# SALT Newsletter

**April 2023**

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Editor: Anja C. Schröder

Cover image: A snapshot of SALT from the video "SALT in 59 seconds"

Above image credit: Melanie Saayman

# Letter from the Head of Astro Ops

Dear SALT Community,

As many of you already know, SALT is currently offline until further notice due to unforeseen tracker repairs. At the time of writing, we're looking at a minimum period of a week, but it could be longer. If you want to know more of the gory details, we have written a very short snippet below. We will, as always, keep you updated.

Before the terrible tracker news came along, we actually had quite good news to share with you! The optics repair for RSS finally took place in March and it went exceptionally well! RSS has been back on the telescope since 31 March and is taking data without a hitch. It was an awesome team effort led by Melanie — Lee and Melanie explain it all below.

The RSS detector upgrade project is also progressing well — Ros gives us a brief update below.

The commissioning of the new instrument on the block, NIRWALS, is going significantly slower than we hoped — partly to do with the telescope and partly to do with the instrument itself. In fact, this week we will be warming up the instrument in order to lubricate the focus mechanism, and it should be cold again by the end of the week. We are not sure when we'll begin on-sky commissioning in earnest yet, but it's unlikely to happen before the end of May. Moses and Marsha also give more details below.

A big thank you from us to all of our PIs for submitting all of the phase 2 proposals by the deadline. This means a lot to us — it allows us plenty of time to review them and discuss any possible changes directly with the PIs prior to activation. And sometimes, depending on how the queue looks during the night, we can even start the new semester observations before the official start date — so it's a win-win! ☺

To finish off, our Meet the Team section introduces Janus Brink, who has actually been working at SALT since the beginning of the project! Janus has recently relocated to Austria, so we figured it was a good reason to introduce himself.

Looking forward to seeing you all in Poland 1 –3 June 2023 for the SALT science conference!

Clear skies and stay safe!

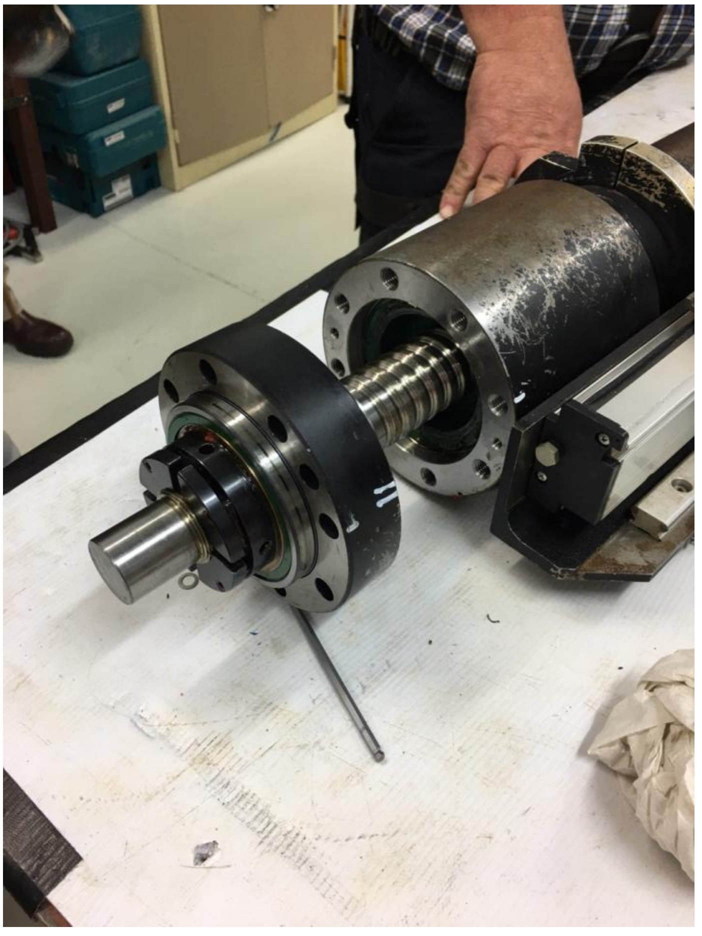
Encarni

# Breaking News – SALT is offline

SALT has been offline since 12 April and we do not yet know when we'll be back on sky.

The reason is damage to one of the hexapod legs on the tracker, H4. The only symptom we had was a series of abnormal tracker stops, which went from a rare event to more and more frequent, severely disrupting observations. After much trouble-shooting, we found that there is severe damage to a lead screw, its nut and the ball-bearings, all of which were found to be dry and rusty and all of which need to be replaced. This was likely caused by a corroded and damaged seal.

Despite their simple name (lead screw, nut and ball-bearings), all of these components are not at all easy to manufacture — and we do not have spares. We have managed to source some new components, made of a different material, which will need to be modified slightly before re-assembly and re-installation. This should tide us over until proper replacement parts can be manufactured and delivered. And yes, while we're off sky, TechOps will also take the opportunity to inspect all of the other hexapod legs! ;)



Even so, the repairs will likely take around a week or so. But watch this space — we'll definitely keep you posted.

*Encarni Romero Colmenero.--*

# SCIENCE HIGHLIGHT

## SALT discovers 8 super-hot white dwarfs and pre-white dwarfs

by Simon Jeffery (Armagh Observatory and Planetarium, UK)

*ABSTRACT. The SALT survey of chemically-peculiar hot subdwarfs found several stars that could not be classified as conventional hot subdwarfs. Eight of these turned out to be extremely hot stars with effective temperatures between 110,000 K and 180,000 K. One is a white dwarf, the remainder are pre-white dwarfs, that is, they are contracting towards the hot end of the white dwarf sequence. Follow-up photometry showed that two are pulsating GW Vir stars. One is the central star of a previously unknown planetary nebula (JeWeKi 1). Four are record-breakers: the hottest DO white dwarf, the two hottest GW Vir stars, and the hottest 'naked' O(H) star.*

--------------------------------------------

The SALT survey of chemically-peculiar hot subdwarfs dates back to the commissioning of the HRS, when we started to investigate helium-rich subdwarf B (He-sdB) stars from the Edinburgh Cape faint blue survey. In 2018, we accelerated the survey in collaboration with South African partners and by using RSS to reach fainter stars. Phase 1 provided classifications for ~100 stars (Jeffery et al. 2021) and, now, we have reached the 300-star milestone.

Selection criteria evolved from only He-sdB stars to any 'helium-rich subdwarf' visible to SALT. Hot subdwarfs up to and hotter than 50,000 K are easily classified by comparing the strengths of lines from hydrogen and neutral and ionised helium. Further stars were added using *Gaia* colours and luminosities. Inevitably, several turned out to not be hot helium subdwarfs. These included normal hot subdwarfs, stars with broad helium absorption lines — white dwarfs — and stars with helium and other emission lines.

We almost discarded these new emission-line stars for being 'out of class' until we recognised their similarity to the central star of the planetary nebula NGC 246, a PG1159 star observed early in the survey. Checking our SALT data, we identified seven emission line stars and one DO white dwarf (Fig. 1), and measured surface temperatures, gravities and helium/hydrogen ratios. The new discoveries range in surface temperature from 110,000 to 180,000 K. They correspond to four different classes, explained as follows.

The nuclear evolution of a low-mass star ends with a hot (100 million K) earth-sized core made of carbon and oxygen, surrounded by a helium shell, surrounded by an enormous hydrogen envelope, which forms an asymptotic giant branch star. Nuclear reactions at the base of the hydrogen envelope make the surface of this supergiant over 100 times the size of the Sun. A combination of nuclear burning and stellar wind depletes the hydrogen, ejects a giant gas cloud (or nebula) and switches off the nuclear reactions. With nuclear power reduced, the luminous star quickly shrinks. The surface heats until, when about the size of the Earth, the star cannot shrink any more and becomes a white dwarf.

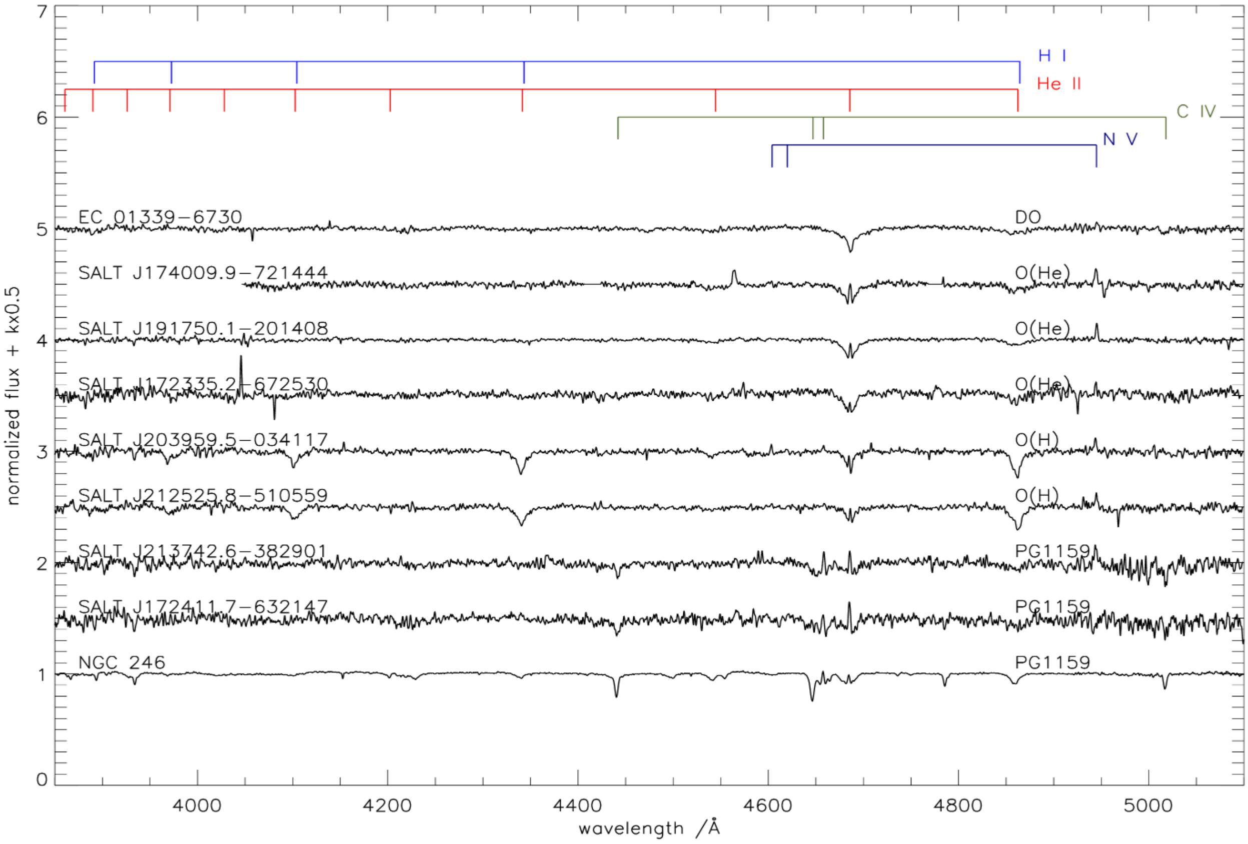



Figure 1. SALT/RSS spectra of hot white dwarfs and pre-white dwarfs. Identifiers are on the left and spectral classes are on the right. Positions of principal lines are indicated at the top. The data are slightly smoothed (FWHM = 0.5 Å). Gaps in the spectrum of J1740 are replaced by continuum. The spectrum of a well-known PG1159 star, the central star of NGC 246, is included for comparison.

Such stars have hydrogen-rich surfaces and when hotter than 100,000 K are known as O(H) stars. They will ionise any remaining surrounding gas to become visible as a planetary nebula. Of two such stars in the SALT sample, J2125 is the central star of a planetary nebula (Fig. 2). J2039 is the hottest O(H) star without a nebula.

Some stars that pass through the O(H) phase and become white dwarfs can re-ignite the helium shell in a very late thermal pulse. Helium-shell ignition drives a convection zone upwards to carry helium and carbon to the surface, and to dredge surface hydrogen down to regions where it is destroyed. The star expands rapidly on a timescale of days to months to become a cool supergiant. Later, it will contract to become a white dwarf once again. This time, however, the surface is helium, carbon and oxygen rich, and hydrogen poor.

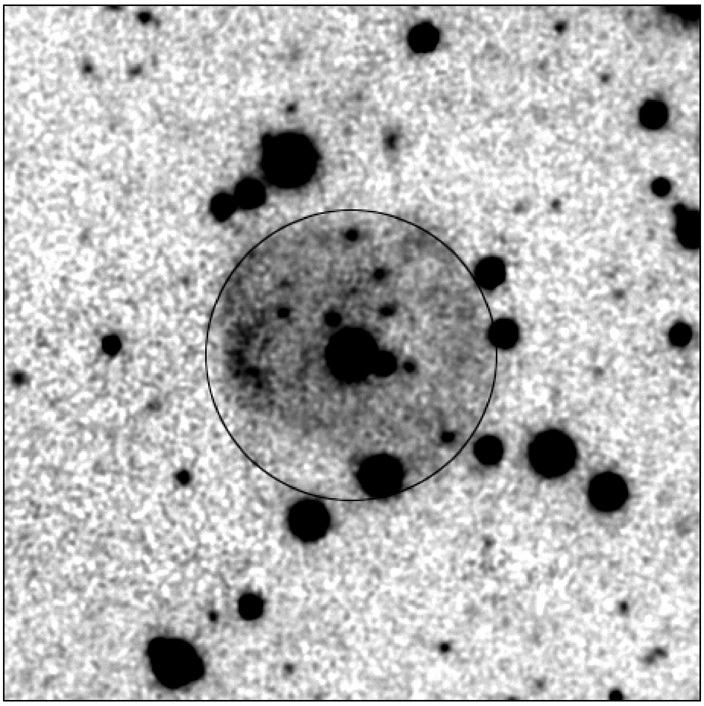


Figure 2. A smoothed g-band image of O(H) star J2039 from the DECam legacy survey revealing the surrounding PN. The circle has an angular diameter of 50 arcsec and the image measures 2 × 2 arcmin2 with north up and east to the left.

Two stars in the SALT sample (J1724 and J2137) show tell-tale signs of strong ionised helium and also emission lines from triply ionised carbon. These two new PG1159 stars were also hot enough to be in the region of the HRD where they can pulsate; such stars are known as GW Vir variables. Dave Kilkenny very promptly showed that, indeed, both stars are pulsating with multiple periods (Figure 3). With surface temperatures of 160,000 and 180,000 K respectively, J1724 and J2137 are the hottest stars in our sample and the two hottest GW Vir stars known.

Three more stars showed ionised helium and nitrogen emission, but without carbon (J1740, J1917, and J1723). These O(He) stars are also contracting pre-white dwarfs, but probably from another route — from R CrB variables and extreme helium stars. The latter likely form from the merger of two white dwarfs: a helium white dwarf accreted onto a carbon-oxygen white dwarf can create a helium-rich supergiant, sustained by a rejuvenated supply of helium. When the fresh helium fuel runs out, these stars will also contract to become O(He) stars and then DO white dwarfs

When the star can contract no more — when its interior is completely electron-degenerate, it becomes a hot white dwarf. DO white dwarfs are the hottest white dwarfs, with spectra dominated by ionised helium. EC 01339-6730 is the hottest DO known.

Most stars evolve incredibly slowly; even their short-lived phases are usually long compared with a human lifetime. To trace their evolution, we identify related stars from their surface chemistries, compare measurements of brightness and temperature and then 'join the dots'. When those dots are at turning points on evolutionary tracks, for example at the hottest points, they become especially important for testing the models described above — such as the very late thermal pulse and double white dwarf merger models.

The SALT survey of chemically-peculiar hot subdwarfs is driven at identifying stars in unusual phases of evolution and placing dots on the timelines of evolution. It has been a fantastic discovery machine; even ‘out-of-class’ stars have yielded significant science. In Phase 3, we will observe 395 new faint blue stars selected on *Gaia* colour and magnitude. Many exciting discoveries are likely.

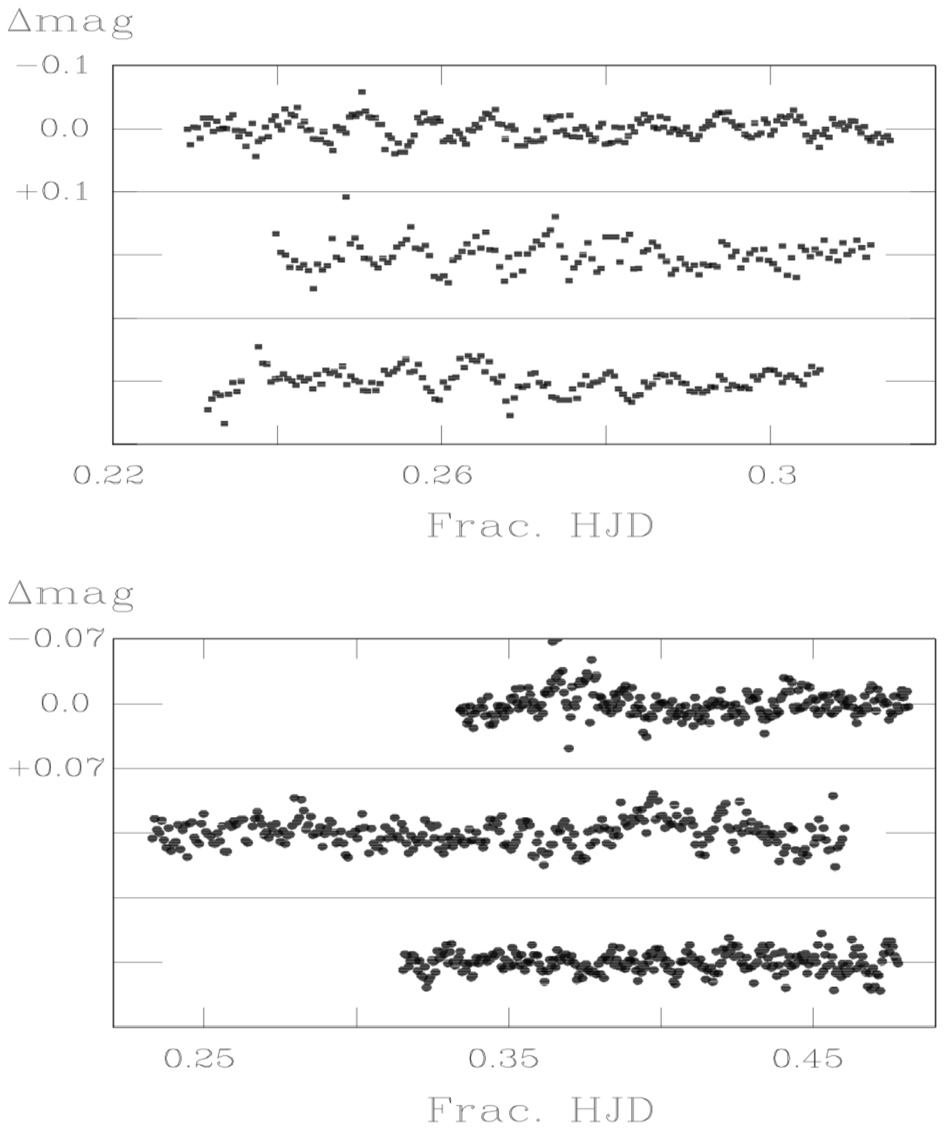


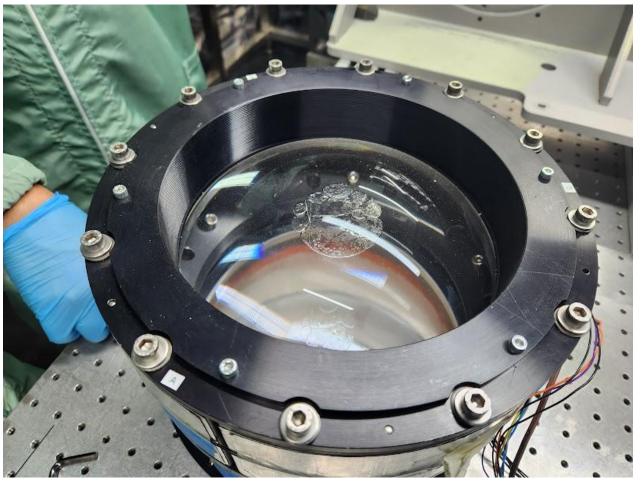

Figure 3. Light curves obtained by Dave Kilkenny with the SAAO 1.0m telescope for the PG1159 star SALT J172411.7−632147 (left) and SALT J213742.6−382901 (right). All data are differentially corrected and have the mean magnitude removed.

**Published as C. S. Jeffery, K. Werner, D. Kilkenny, B. Miszalski, I. Monageng and E. J. Snowdon, (2023), MNRAS 519, 2321–2330, https://doi.org/10.1093/mnras/**

# RSS shutdown

The RSS 'Big 5' project aims to substantially upgrade many aspects of the RSS spectrograph. These are: a new 700 l/mm grating, a new set of longslits, new collimating optics (doublet and triplet) and a new detector. The recent installation of PG0700 marked the completion of the first of the Big 5. The manufacturing of new longslits is progressing well, as is work on the new monolithic detector and controller. This leaves the doublet and triplet replacement, of which we will report here.

RSS was lifted from the telescope on 28 February to mark the start of the major engineering project to replace the old collimating optics. Both the doublet and triplet had certainly seen better days (see image to the right), so the entire SALT team was very excited to embark on the five-week long project to install pristine lenses. RSS remained in its new home in the spectrograph room until it was lifted back onto the payload on 31 March. There were only three nights in this period where the telescope was completely offline, otherwise HRS and SALTICAM science (and NIRWALS commissioning) continued as normal.



In the following, we highlight some of the work that was undertaken during these weeks but, to cut a long story short, the project was very successful and science data is already being taken at the time of writing! More details on the analysis of the commissioning and early science data will be given in the next newsletter. For now, back to the gory details…

The first week of the shutdown involved performing baseline engineering tests with RSS in the spectrograph room and some preparatory work on the new triplet in the snazzy new clean 'tent' set up next to RSS. The new doublet and triplet had been transported from Cape Town to Sutherland a week before. The team in Cape Town had noticed trapped air in the bladders and fluid interfaces of both lens groups, and the plan was to deal with this on site. Removing the trapped air and topping up the fluid without introducing more air into the triplet was quite a challenge and required good teamwork and adaptation of the filling pro-

cedure. In the end, a modification was made to the triplet bladder cover to keep the bladders in a more preferable orientation.

The main event for the second week was the removal of all of the optics from RSS. The doublet, field lens, waveplates and slitmask mechanism were removed first, allowing the optical team to take some measurements with the old triplet in. The main group was removed later in the week, leaving RSS with nothing but the camera, gratings and fold mirror intact.

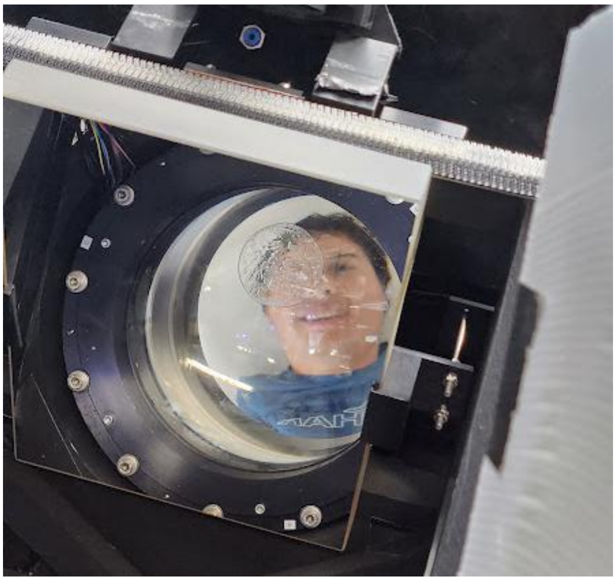
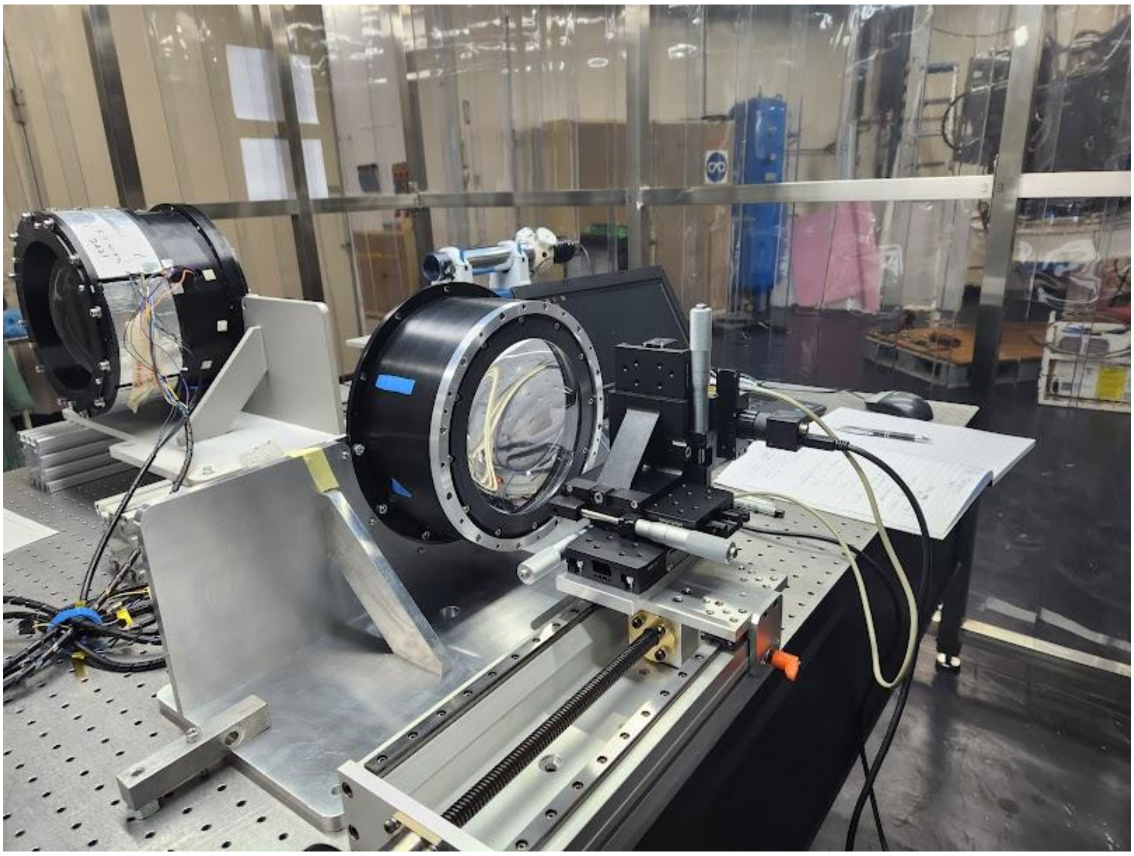


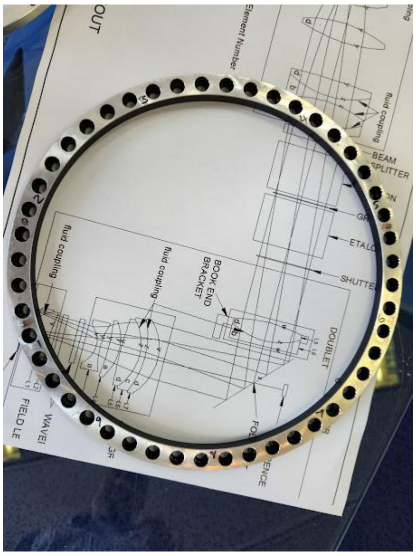
Photo of Nico looking up into the RSS collimator after the slitmask, field lens, waveplates, and doublet were removed, taken through the RSS fold mirror and main group. The horrible air bubble in the old triplet is clearly visible.

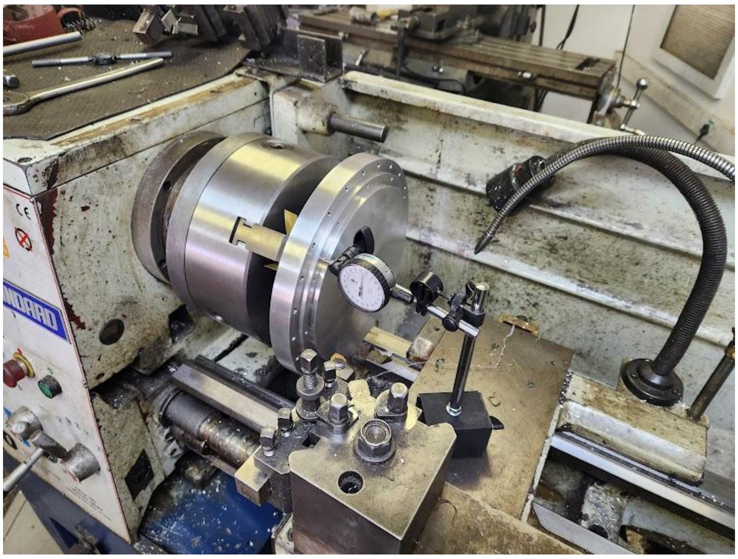
The third week started with the optical team separating the main group. The RSS Collimator Main Group is a complex opto-mechanical assembly containing two fused quartz singlets and a liquid coupled triplet. The triplet consists of two $CaF_2$ outer lenses with an NaCl (yes, salt!) lens in between them. Complicating the triplet replacement was the fact that the new triplet had a slightly different optical design prescription from the old triplet. The differences were



In the foreground is the new triplet in the process of being measured with the PSM. In the background is the main group (with the old triplet) being measured with the alignment telescope.

large enough that it required two of the main group shims to be machined to different thicknesses. The new shim thicknesses could only be calculated after doing meticulous measurements on the singlets and triplet assemblies, and the two old shims. The shims were very precisely machined in the SALT workshop, by Nicolaas, using a jig designed by Alrin specially for this purpose.

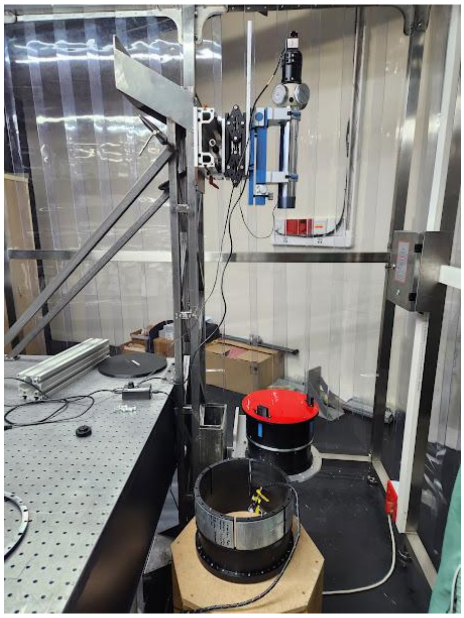


*Left*: One of the main group shims. *Right*: The jig for machining the main group shims being set up on the lathe in the SALT workshop.

Alongside the major work, RSS also received a bit of mechanical maintenance. The articulation drive was taken apart with the aim of making it run more smoothly. A small misalignment between the base plate and gear was discovered and corrected by the TechOps team. To align the new triplet to the existing singlets, a jig had been built in the clean tent to quickly align the new triplet to the singlets.

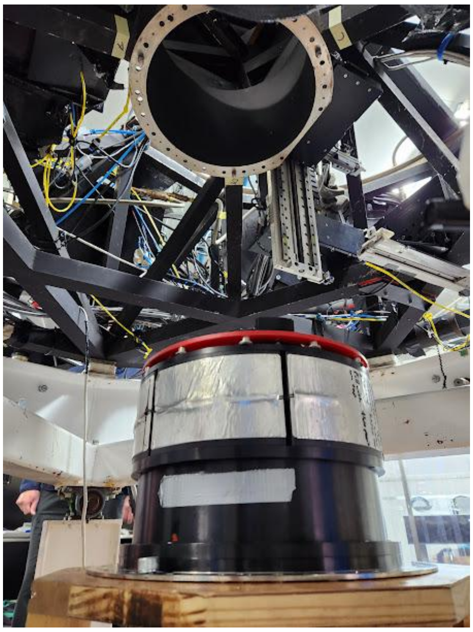
During transportation from Cape Town to Sutherland, one of the bladders on the new doublet had burst, most likely due to the excess air trapped inside and the change in air pressure. The team was prepared for this possibility, and the damaged bladder was replaced with a spare. The new doublet still had a troublesome leak that Deon and Nico eventually tracked down, and soon that problem was solved as well.



Main Group Alignment Jig, with the alignment telescope pointing down toward the main group.

It was all-hands on deck for the fifth and final week of shutdown. The hard work and excellent preparation of the optics team allowed for the main group, field lens and doublet to be installed and aligned incredibly efficiently. In fact, it took less than two days from starting to reinstalling the optical elements to RSS being completely rebuilt and reconnected to the necessary subsystems! By Tuesday evening we had already taken the first data with the new optics and could confirm that everything looked great. Only minor adjustments to the focus and detector alignment were needed, which is an incredible result after such invasive engineering!

The next few days were spent completing a full set of engineering tests and preparing the payload for the RSS lift. A few final small issues with RSS mechanisms were sorted out by TechOps before the spectrograph was lifted on Friday morning, 31 March. The whole process went without a hitch, and the on-duty astronomer was taking on-sky data that same night!



Right: Main group containing the new triplet underneath the still empty RSS, moments before installation.

Below: RSS being lifted up to the payload.

A huge congratulations to the whole SALT team for completing this massive milestone!!

*Lee Townsend & Melanie Saayman.--*

# RSS detector upgrade project

We are making progress on the new RSS detector, which will hold a monolithic 6K x 6K CCD from Teledyne e2v. The CCD arrived safely at SAAO last year, and the cryostat design is now fairly mature. We have started the procurement process for the field-flattening lens that will form the cryostat window.

Bhushan Joshi, an engineer from IUCAA, visited SAAO in March 2023 to help us with the IUCAA Digital Sampler Array Controller (IDSAC) system that we plan to use to control the CCDs in RSS and the new red arm spectrograph. Bhushan is an expert on the IDSAC, which is currently being used in the Sibonise instrument on SAAO’s Lesedi telescope as well as in a test cryostat setup in the lab. He and the SAAO detector team were able to optimise the system to solve some outstanding issues with the Sibonise CCD readout. They measured low readout noise, which is very promising, and ran informative tests on various readout modes. We are grateful to Bhushan and the IUCAA team for their support.

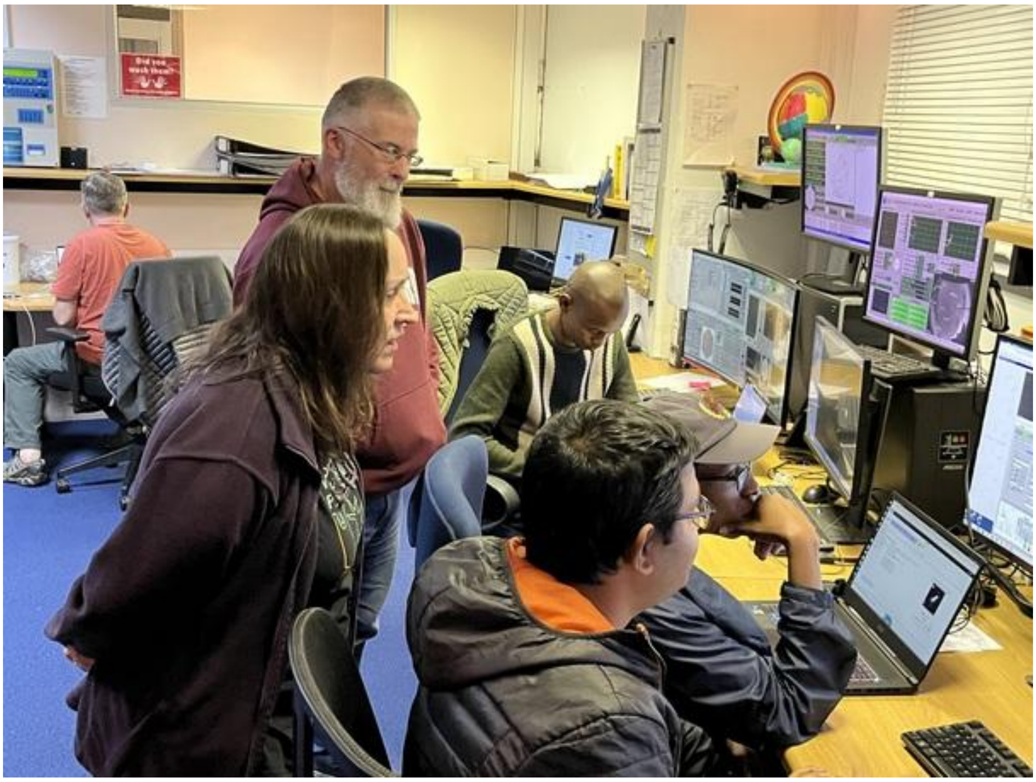
In the next few weeks the Sibonise instrument will be put through its paces to confirm and report on the results. We will hold a concept design review for the RSS detector control system PLC architecture in early April.

*Rosalind Skelton.--*

# NIRWALS aka NIR spectrograph

Over the last few months, the NIRWALS and SALT teams have been working on a number of things. The alarm notification system to protect the instrument during electricity outages (or when switching between main and backup electricity) has been implemented and tested. The astronomer interface control software (NCON) has also been further improved, and astronomers have successfully taken a lot of NIRWALS test data using NCON. NIRWALS data was taken at the start of the year to study the dark stability of the detector. During further tests, a problem was discovered with the focus mechanism; this will be worked on over the next few weeks. Despite this problem, tests were taken to try to better understand the positioning of the object and sky bundles by the Fibre Instrument Feed (FIF) relative to the optical centre of the telescope field of view. Early on-sky data showed differential illumination of the two bundles, which directly affects the ability to do precise sky subtraction. Work was also done on the data processing software and to refine the data reduction pipeline.

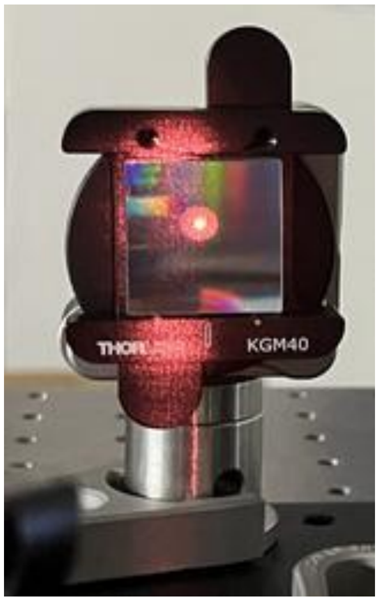
Further work needs to be done to determine the optical centre. More resources have been allocated to do this because the exact positioning at the optical centre will greatly improve the ability to use the sky bundle for sky subtraction as designed. More work will also be done on the data processing software and data reduction pipeline.There will also be further development and testing of NCON and other telescope software. We anticipate that the next stage of commissioning will happen in May.



*Moses Mogotsi & Marsha Wolf.—*

## HRS Laser Frequency Comb update

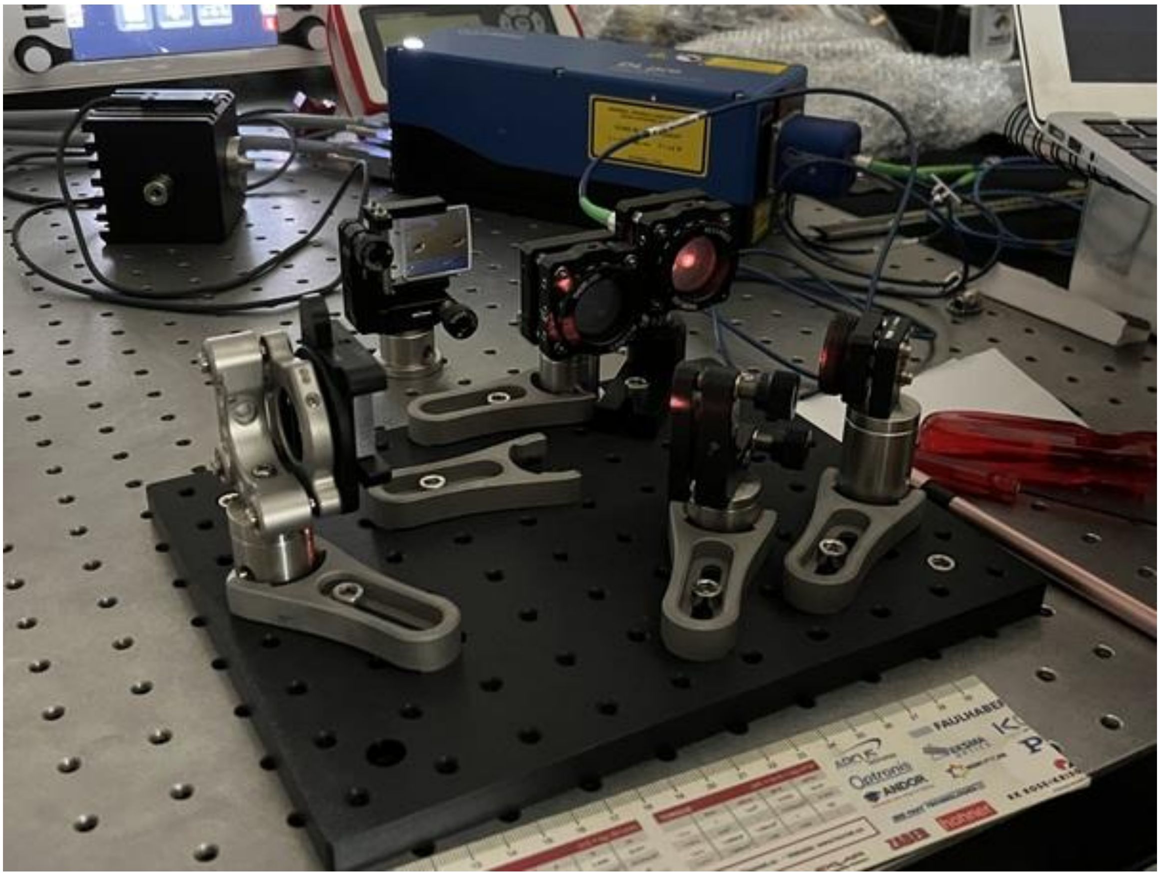
The past few months have been an exciting time for the laser frequency comb (LFC) project. The main laser was tested in the lab in Cape Town following its return from warranty repairs in the UK and, happily, all is well! Then the final shipment from Thorlabs arrived shortly before the holidays, so fun was had unboxing everything and carefully checking through the 13-page packing list.




Early in the new year, the SAAO mechanical workshop set about machining the few remaining parts in preparation for Richard McCracken's short visit during the first week of February. Richard is a laser physicist at Heriot-Watt University in Edinburgh and the project lead for the SALT HRS LFC development. After numerous monthly Zoom meetings about the project, and with all of the main components now at the SAAO in Cape Town, it was time for an in-person sanity check. His four day visit was intended to identify any issues that could impact on the integration and installation of the comb, scheduled for later in the year. This included assembling a number of comb modules and identifying the various small components that will need to be ordered and/or produced in the lead-up to the next trip, which will be for the full integration of the comb up at SALT.

A few minor snags were identified and addressed along the way and one component (an acousto-optic modulator unit) was found to be unsuitable for our purposes, so an alternative (an electro-optic modulator) has been ordered. It has a relatively long lead-time and so the integration of the LFC will now be a few months later than originally planned. All of the hardware will be sent up to Sutherland during the coming months and then Richard and two of his colleagues will join the local project team members at SALT once everything's ready, hopefully in August this year.

Development of the precision radial velocity (PRV) pipeline is also ongoing, with Daniel Holdsworth making good progress on the challenging wavelength solution. An update on this effort will be given at the upcoming Extreme Precision Radial Velocity (EPRV) Conference series, taking place in Santa Barbara during the last week of March. Following the EPRV meeting, Daniel will spend a few weeks in South Africa for observing and the opportunity to work more closely with SALT staff on the HRS high-stability mode pipeline.



*Lisa Crause.--*

# MEET THE TEAM: Janus Brink

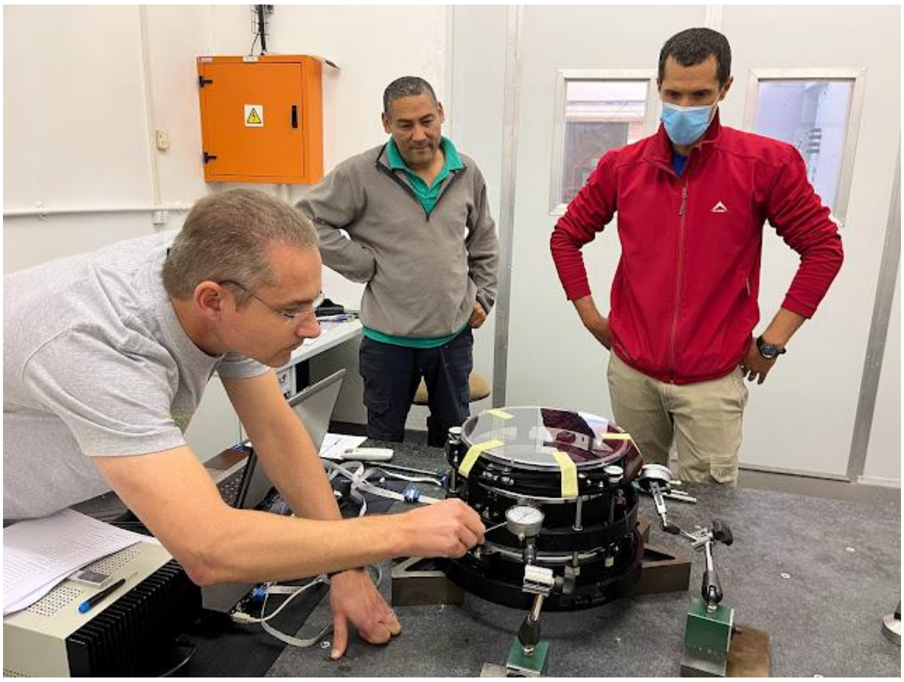
**Senior Software Engineer**

Hello everyone,

I graduated as an electronic engineer at the University of Pretoria, where I completed a master's degree in computer engineering, specialising in pattern recognition. My professional career started in the telecommunications industry, but being an avid amateur astronomer, I gladly joined the SALT Project Team in 2002 as a software engineer. I became involved in all aspects of the project, from the design of the core control system software to the mechanics and optics of the telescope and its instruments. I obtained a master's degree in astronomy and space science at the University of Cape Town in 2010 as part of my work on commissioning the spectro-polarimetry mode of the Robert Stobie Spectrograph. It's been a great 21-year journey from seeing the foundations of the building being cast, the first seven primary mirror segments installed, through the days of the image quality fix, commissioning of all the first-generation SALT instruments and upgrading many of the telescope systems along the way.

My work is currently focused on a mixture of telescope operations and projects – specifically assisting with the telescope upgrades to support commissioning of our new near-infrared spectrograph (NIRWALS) and working with the MaxE project team on the optical design and analysis to upgrade the Robert Stobie Spectrograph to a simultaneous dual-beam instrument. I recently relocated to Austria, but am happy to be able to continue contributing to the development of SALT and its instruments going forward!

Cheers, Janus



# SALT SCIENCE PAPERS

## December 2022 – March 2023

Below is the list of SALT publications since our last newsletter (for our full list of publications, please visit http://astronomers.salt.ac.za/data/publications/). We encourage SALT users to inform us of any papers making use of SALT data, and to double check the link above after publication.


- Gasealahwe, K. V. S., Monageng, I. M., Fender, R. P., et al. 05/2023: The 2019 outburst of AMXP SAX J1808.4-3658 and radio follow up of MAXI J0911-655 and XTE J1701-462, MNRAS 521, 2806 -- https://ui.adsabs.harvard.edu/abs/2023MNRAS.521.2806G
- Sebastian, D., Swayne, M. I., Maxted, P. F. L., et al. 03/2023: The EBLM project - IX. Five fully convective M-dwarfs, precisely measured with CHEOPS and TESS light curves, MNRAS 519, 3546 -- https://ui.adsabs.harvard.edu/abs/2023MNRAS.519.3546S
- Guha, L. K., & Srianand, R. 03/2023: Nature of the galaxies on top of quasars producing Mg II absorption, MNRAS 519, 3319 -- https://ui.adsabs.harvard.edu/abs/2023MNRAS.519.3319G
- Haberl, F., Maitra, C., Kaltenbrunner, D., et al. 03/2023: SRG/eROSITA-triggered XMM-Newton observations of three Be/X-ray binaries in the LMC: Discovery of X-ray pulsations, A&A 671, A90 -- https://ui.adsabs.harvard.edu/abs/2023A&A...671A..90H
- Jeffery, C. S., Werner, K., Kilkenny, D., et al. 02/2023: Hot white dwarfs and pre-white dwarfs discovered with SALT, MNRAS 519, 2321 -- https://ui.adsabs.harvard.edu/abs/2023MNRAS.519.2321J
- Karachentsev, I. D., Makarova, L. N., Koribalski, B. S., et al. 02/2023: Peekaboo: the extremely metal poor dwarf galaxy HIPASS J1131-31, MNRAS 518, 5893 -- https://ui.adsabs.harvard.edu/abs/2023MNRAS.518.5893K
- Kwok, L. A., Jha, S. W., Temim, T., et al. 02/2023: A JWST Near- and Mid-infrared Nebular Spectrum of the Type Ia Supernova 2021aefx, ApJL 944, L3 -- https://ui.adsabs.harvard.edu/abs/2023ApJ...944L...3K
- Tofflemire, B. M., Kraus, A. L., Mann, A. W., et al. 02/2023: A Low-mass, Pre-main-sequence Eclipsing Binary in the 40 Myr Columba Association-Fundamental Stellar Parameters and Modeling the Effect of Star Spots, AJ 165, 46 -- https://ui.adsabs.harvard.edu/abs/2023AJ....165...46T
- Kollatschny, W., Grupe, D., Parker, M. L., et al. 02/2023: The outburst of the changing-look AGN IRAS 23226-3843 in 2019, A&A 670, A103 -- https://ui.adsabs.harvard.edu/abs/2023A&A...670A.103K
- Kasai, E., Goldoni, P., Pita, S., et al. 01/2023: Optical spectroscopy of blazars for the Cherenkov Telescope Array - II, MNRAS 518, 2675 -- https://ui.adsabs.harvard.edu/abs/2023MNRAS.518.2675K
- Liu, Z., Malyali, A., Krumpe, M., et al. 01/2023: Deciphering the extreme X-ray variability of the nuclear transient eRASSt J045650.3−203750. A likely repeating partial tidal disruption event, A&A 669, A75 -- https://ui.adsabs.harvard.edu/abs/2023A&A...669A..75L
- Maitra, C., Kaltenbrunner, D., Haberl, F., et al. 01/2023: Broadband study and the discovery of pulsations from the Be/X-ray binary eRASSU J052914.9−662446 in the Large Magellanic Cloud, A&A 669, A30 -- https://ui.adsabs.harvard.edu/abs/2023A&A...669A..30M
- Buckley, D. A. H., Britto, R. J., Chandra, S., et al. 12/2022: A multiwavelength study of the flat-spectrum radio quasar NVSS J141922-083830 covering four flaring episodes, MNRAS 517, 5791 -- https://ui.adsabs.harvard.edu/abs/2022MNRAS.517.5791B