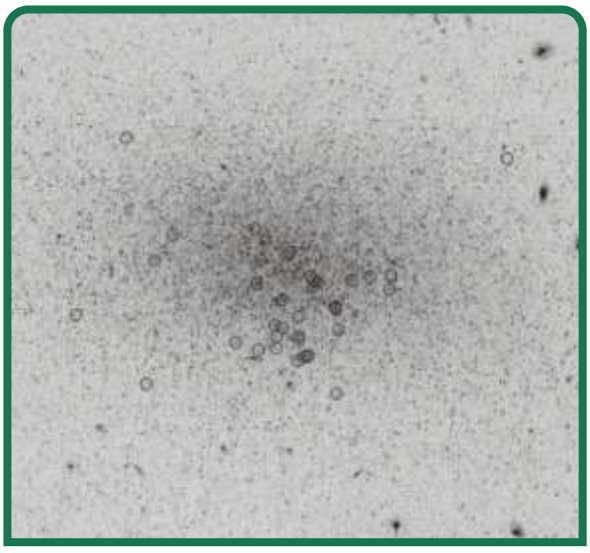


Fig 12: The HST/ACS image of KK 258 in the F606W filter. The image size is 3.0 × 1.6 arcmin. Blue stars with F606W - F814W < 0.2 and F814W < 25.5 are shown with open circles.

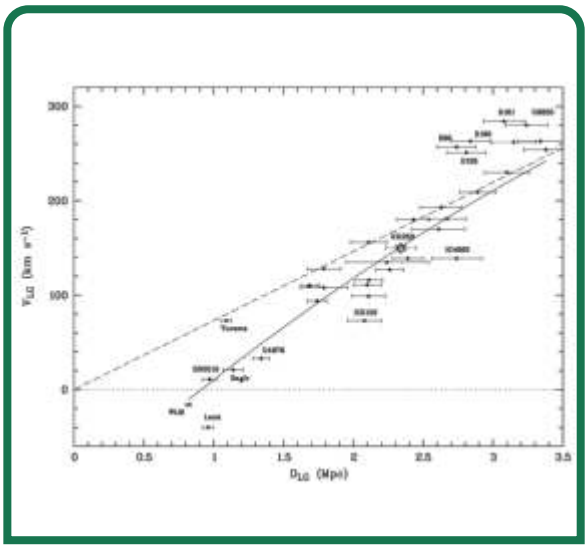


Fig 13: The relation between radial velocities and distances of the 35 nearest isolated galaxies. The position of KK 258 is shown with a star.

Star Clusters in a Nuclear Star Forming Ring: The Disappearing String of Pearls

Using archival Hubble imaging data, the group led of Petri Vaisanen (SAAO/SALT) identified a Lenticular galaxy, NGC 2338, with a very striking starburst ring around its nucleus, like a pearl necklace (Fig. 14). They took spectroscopy of the target with SALT, and combining the results of the spectral analysis of the stellar populations and gas and dust characteristics with the multi-colour photometric HST data, they were able to characterize the ring. It is very young, only a few Myr, forming a population of clusters tightly wound around the core of the galaxy. The clusters, each containing 10^3 - 10^4 stars, are blue and white in the HST image shown in Fig 14. Moreover, their ages form a sequence, getting younger in the direction of the arrows. This scenario fits together with one particular theory of ring formation, the "beads-on-a-string" model, where gas is funneled to two contact points where new stars are born and rotation moves them out systematically.

The authors also found that these clusters are disappearing very rapidly, in only a few 10^6 years. These kinds of objects are thought to be the progenitors of Globular Clusters, as in our own Milky Way. The results show that for these clusters to survive longer, they have to be ejected from the violent nuclear regions of galaxies or regions of galaxy collisions. Though the ejections can be disastrous for the survival of galaxies themselves, they are likely saviours of the clusters themselves. As reported by Petri Vaisanen of SALT/SAAO and Sudhanshu Barway of SAAO.

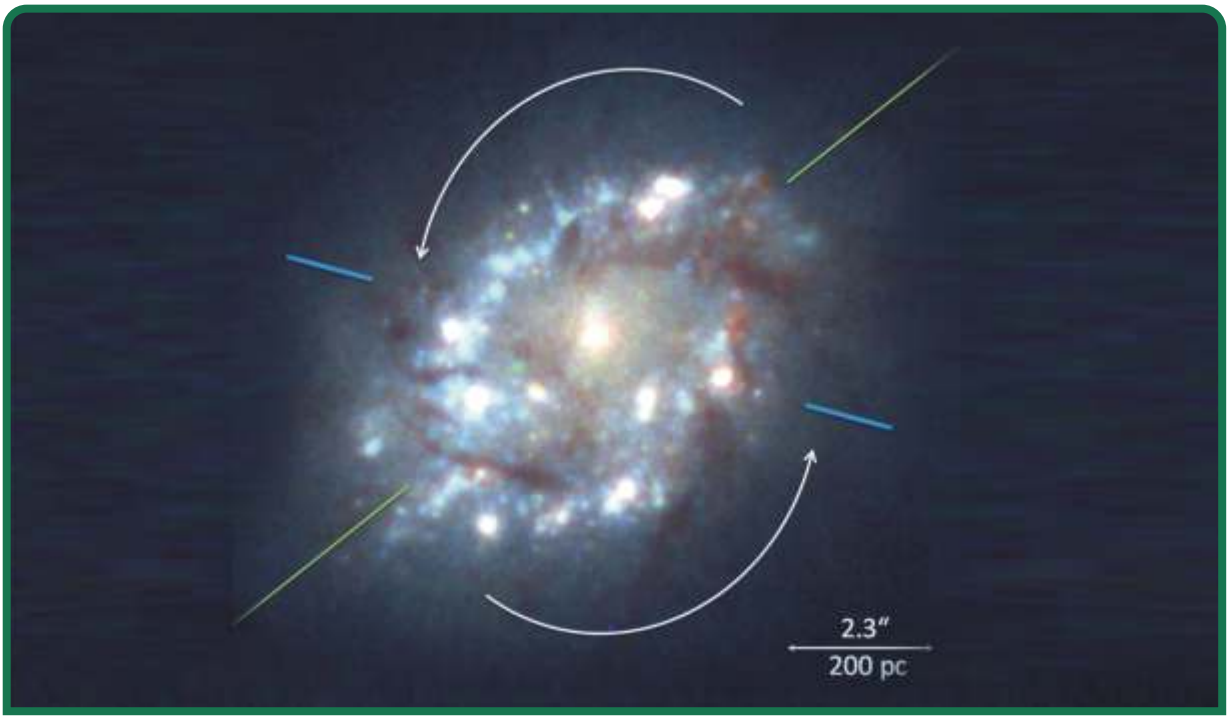


Fig. 14: This V and I-band HST/WFPC2 image shows the core of NGC2328 galaxy surrounded by bright super star clusters. SALT spectroscopy combined with HST photometry revealed the ages and masses of these clusters. Clusters get younger along the arrows. The blue lines, where the youngest clusters are positioned, are the contact points where gas funnelling towards the centre of the galaxy from the outer disk hits the ring.

Spectroscopic Survey of WISE-selected Obscured Quasars with SALT

Research into the evolution of galaxies requires an exploration of the role played by active galactic nuclei (AGNs), highly luminous objects powered by accretion onto a central supermassive black hole. It has been observed that the most luminous AGNs, namely quasars, are capable of influencing gas kinematics, temperature, and content throughout their hosts, which has far-ranging implications for galaxy-scale star formation. However, current research may be biased, as AGN are usually identified in the optical and it is vital to uncover the full population of these objects. Specifically, it is important to target obscured AGNs, where central or galaxy-scale dust blocks much of the emission from near the black hole. In these objects, the obscuration allows for properties of the host galaxy to be observed, but, selecting large numbers of obscured AGNs requires observations at longer wavelengths where dust has less of an effect on the observed spectral energy distribution (SED).

Kevin Hainline, Ryan Hickox and Christoper Carroll (Dartmouth college) and their collaborators used optical and infrared photometry from the Sloan Digital Sky Survey (SDSS) and Wide-field Infrared Survey Explorer (WISE) to select a sample of 40 objects with evidence for emission from nuclear dust heated by the presence of an AGN. By observing these objects with optical spectroscopy from the Robert Stobie Spectrograph (RSS) on SALT, one can search for the presence of optical emission lines excited by an AGN to confirm that these galaxies are indeed hosting powerful quasars. Many authors have proposed methods for using WISE photometry to select AGNs, but this survey is the first blind search for obscured AGNs based solely on their optical and infrared colors.

Forty candidate obscured quasars across three queued campaigns were observed between November 2012 and March 2014 with SALT RSS. Targets were chosen using optical to infrared colors that indicated that the optical portion of the SED was dominated by light from the host galaxy, while the infrared showed evidence for a power-law component coming from very hot dust near the black hole. Out of the 40 objects, redshift identification were made for 35 objects, and for the remaining five objects, an average redshift of $<z> = 0.52$ was found, primarily due to the optical photometric limits placed on the targets. Two galaxies were found at $z > 2.0$, and have evidence for powerful emission lines indicating they were luminous high-redshift quasars.

For the objects in the sample with reliable redshifts, emission line ratios were used to explore the source of the ionization in these objects. Results for a large number of objects where [NeIII] (386.9 nm) and [OII] (372.7 nm) were reliably measured are shown in Fig. 15. Objects in the SALT sample have large ratios of [NeIII]/[OII] and red rest-frame optical colours, in line with SDSS spectroscopically-selected AGNs. This, in combination with the broad-band SEDs for these objects, provides strong evidence that our survey did indeed result in the selection of obscured AGNs.

The results from this survey also led to the discovery of a small population of very highly obscured AGNs, where dust obscures the central black hole even into near-IR wavelengths. These objects may exist in an important stage in galaxy evolution following a major merger and SALT RSS is currently obtaining new observations to explore a larger sample of these objects. Follow-up hard X-ray observations with The Nuclear Spectroscopic Telescope Array (NuSTAR) will be obtained for the most obscured quasars in the sample.

These high-energy observations will probe the properties of the obscuration and better explore the intrinsic properties of these infrared-selected obscured quasars. As reported by Kevin Hainline, Ryan Hickox and Christoper Carroll of Dartmouth College.

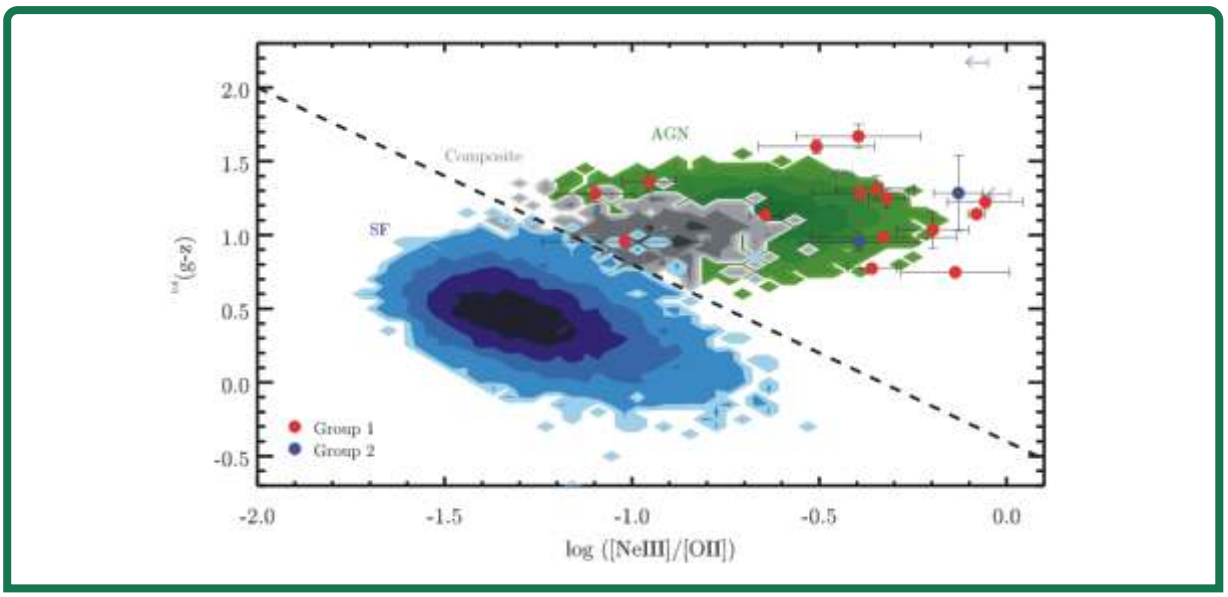


Fig 15 : Rest-frame g-z color plotted against log([NeIII]3869 / [OII]3727) flux ratio. SALT objects in the sample with significant detections of [NeIII] and [OII] are plotted with red and blue points based on the photometric criteria used to select them. Also plotted are SDSS galaxies initially selected in Trouille et al. (2011 ApJ, 742, 46) from their position on the standard optical emission-line diagnostic "BPT diagram" (Baldwin et al. 1981 PASP, 93, 5) with green (AGNs), blue (star-forming), and grey (composite) contours. The objects that comprise the SALT sample have positions on this diagram similar to BPT-selected AGNs, and, supported by evidence from SED decomposition for these sources, they are likely luminous obscured quasars.

A dust-unbiased quasar sample for the MeerKAT Absorption Line Survey (MALS)

The MeerKAT Absorption Line Survey (MALS) is one of the ten large surveys to be carried out with the MeerKAT radio telescope in South Africa. The main objective of the survey is to carry out a sensitive blind search for HI 21-cm and OH absorption lines, and trace the evolution of cold atomic and molecular gas in galaxies at z<1.5 . A dust-unbiased sample of bright (>200 mJy at 1 GHz) radio loud quasars (RLQs) at z>1.5 is required to achieve this and build a comprehensive picture of high-z interstellar medium and its relationship with the ongoing starformation in the host galaxies. Researchers from IUCAA, together with those at institutes in South Africa and Rutgers, are carrying out an ambitious spectroscopic campaign at optical wavelengths with SALT to build the first, large, purely infra-red selected sample of radio loud quasars (RLQs) at z>1.5 , that will be well-suited for MALS and also address various fundamental issues related to the initial phases of AGN evolution. As part of this campaign the team is observing a sample 300 RLQs using SALT.

The sample is purely selected on the basis of WISE IR colors (see Fig. 15) i.e. is dust unbiased. To date they have observed about 150 candidates. The data analysis is in progress and has led to the discovery ~70 new RLQs at z>1.5 (see Fig. 16). As reported by Neeraj Gupta of IUCAA, India.

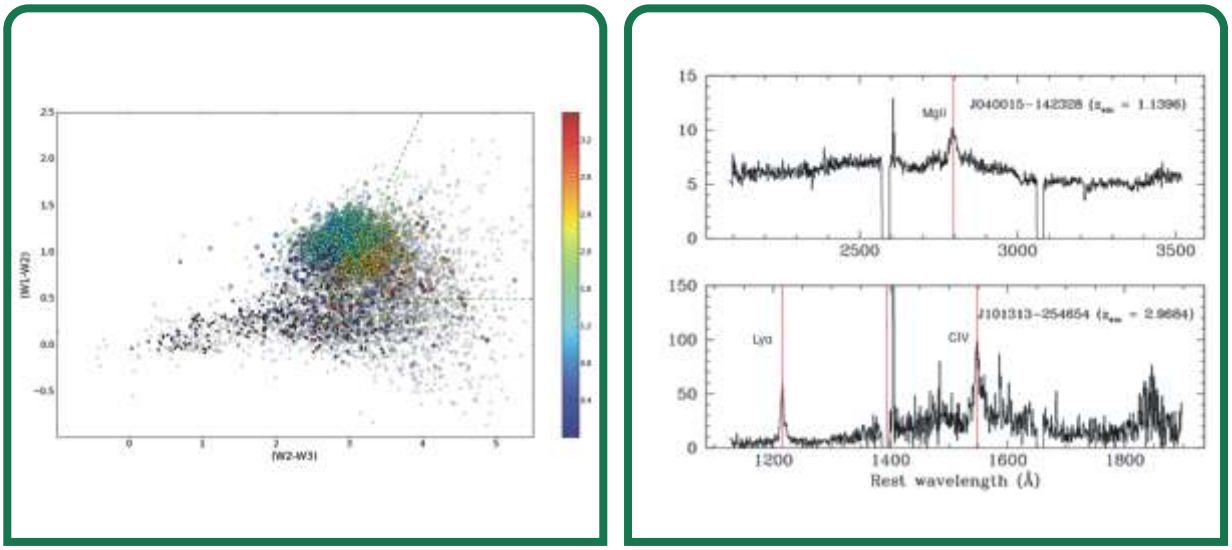


Fig 16: Left: WISE IR colours for radio sources (dec <20°, >200mJy) (grey). Galaxies identified in the literature are shown as small black points while known quasars are colour-coded as a function of their redshift. The dashed line mark the region (selection criteria) used to select candidates from SUMSS and NVSS. Right: SALT spectra of two candidate RLQs.

Gravitationally Lensed Supernovae behind CLASH Galaxy Clusters

Patel and collaborators have presented observations of three gravitationally lensed supernovae behind massive galaxy clusters in the Hubble Space Telescope CLASH Multi-Cycle Treasury program (see Fig. 17). SALT RSS spectroscopy was used by Saurabh Jha and graduate students Brandon Patel and Curtis McCully (all at Rutgers University) to measure the redshift of the host galaxy of one of these supernovae (with emission lines giving z = 1.14). Excitingly, two of the three objects were Type Ia supernovae (SNe Ia), "standardizable" candles whose intrinsic luminosity can be inferred from measurement of their multi-color light curves. Patel et al. showed that the SNe Ia were brighter than other "field" SNe Ia at similar redshifts, and ascribe this to gravitational lensing magnification. The authors compared the absolute lensing magnification inferred from the supernova observations to the predicted magnification from the cluster mass models and found good quantitative agreement. In the future, the supernova-measured magnifications will be used as inputs to the lens models, allowing for a better understanding of the distribution of luminous and dark matter in galaxy clusters. As reported by Saurabh Jha of Rutgers University.

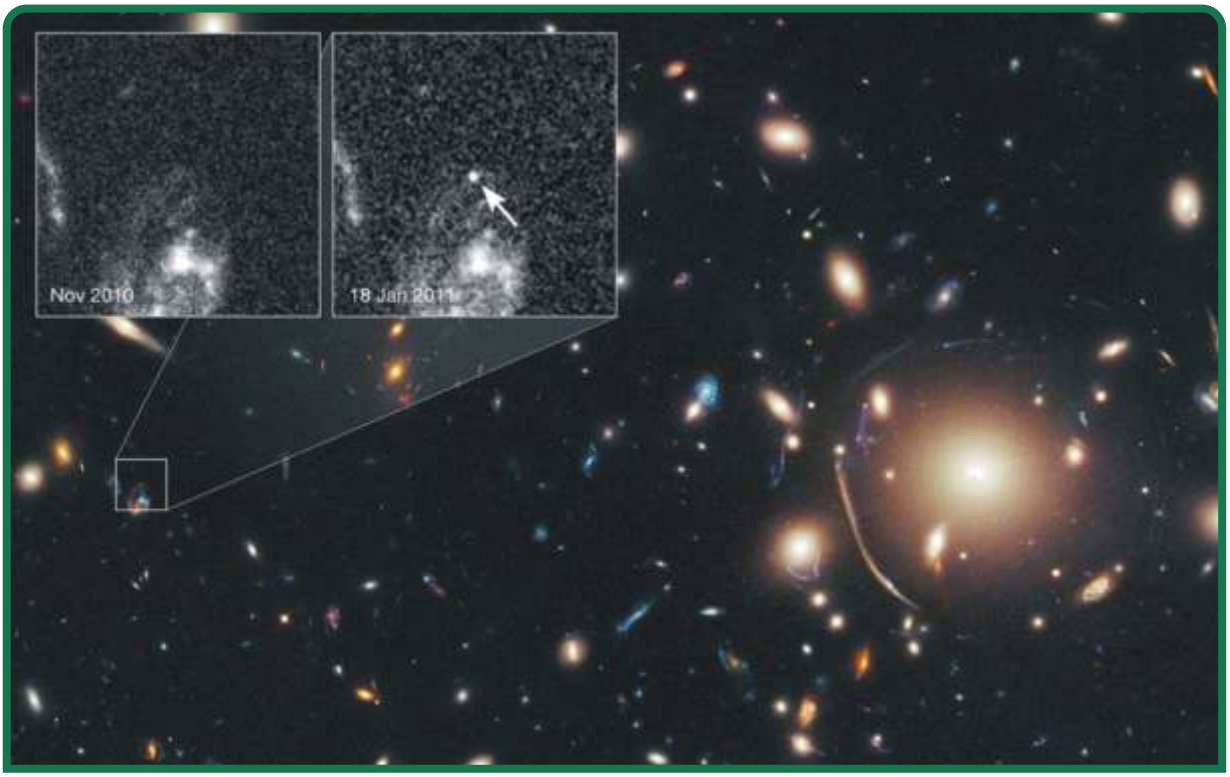


Fig 17: A Supernova detected in a strongly lensed galaxy.

Spectroscopic observations of Galaxy Clusters and a type II Quasar detected by ACT

The Atacama Cosmology Telescope (ACT) project is a large international collaboration of scientists that is surveying the southern sky at mm - band wavelengths to map the Cosmic Microwave Background (CMB). One main goal of the project is an accurate census of massive clusters of galaxies, which can be detected by ACT using the distinctive spectral signature they imprint on the CMB spectrum. ACT researchers at several South African institutions (University of KwaZulu - Natal, University of Western Cape, and the South African Astronomical Observatory) and Rutgers University are collaborating on multiwavelength studies of the ACT cluster sample.

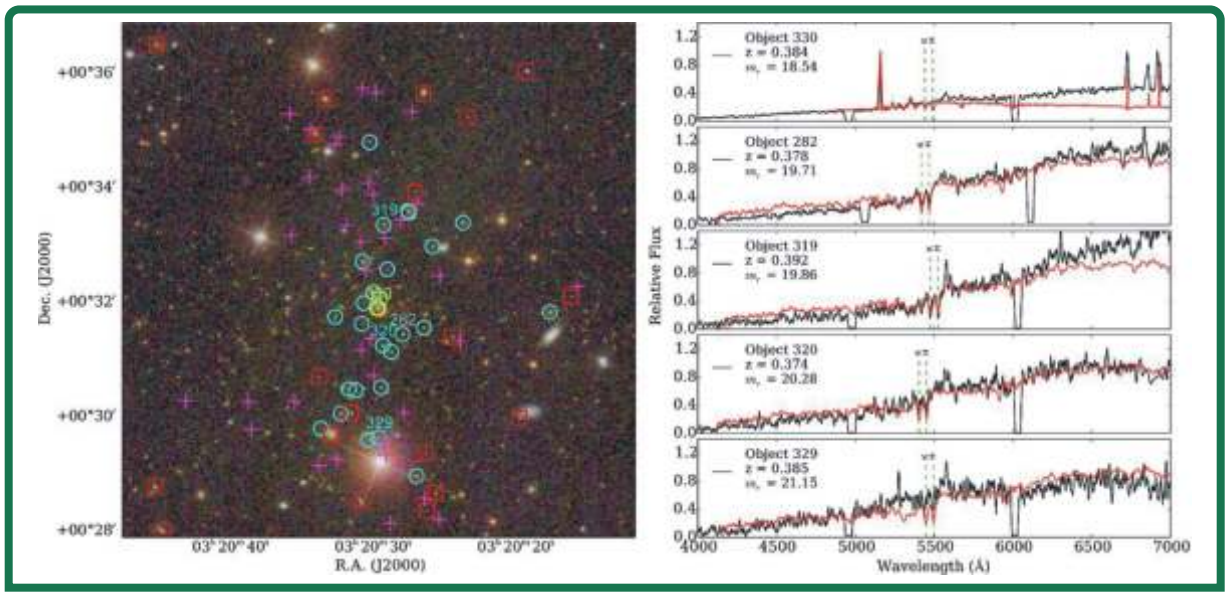
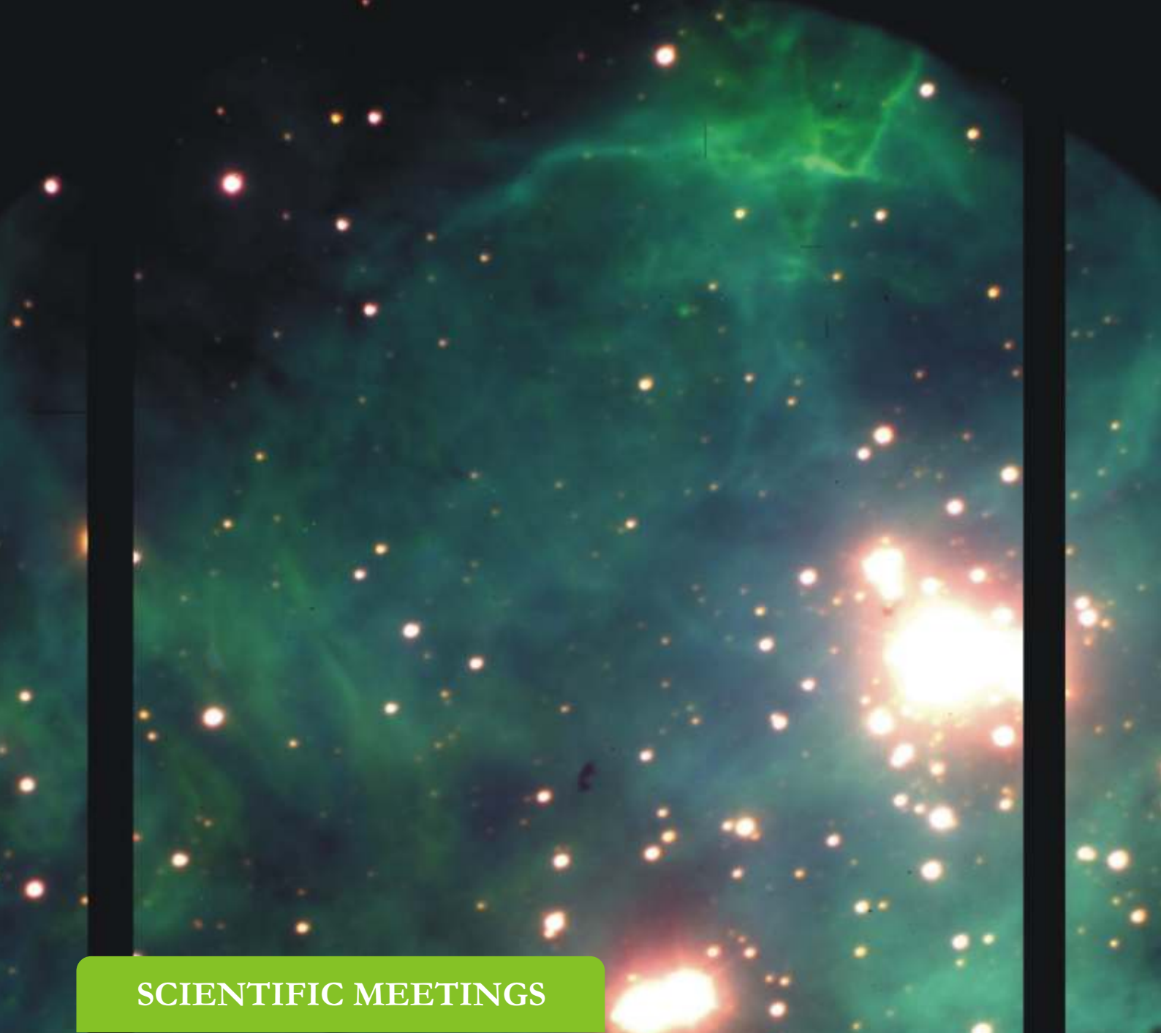


Fig 18: The z = 0.38 cluster ACT-CLJ0320.4+0032. The left-hand panel shows 9 arcmin x 9 arcmin false colour SDSS optical image (g, r, i). Objects highlighted with cyan circles are spectroscopically confirmed members. Spectra for objects marked with ID numbers are shown in the right-hand panel. Black lines correspond to SALT RSS spectra (smoothed with a 10 pixel boxcar), while red lines show the best-matching redshifted SDSS spectral template in each case.

In this SALT project the team used the multi-object spectroscopic mode of the Robert Stobie Spectrograph to measure the redshifts of 191 galaxies in 7 massive galaxy clusters discovered by ACT. For each cluster a dynamical mass estimate was obtained from the line-of-sight velocity dispersion of member galaxies; values obtained ranged from 5×10^{14} $M_{\odot}$ to 2×10^{15} $M_{\odot}$. These results are being used in a follow-up ACT study to set cosmological constraints from the ACT cluster sample. For one particular cluster, ACT-CL J0320.4+0032 at z = 0.38, shown in the accompanying figure (Fig. 18) our RSS observations revealed that the brightest cluster galaxy (Object 330 in the figure) hosts a Type II quasar, which is rare among known systems. Additional follow-up observations are underway to investigate this system in more detail. As reported by Jack Hughes and Matt Hilton based on Kirk et al., submitted in Oct 2014 and now published as 2015, MNRAS, 449, 4010.



SCIENTIFIC MEETINGS

SALT Science workshop at IUCAA

A one day SALT-science workshop was held in IUCAA, Pune prior to the 36th meeting of the SALT board, in November. There were talks by the SALT users from IUCAA and representatives from the partner institutions covering wide range of science topics. There were presentations of research summaries from all the SALT partner institutes. Faculty members and students from different Indian universities participated in this workshop. A public lecture was arranged in the evening. There was good participation of general public for this lecture.




EDUCATION & PUBLIC OUTREACH

The SALT Collateral Benefits Division of SAAO reached very large number of people through various education and outreach activities during 2014. These activities, which included public tours to SALT, visits at the Sutherland Visitor centre, social development activities in the Community Development Centre, teacher training, astronomy quiz, public lectures, stargazing sessions and many others targeted the members of the general public, teachers and learners.

Public Visits to SALT

SALT has thoroughly transformed Sutherland into one of South Africa's, and particularly the Northern Cape's, prime tourist attraction. The Observatory hosted 13,721 visitors in 2014 in the form of day and night tours. The day tours include visits to the SALT and other telescopes located on the plateau, tour and interaction with the exhibits in our Visitor Centre, an astronomy talk and when possible interaction with available astronomers. The Night tours include an introduction to the night sky, tour of Visitor Centre and a stargazing session at our Visitor Telescopes. The number of repeat visitors is increasing and this is an indicator of the power of the beautiful Sutherland skies, our telescopes and the welcoming and enthusiastic nature of tour guides in Sutherland.

The Sutherland Community Development Centre

The Sutherland Community Development Centre, which we open in 2012, continues to be a beacon of hope and platform for community development in Sutherland. There were numerous activities organised in the Centre during the year.

The Book and DVD of the film entitled "My room at the centre of the Universe" was launched at the Community Development Centre. The Book and the DVD are educational resources that were developed by SALT Collateral Benefit Program (SCBP) in partnership with Africa meets Africa. 180 local residents attended the event, which was a proud moment for the community as the cast members of the DVD were children of




Sutherland. The SCBP supported a variety of local upliftment and other charitable initiatives in the Sutherland and the surrounding district during the year. Members of the public, particularly the learners and teachers based in Sutherland, continue to make use of the computers in the community development centre.

The Sutherland Visitor Centre

The SCBP team is continuously monitoring, maintaining and developing the Visitor Centre. New interactive exhibits have been included in the Visitor Centre and on the plateau, including "the people's dome"- a dome which has a clear view of the night sky and - is a symbolic acknowledgment of the role by the community in preserving the pristine night skies and also their good relationship with the Observatory. The iPad exhibit consisting of three iPads loaded with astronomy software, quizzes and films has been added at the Visitor Centre. Lastly a Cultural exhibit featuring the oldest member of the Sutherland community (a 106 year old Oom Cloete) is also included.




CORPORATE GOVERNANCE

The affairs of the SALT Foundation are regulated by the Shareholder's Agreement, signed at the formation of the Company.

In terms of this agreement, the Company is controlled by a Board of Directors comprising two members from the National Research Foundation and one member from all the remaining partner institutions. The Directors are elected at the Annual General Meeting of the Company and serve for a period of three years, following which they may be re-elected.

With the exception of Dr. Darragh O'Donoghue, all Board members are independent, Non-Executive Directors. In this reporting period, the Board comprised of the following members:

Prof Michael Shara
(Chair) American Museum of Natural History

Prof Brian Chaboyer
Dartmouth University

Prof Gordon Ernest Bromage
United Kingdom SALT Consortium

Prof Chris Clemens
University of North Carolina

Prof John P. Hughes
Rutgers University

Prof Ajit Kembhavi
Inter-University Centre for Astronomy & Astrophysics

Prof Wolfram Kollatschny
Göttingen University

Dr Darragh O'Donoghue
National Research Foundation

Prof Larry Ramsey
(Resigned 19/11/2014)
Hobby-Eberly Telescope Board

Prof Roger Reeves
(Resigned 4/6/2014)
University of Canterbury

Prof Michael Albrow
(Appointed 4/6/2014)
University of Canterbury

Prof Marek Sarna
Nicolaus Copernicus Astronomical Centre

Dr Albert van Jaarsveld
(Resigned 19/11/2014)
National Reseach Foundation

Prof Nithaya Chetty
(Appointed 19/11/2014)
National Research Foundation

Other officers of the Company include **Mrs. Lizette Labuschagne** (Chief Financial Officer) and **Mr. Ismail Osman** (Company Secretary and Business Manager).

The Board meets twice a year, usually in May and November. The SAAO Director and senior staff involved in the operations of the telescope also attend the Board meetings.

Operations Contract

In terms of the Shareholder's Agreement, SALT is operated on behalf of the SALT Foundation by the SAAO and managed by the SAAO Director. With the exception of Dr. David Buckley and Dr. Darragh O'Donoghue, the staff who carry out the day-to-day operational activities are SAAO employees. Drs. Buckley and O'Donoghue are the SALT Foundation's only two employees and they assist the SAAO with the execution of the SALT Operations Contract: Dr. Buckley is the SALT Science Director and Astronomy Operations Manager and Dr. O'Donoghue is the SALT Instrumentation Director. Engineering operations are managed by the SALT Technical Operations Manager, Mr. Chris Coetzee.

The operations plan and budget are presented by the SAAO Director at the November Board meeting for the following financial year.

The Board Executive Committee

The Board has delegated authority to the Board Executive Committee (BEC) to manage the Company during the period between Board meetings. The BEC meets every 6 weeks and receives reports on the operations and development of the telescope from the SAAO Director and other senior staff with the relevant responsibility. The BEC comprises 4 Board members. In this reporting period, they were: Prof. Mike Shara (Chair), Prof. Larry Ramsey, Prof. Brian Chaboyer and Dr. Darragh O'Donoghue.

The Finance and Audit Committee

Although the full Board takes responsibility for the Annual Financial Statements of the Company, the Board has appointed a Finance and Audit Committee (FAC) to interrogate the management of the financial affairs of the Company at a detailed level. This committee meets at least twice a year, shortly before Board meetings, and presents a report at the Board meeting. In this reporting period, the members of the FAC were: Prof E. Wilcots (Chair), Prof M. Wybourne, Prof G. Bromage, Prof J. Hughes and Prof R. Reeves.

Technical Operations Team

Adelaide Malan
Anthony Koeslag
Chris Coetzee
David de Bruyn
Deneys Maartens
Denville Gibbons
Eben Wiid
Etienne Simon
Francois Strümpfer
Grant Nelson
Hitesh Gajjar
Janus Brink
Johan Hendricks
Jonathan Love
Keith Browne
Martin Wilkinson
Nicolaas Jacobs
Ockert Strydom
Paul Rabe
Raoul van den Berg
Timothy Fransman
Vic Moore
Willa de Water
Wouter Lochner

Astronomy Operations Team

David Buckley
Steve Crawford
Éric Depagne
Christian Hettlage
Thea Koen
Paul Kotze
Alexei Kniazev
Fred Marang
Brent Miszalski
Encarni Romero-Colmenero
Luke Tyas
Veronica van Wyk
Petri Vaisanen

LIST OF PUBLICATIONS

Publication: Refereed Journals

01. Bufano, F., Pignata, G., Bersten, M., et al., "SN 2011hs: a fast and faint Type IIb supernova from a supergiant progenitor", 2014, MNRAS, 439, 1807.

02. Danehkar, A., Todt, H., Ercolano, B., et al., 2014. "Observations and three-dimensional photoionization modelling of the Wolf-Rayet planetary nebula Abell 48", 2014, MNRAS, 439, 3605.

03. de Martino, D., Casares, J., Mason, E., et al, "Unveiling the redback nature of the low-mass Xray binary XSS J1227.0-4859 through optical observations", 2014, MNRAS, 444, 3004.

04. Feast, M. W., Menzies, J. W., Matsunaga, N., Whitelock, P. A., "Cepheid variables in the flared outer disk of our galaxy", 2014, Nature, 509, 7500, 342.

05. Gvaramadze, V. V., Kniazev, A. Y., Berdnikov, L. N. et al., "Discovery of a new Galactic bona fide luminous blue variable with Spitzer", 2014, MNRAS, 445, 74.

06. Gvaramadze, V. V., Chené, A.-N., Kniazev, A. Y et al., "Discovery of a new Wolf-Rayet star and a candidate star cluster in the Large Magellanic Cloud with Spitzer", 2014, MNRAS, 442, 929.

07. Gvaramadze, V. V., Menten, K. M., Kniazev, A. Y et al., "IRC -10414: a bow-shock-producing red supergiant star", 2014, MNRAS, 437, 843.

08. Hainline, K. N., Hickox, R. C., Carroll, C. M., et al., "Spectroscopic Survey of WISE-selected Obscured Quasars with the Southern African Large Telescope", 2014, ApJ, 795, 124.

09. Hajduk, M., Gładkowski, M., Soszyński, I., "Search for binary central stars of the SMC Pne", 2014, A&A 561, A8.

10. Hajduk, M., van Hoof, P.M., Gęsicki, K. et al., "The evolving spectrum of the planetary nebula Hen 2-260", 2014, A&A 567, 15.

11. Holdsworth, D.L., Smalley, B., Gillon, M., et al, "High - frequency A - type pulsators discovered using SuperWASP" 2014, MNRAS, 439, 2078.

12. Hryniewicz, K., Czerny, B., Pych, W., et al., "SALT spectroscopy of LBQS 2113-4538: variability of the MgII and FeII component", 2014, A&A 562, A34.

13. Jones, D., Boffin, H. M. J., Miszalski, B et al., "The post-common-envelope, binary central star of the planetary nebula Hen 2-11", 2014, A&A, 562, 89.

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15. Karachentsev, I. D., Makarova, L. N., Tully, R. B et al., "KK258, a new transition dwarf galaxy neighbouring the Local Group", 2014, MNRAS, 443, 1281.

16. Kilkenny, D.; Welsh, B. Y.; Koen, C et al., "A search for p-mode pulsations in white dwarf stars using the Berkeley Visible Imaging Tube detector", 2014, MNRAS, 437, 1836.

17. Loubser, S. I., "Stellar populations in central cluster galaxies: the influence of cooling flows", 2014, MNRAS, 439, 416.

18. Margutti, R., Milisavljevic, D., Soderberg, A. M., et al., "A Panchromatic View of the Restless SN 2009ip Reveals the Explosive Ejection of a Massive Star Envelope", 2014, ApJ, 780, 21.

19. Milisavljevic, D., Margutti, R., Crabtree, K. N. et al., "Interaction between the Broad-lined Type Ic Supernova 2012ap and Carriers of Diffuse Interstellar Bands", 2014, ApJ, 782, L5.

20. Miszalski, B. & Mikołajewska, J., "Identification of new Galactic symbiotic stars with SALT - I. Initial discoveries and other emission line objects", 2014, MNRAS, 440, 1410.

20. Miszalski, B. & Mikołajewska, J., "Identification of new Galactic symbiotic stars with SALT - I. Initial discoveries and other emission line objects", 2014, MNRAS, 440, 1410.

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22. Modzelewska, J., Czerny, B., Hryniewicz, K. et al., "SALT long-slit spectroscopy of CTS C30.10: two-component Mg II line, 2014", A&A, 570, A53.

23. Narloch, W., Kaluzny, J., Krzeminski, W. et al., "New observations of the old magnetic nova GQ Mus", 2014, Baltic Astronomy 23, 1.

24. Norris, M.A., Kannappan, S.J., Forbes, D.A., et al, "The AIMSS project - I. bridging the star cluster-galaxy divide", 2014, MNRAS, 443, 1151.

25. Onofrio, R., & Wegner, G. A. , "Search for Higgs Shifts in White Dwarfs", 2014, The ApJ, 791, 125.

26. Oszkiewicz, D.A., Kwiatkowski, T., Tomov, T. et al., "Selecting asteroids for a targeted spectroscopic survey", 2014, A&A, 572, A29.

27. Patel, B., McCully, C., Jha, S. W., et al., "Three Gravitationally Lensed Supernovae behind CLASH Galaxy Clusters", 2014, ApJ., 786, 9.

28. Semena, A. N.; Revnivtsev, M. G.; Buckley, D. A. H. et al., "On the area of accretion curtains from fast aperiodic time variability of the intermediate polar EX Hya", 2014, MNRAS, 442, 1123.

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31. Wold, I.G.B., Barger, A.J., Cowie, L.L ., "z ~ 1 Lyα emitters. I . The luminosity function", 2014, ApJ, 783: 119.

32. Zhekov, S.A., Tomov, T., Gawronski, M.P., et al., "A multiwavelength view on the dusty Wolf-Rayet star WR 48a", 2014, MNRAS, 445, 1663.

Non-Refereed Publications

01. Brink, Janus D.; Strydom, Ockert J.; O'Donoghue, Darragh E.; Wiid, Eben P., "Commissioning the SALT fiber instrument feed", 2014, Advances in Optical and Mechanical Technologies for Telescopes and Instrumentation, Proceedings of the SPIE, Volume 9151, id. 915121.

02. Buckley, D.A.H., Potter, S.B., Kotze, E., et al. 2014. "New observations of accretion phenomena in magnetic cataclysmic variables". Physics at the Magnetospheric Boundary, Geneva, Switzerland, Edited by E. Bozzo; P. Kretschmar; M. Audard; M. Falanga; C. Ferrigno; EPJ Web of Conferences, 64: 07005.

03. Crause, Lisa A.; Sharples, Ray M.; Bramall, David G. et al., "Performance of the Southern African Large Telescope (SALT) High Resolution Spectrograph (HRS)", Ground-based and Airborne Instrumentation for Astronomy V, Proceedings of the SPIE, Volume 9147, id. 91476T.

04. Crawford, S.M., Koeslag, A., Romero-Colmenero, E., et al., 2014. "Tracking progress: monitoring observing statistics and telescope usage at the Southern African Large Telescope" Observatory: Proceedings of the SPIE, Volume 9149, id.: 914909-1. eds.Alison B. Peck, Chris R. Benn, Robert L. Seaman.

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13. Loubser, I., "Dissecting galaxies with the Southern African Large Telescope (SALT)", 2014, AAS, 22340402L

14. Throop, Henry B.; Gulbis, Amanda; Grundy, Will, et al., "New rotationally resolved spectra of Pluto-Charon from 350 - 900 nm", 2014, DPS4640404T

15. Wolf, M.J., Mulligan, M.P., Smith, M.P., et al., 2014. Project status of the Robert Stobie spectrograph near infrared instrument (RSS-NIR) for SALT. Ground-based and airbone instrumentation for astronomy V,: Proceedings of the SPIE, Volume 9147, id. 91470B eds. Suzanne K. Ramsay, Ian S. McLean and Hideki. Takalami. SPIE. *http://adsabs.harvard.edu/abs/2014SPIE.9147E..0BW*

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