SALT

Newsletter

August 2023

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Editor: Anja C. Schröder

Cover image: Diffraction grating and cylindrical lens in the unit feeding the spatial light modulator in one of the LFC's optical assemblies. -- *Credit*: Lisa Crause

Letter from the Head of Astro Ops

Dear SALT Community,

So much has happened (and is still happening) since the last newsletter, I don't even know where to begin!

It was again a huge pleasure to see so many of you at the SALT Highlights conference in Poland in June, and to hear all the exciting science SALT has been contributing to. It's really wonderful to see how the community has grown – and grown up! Together, we have all gained an excellent understanding in using our quirky telescope and we're able to achieve truly exciting results. A huge thank you to Joanna Mikołajewska and the entire LOC for a most excellent workshop and organization – Ros gives a brief summary below.

At the time we circulated our last newsletter, SALT was offline due to a problem with the tracker. That was fixed in record-time by the SALT and SAAO teams working together, sourcing spare parts and modifying them in our own SAAO workshop, and we would have been back on sky on 22 April had it not been for the atrocious weather that kept us closed until 26 April. Eben and Anja write about this below. From our side, a huge thank you – that was amazing!!

Another bit of good news is that the RSS optics repairs Melanie explained in the last newsletter has achieved its main goal and the RSS internal scattered light is nearly non-existent. Yay! Huge thank you to everyone!

NIRWALS commissioning is progressing, albeit slower than anticipated. This is mainly because what we are trying to do (extending the wavelength range of the telescope, using an IFU) is totally new for SALT, and we don't know what we don't know until we get there! Moses gives a brief overview of the project status below.

It has also been "raining" visitors to Sutherland recently! The team from Heriot-Watt University were in Sutherland with Lisa until earlier this week, installing the first phase of the LFC. She explains everything below, so I won't steal her thunder.

And Tim Pickering, a previous SALT Astronomer and the 'Tim' behind the nickname 'TimDimm' for our seeing monitoring system, was in Sutherland in June to do some desperately needed upgrades. Unfortunately, they couldn't finish everything at the time, but we should have TimDimm back on sky very soon. Tim tells all below.

To finish off, Shamiel, one of our newest software engineers responsible for our detector software, introduces himself below.

Clear skies and stay safe!

Encarni

SCIENCE HIGHLIGHT

Helium-burning on white dwarf surface

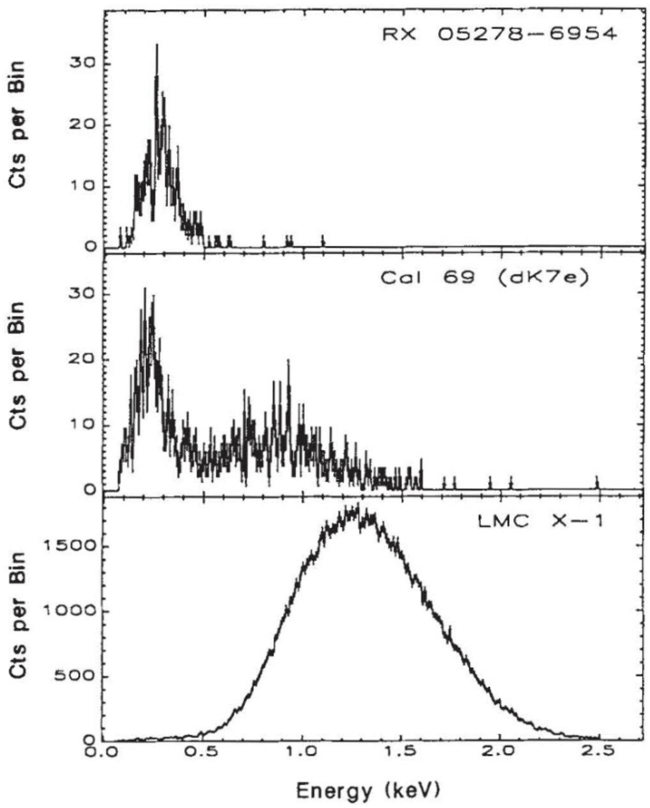
by Jochen Greiner (Max-Planck Institut für Extraterrestrische Physik, Germany) & David Buckley (SAAO, South Africa)

Summary: A white dwarf explodes as a supernova once its accreted mass exceeds the Chandrasekhar limit of about 1.4 solar masses. A newly discovered binary system in the Large Magellanic Cloud is found to be in such a high-accretion phase, with the accreted matter steadily burning on the white dwarf's surface, emitting luminous X-ray radiation. Unusual in this system is the fact that helium is accreted and burnt instead of hydrogen. The measured luminosity suggests that the mass accumulation on the white dwarf proceeds slower than previously considered possible. This in turn implies a better match with the observed number of low-luminosity supernovae of type Iax.

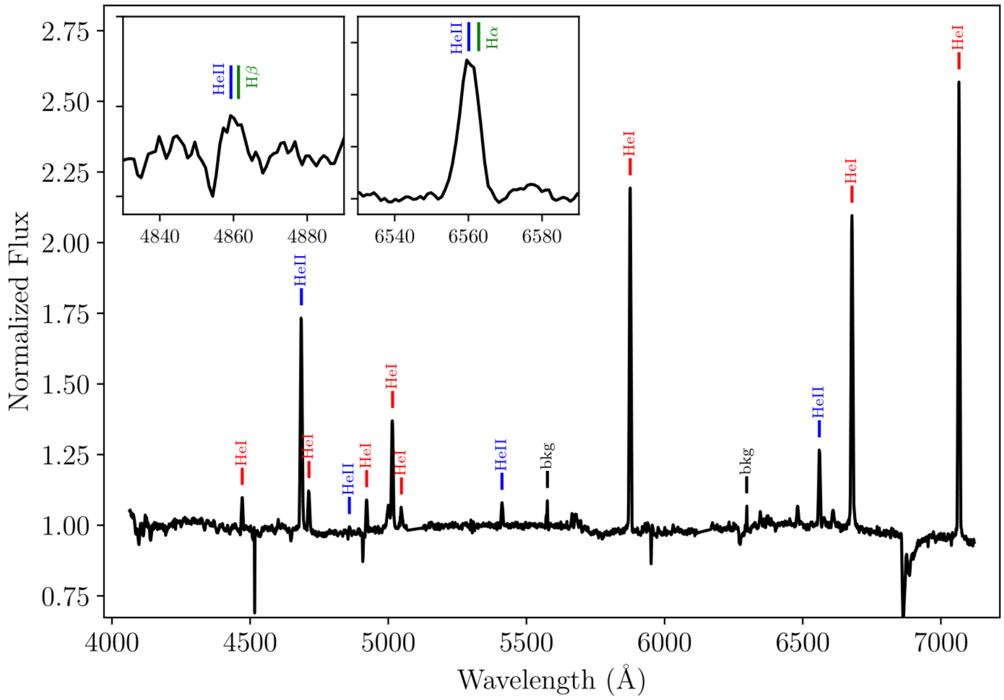
Exploding white dwarfs represent not just the main source of iron in the Universe, but are also an important tool for cosmology: as so-called type Ia Supernovae (SN Ia), they all shine at about the same luminosity, allowing us to determine their distances. However, even after many years of intensive research, the details of the mass accumulation onto the white dwarf towards the Chandrasekhar mass remain debated.

When ROSAT observations in the early nineties established supersoft X-ray sources with stable hydrogen surface burning as a new class of object, they were temporarily considered as potential candidates for the progenitors of SN Ia because of the gradual mass accumulation due to the steady burning. The only flaw in this interpretation is the dominant abundance of hydrogen of these objects, while SN Ia do not show hydrogen in their spectra.

Binaries with helium accretion onto a white dwarf and subsequent stable burning have been predicted for 30 years but could not be identified so far. Recently, a supersoft X-ray source was discovered to exhibit a wealth of helium emission lines in its optical spectrum. This source, named [HP99] 159 according to its entry in the Haberl-Pietsch catalogue of ROSAT-observed X-ray sources in the Magellanic Clouds, is known since the nineties and was also observed with XMM-Newton and eROSITA. Optical spectroscopy with the SALT telescope allowed



Examples of X-ray sources. *Top*: supersoft (that is, low-energy) source; *middle*: soft source; *bottom*: hard source.



Low-resolution optical spectrum of [HP99] 159, taken with the SALT/RSS-Spectrograph in South Africa on 2020-08-14. The main emission lines are marked; they are all due to helium (the "bkg" labelled peaks are residua from the removal of sky lines). The two small inserts show two regions where He- und H-lines are close to each other, and that in both cases the signal is from He II (485.9 nm, 656.0 nm) and not from hydrogen (486.1 nm, 656.3 nm).

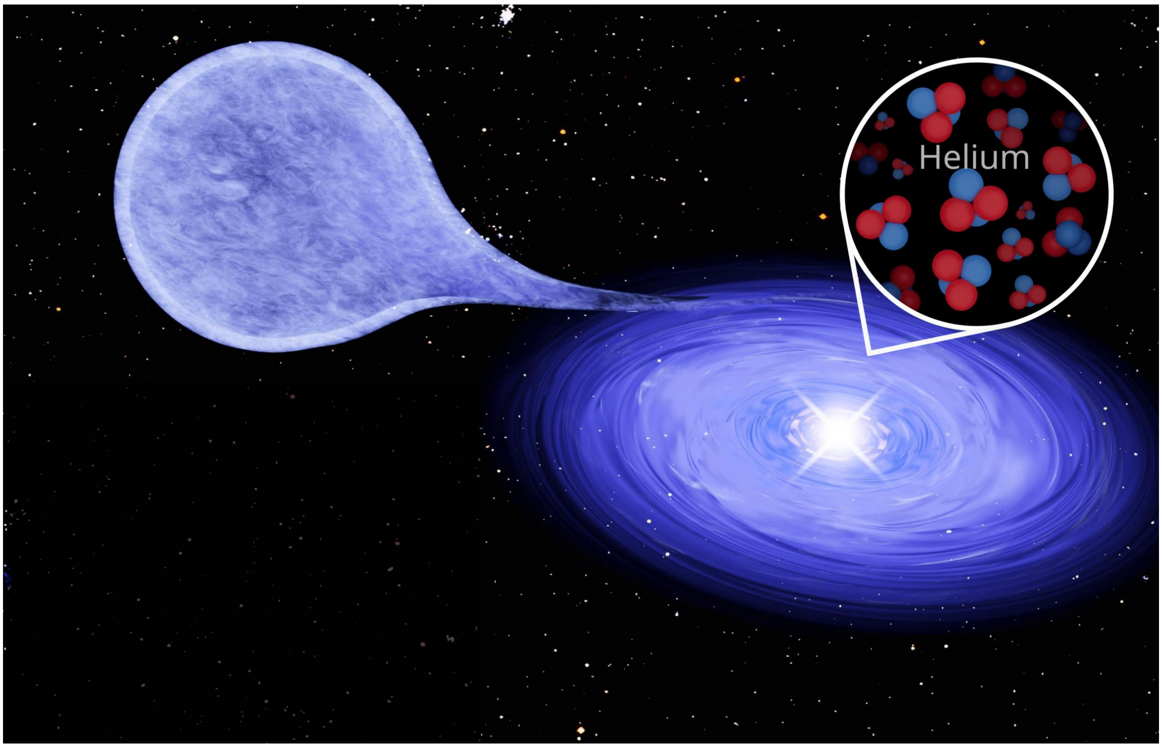
us now to identify this X-ray source. The typical double-peaked structure of all the optical emission lines points to their origin in an accretion disc, and the characteristic redshift of the lines places the source in the Large Magellanic Cloud. The big surprise is the fact that we find primarily emission lines from helium (see figure).

As spectacular as it is, this finding does not yet solve the problem of the SN Ia progenitors: theoretical models predict that about 2 – 5% of the matter of the donor star in the binary system is stripped off during the course of the supernova explosion and distributed in the circumstellar environment. However, this circumstellar helium is not generally seen in SN Ia. There is, however, a sub-class with smaller luminosity, the so-called SNe Iax, which experience a lower-energy explosion with less helium being stripped off.

The measured X-ray luminosity of this new system [HP99] 159 suggests that it could end in such a SN Iax. Despite the fact that the X-ray luminosity is nearly 10x smaller than standard models of steadily burning white dwarfs predict, the luminosity has not changed over the last 50 years. This indicates that the typically expected range of unstable burning at low rates is prevented by some physical effect not yet incorporated in the models. Potentially most important is the rotation of the white dwarf. As the matter overflowing from the donor first piles up in an accretion disc, the matter, once accreted on the white dwarf, also transports angular momentum onto the white dwarf, possibly spinning it up with time. The growing centrifugal force reduces the helium density, thus stabilising the burning. In addition, turbulent mixing could be triggered, which also leads to more stable burning.

If also slowly accreting white dwarfs can burn helium steadily and reach the Chandrasekhar limit, the observed population of SN Iax (which is nearly 30% of all SN Ia) can be readily explained. This would suggest about 30 helium accreting supersoft X-ray sources in our Milky Way, and a handful in the Magellanic Clouds. Further X-ray observations with eROSITA, combined with optical spectroscopy, could identify more of such sources and thus allow us to obtain tighter constraints on the SN Ia progenitors.

The interpretation of [HP99] 159 as a SN Iax progenitor turns the world of SN Ia somewhat upside down: After the discovery that SN Ia can be used as standard candles for cosmology, the explanation of an explosion at a fixed mass, the Chandrasekhar mass, to obtain similar explosion properties seemed obvious. If in our new interpretation only the minority of SNe Iax is due to the explosion of Chandrasekhar mass white dwarfs, there must be a different explanation for the classical SNe Ia. This is likely not a problem since in the meantime stellar astrophysicists have found various ways to achieve explosions before reaching the Chandrasekhar limit. However, which evolutionary path will finally explain the classical SN Ia and what actually makes them standard candles will continue to be hotly debated.



An artist's imprssion of the binary system underlying a supersoft X-ray source: when exceeding the Roche-lobe, matter overflows from a relatively massive donor star to the white dwarf. The optical spectrum demonstrates that the accretion disk around the white dwarf consist nearly exclusively of helium, with only little fractions of NII und SiII. – *Credits*: composition: F. Bodensteiner; background image: ESO.

Published as Greiner et al. (2023), Nature, Issue 8953, Vol. 615, pp 605 – 609

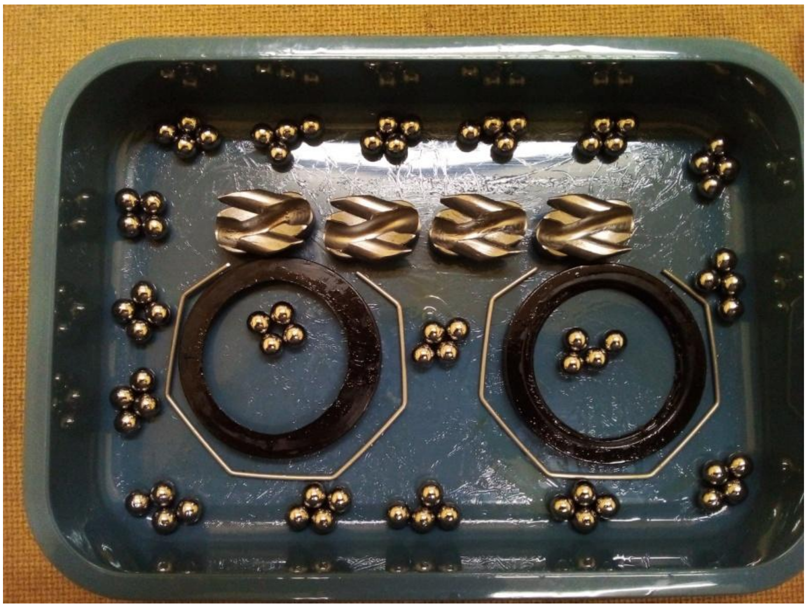
Fixing the tracker

On Wednesday, 12 April, SALT was taken offline because of a series of unexplained tracker stops, which turned out to be caused by severe damage to a lead screw, its nut and the ball-bearings, all of which were found to be dry and rusty. Despite the difficulties finding spares, the team managed to get everything fixed and SALT back on sky by Saturday, 22 April.

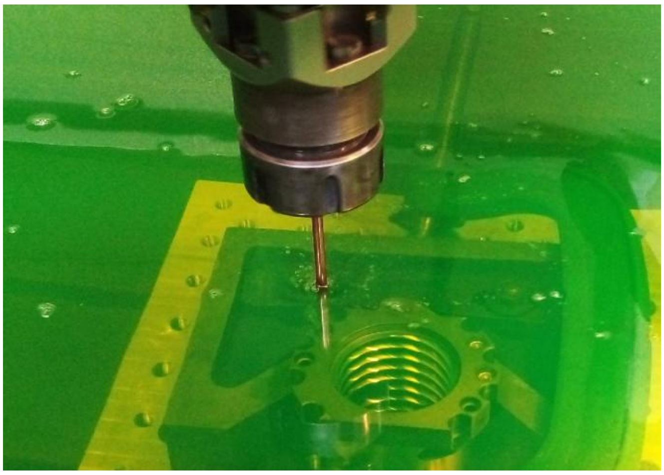
The SALT tracker is mounted in a hexapod configuration that has six adjustable length support legs that can point the tracker in six degrees of freedom along with the tracker X, Y and Rho stages. These support legs offer extremely good accuracy and repeatability and were manufactured for SALT by Scheaffler in Germany almost a quarter of a century ago. There were never any parts available for these support legs, and it was always regarded as an item that must not be fiddled with at all. We only have one simple drawing of these hexapod assemblies and the drawing does not have any dimensions of the internal parts in the ball screw.

During the March shutdown, it was mentioned that there was a strange knocking sound coming from the tracker when it is moving. After RSS was tested and back on sky on the tracker, we found that the knocking noise definitely came from hexapod number 4, or H4, as we refer to it. After a couple of nights with increasingly more tracker failures, the Tech Ops team decided to remove the H4 leg to determine where the problem was located. When the ball screw and motor was split, we immediately confirmed that our worst fears were true: we had a failed hexapod leg, and we did not have any spares for repairs or any clue as to what to expect when we would open up the assembly. The tracker accuracy is of utmost importance, and we realized that if we were to disassemble the H4 assembly, we could not do this without disturbing the encoder that gives the very important position feedback to the control system.

On 13 April, the team took the ball screw down to the SALT workshop and disassembled the unit. The ball screw was indeed beyond repair. After giving the bad news to the board, we immediately started the search for spares or replacement parts that we could use or modify to make them fit into our system and to get the telescope back on sky without losing any unnecessary on-sky time. All the possible bearing suppliers were contacted and haunted for feedback. One supplier promised to deliver the spares in about 10 months! A few days later, the supplier informed us that they had parts that we could possibly alter for use in the H4 leg. They were picked up on Wednesday morning, and already by afternoon



The internal parts of the ball screw nut that was disassembled for machining on the nut housing



Counter bore holes being sparked into the rock hard steel frame.

A new ball screw (left) and the wire cut and spark eroded ball screw nut housing (right).

the design was finalised and the material required for the fix was ready to be machined.

During the next two days, we had lathes and mills running and spitting out shavings till late at night while the wire cutter and spark eroder had to fight with otherwise seemingly impossible-to-machine materials. The support from the whole SAAO team in Cape Town, especially the SAAO workshop, was amazing. There was not a single idle moment, and when the parts were assembled on Friday they all fitted like a glove!

The new parts arrived in Sutherland late on Friday, 21 April, and the SALT team was ready for installation on Saturday morning. The H4 assembly was exteremely tricky: it was some fun and games getting the ball screw in place 10m above the first floor with technicians hanging from pipes and beams!

The assembly and test of the H4 leg turned out to be a huge success. We managed to get the H4 encoder back to about 30 microns from where it was before the fix, with the tracker pointing to within 2 – 5 arcseconds from what it was before the H4 fix. Since then not a single failure or following error occurred on the H4!

All in all, what at first seemed like an unbridgeable divide to get SALT operational again, was sorted out in just over one week without breaking much of a sweat. Many hands make light work, in our case great teamwork from many extremely capable hands directs the light to make SALT work: Congratulations to the incredibly competent staff in the SAAO workshop!

The newly designed part to fit the flanged ball screw nut into the H4 assembly

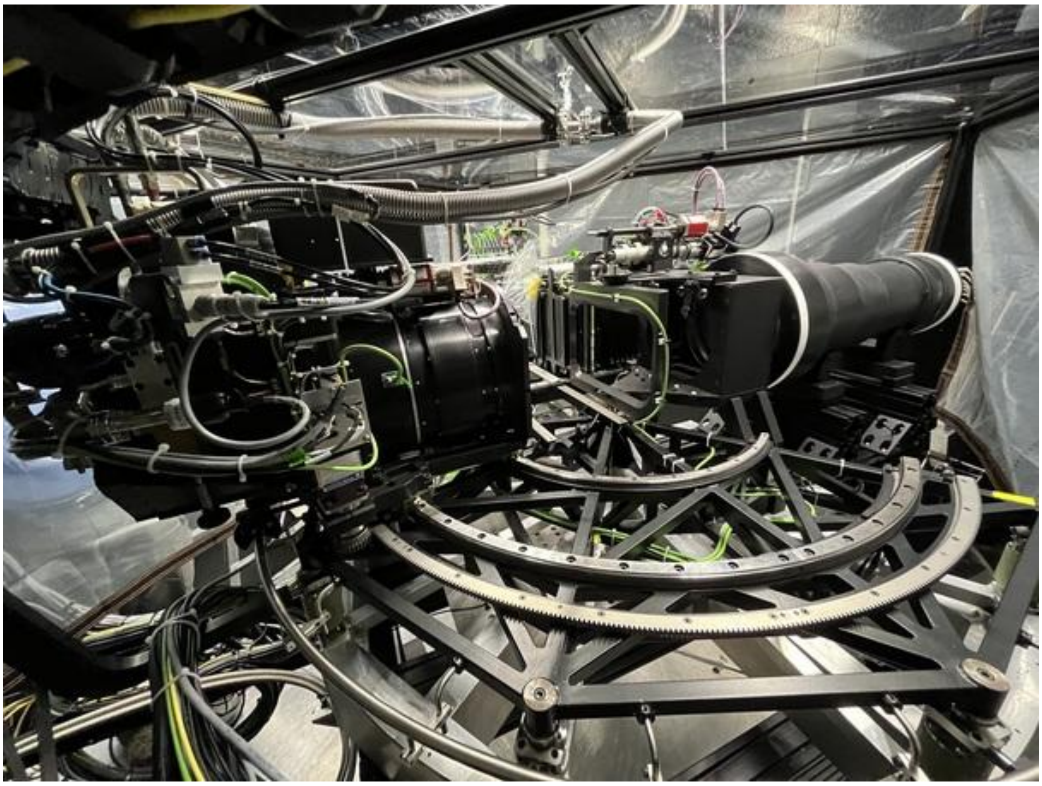
Eben Wiid & Anja Schröder.—

NIRWALS commissioning: an interim report

After the initial commissioning run in October 2022, NIRWALS work has continued into 2023. The glycol and instrument cooling system were improved and alarms were implemented to ensure that the instrument has more protection during power cuts. The instrument control software interface has also been improved and we can now take data in a stable manner with the instrument. We continue to add functionality to the software and are working on improving the way the header information is written into the files.

Data from the previous commissioning run showed that there were large differences between the illumination of the sky and object bundles. The instrument was designed to utilize the sky bundles for sky subtraction, so, this required more investigation. Tests were made to determine whether this had to do with the alignment of the Fibre Instrument Feed or differences in the vignetting over an observing track. The latter seems to be the major contributor to the differences in illumination. Work is ongoing to model and understand this better so that the flat fielding and sky subtraction can be improved.

Progress was made with the data reduction, and the data can now be manually reduced better than before. This progress is currently incorporated into the automated pipeline. Further work to improve the data pre-processing and to characterise the variation in the dark current is continuing. This pre-processing will be an essential step before the data is reduced by the automated pipeline. The next stage of on-sky commissioning started recently and various tests will be performed over the next few months to characterise the combined instrument and telescope performance and ready NIRWALS for science!



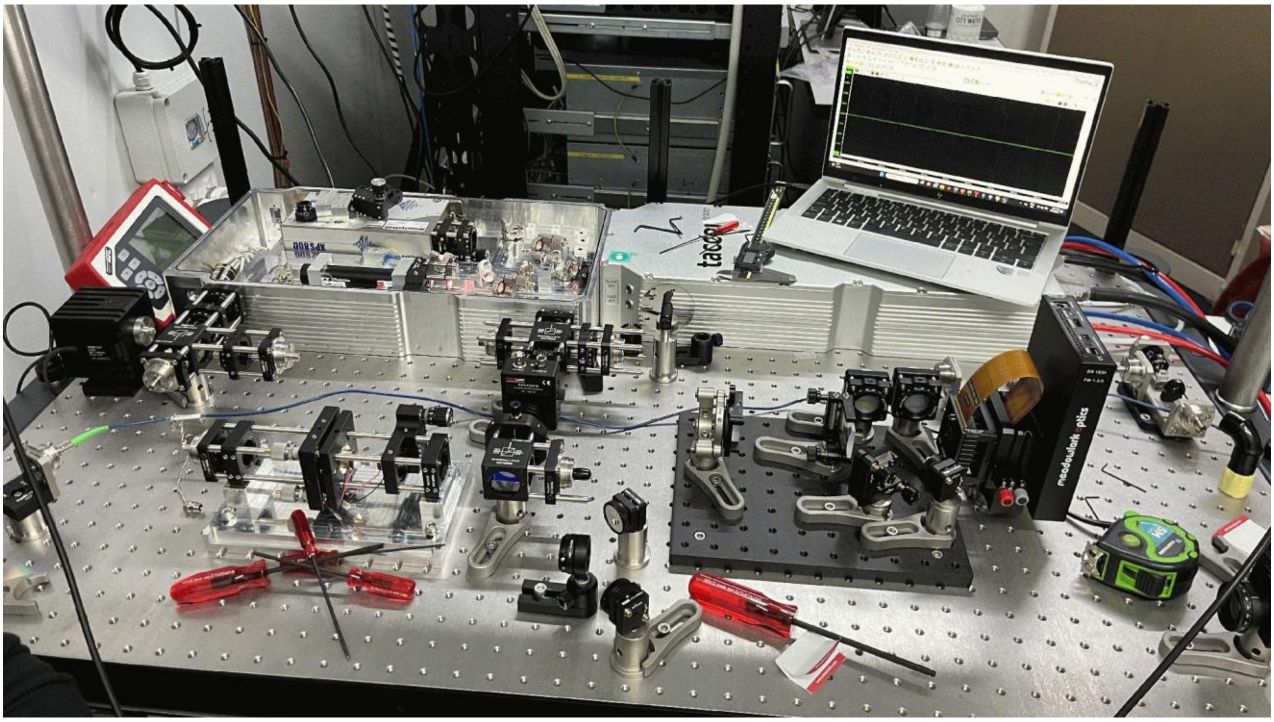
Moses Mogotsi.—

LFC update

With most of the laser frequency comb (LFC) gear having made its way to the telescope over the past few months, and with just a few small orders still to be received, the Heriot–Watt University (HWU) team had booked flights in anticipation of doing the integration at SALT during the first two weeks of August. However, we were frustrated to learn — just ten days before the final key component was due to be delivered — that this electro-optic modulator (EOM) will now be delayed by a further three months, due to the worldwide chip shortage!

Rather than postponing the integration campaign, and then running into HWU teaching commitments during the latter part of the year, the plan was adjusted. Two, rather than three, members of the HWU team (Richard McCracken and Shan Cheng) would come out to SALT at the start of August, but just for one week, instead of two. The goal being to complete as much of the assembly and integration as possible, and to uncover any snags and unknowns that would otherwise have been waiting for us. Then once the EOM arrives, we will schedule the second HWU visit (towards the end of the year), to complete the installation. While this setback was disappointing, proceeding in this way was invaluable in terms of mitigating assorted risks and it also allows more time for SALT Ops to engage with the team from HWU.

Prior to the LFC team's arrival, Tech Ops reorganised the HRS electronics (outer) room for the astrocomb installation. The two HRS cryocoolers (for the Red and Blue cryostats) were relocated to make space for the comb optical bench and the door to the inner room (that houses the vacuum tank in its interlocking styrostone enclosure) was flipped around so that it opens away from the new bench. All of the new hardware was also sorted and carefully packed into one of the cabinets in the outer room to free up space, and the large optical bench in the spectrometer room was made available. The spectrometer room itself was also tidied up to the point of being unrecognisable — wow!

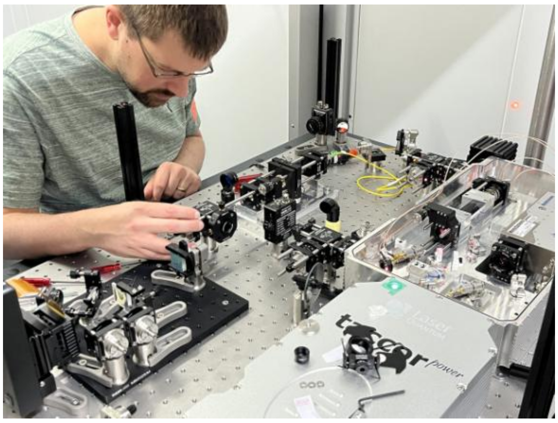


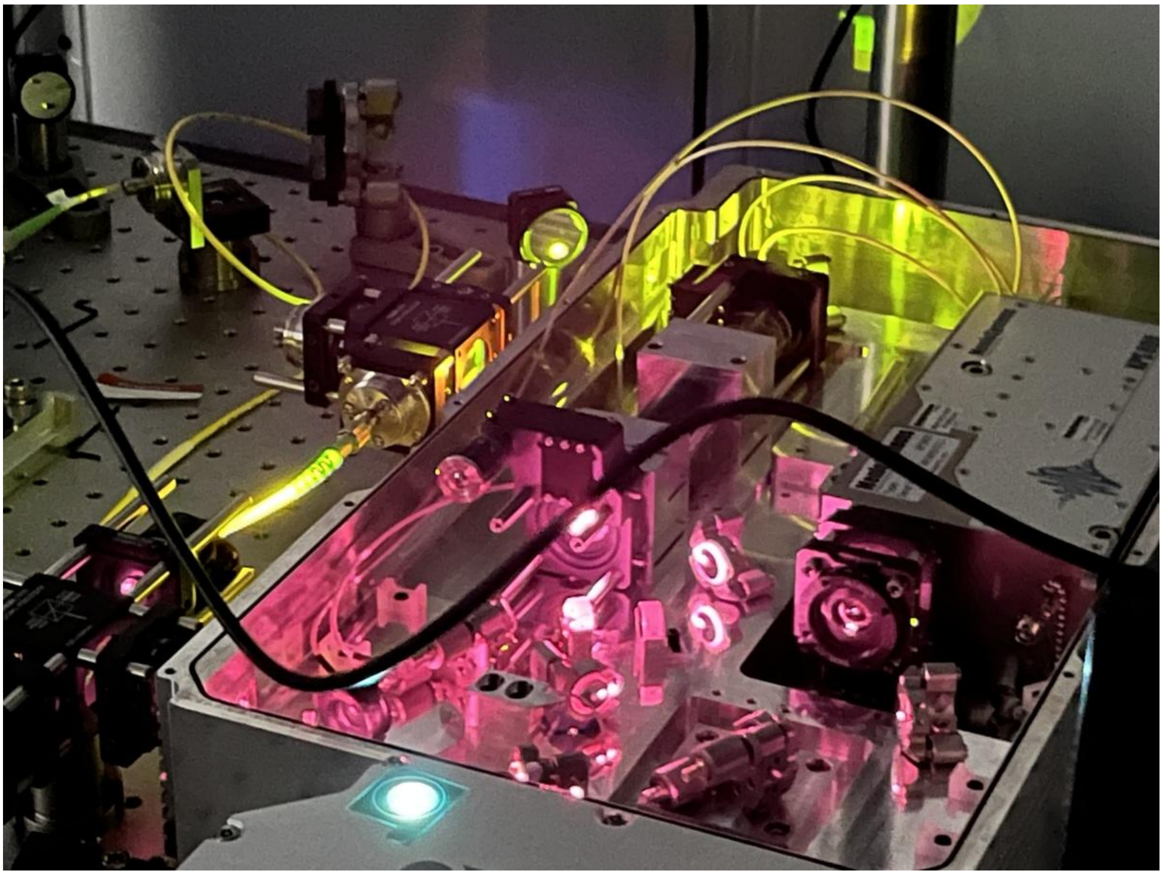
The main laser (beneath the laptop), the comb chassis (to the left) and the various modules that will be fibre-coupled to make up the LFC, all being set up on the new optical bench inside the HRS electronics room during the first week of August.

Lisa and Malcolm fetched Richard and Shan at the airport the morning of Tuesday the 1st of August and other than stopping for a great lunch at the Veldskoen farmstall on the way, headed straight to SALT. Having flown all the way from Edinburgh (via London) and then spent another five hours in a car, the intrepid laser physicists were somehow still eager to get started that evening! The ensuing week was a fascinating blur of lasers, optics and electronics as the team assembled, aligned, tested, re-aligned and re-re-aligned the various modules that will make up the LFC.

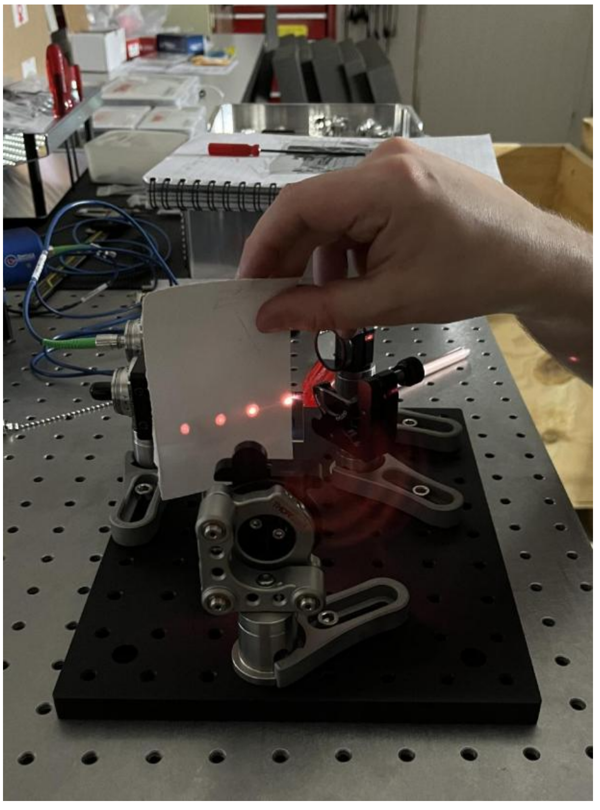
The main titanium-sapphire laser the forms the heart of the system gave us a good scare when it again refused to play for a day or so. But after getting permission from the UK-based supplier to open up the controller unit, a bad connection was soon found and fixed. Then the manufacturer's laser techs were able to connect to the laser unit and tweak various parameters (including dialling up the pump laser's power from 11 to almost 12W!) to get it to wake up reliably. We also tested the single-mode fibre that had been left behind at the end of the LFC field trial back in 2016 (see the various LFC posts in the SALT Astro blog*) and were relieved to find that it still works! This allowed us to briefly inject some faint super-continuum light into the spectrograph on the last night of the campaign. While the resulting image was not objectively spectacular, this was a huge milestone to reach in such a short period of time!

We will need to remake and/or modify a couple of parts, order a few more things and complete the building of various electronics boxes needed for the different locking loops before the HWU team returns. But like Richard's brief visit to Cape Town in February, this trip was hugely productive, instructive and enjoyable. The stressful part was driving back to Cape Town on Tuesday the 8th to get them to the airport during the incredibly disruptive taxi strike that was underway at the time. Happily, the roads were actually calm and far quieter than usual that day (following the chaos of the previous day) and so we got them to the airport with plenty of time to spare. Now stay tuned for Phase II of the LFC integration later in the year!





All of the optics and electronics inside the comb chassis, showing the incoming (pink) Ti:sapphire light being transformed into a super-continuum (yellow) within the photonics crystal fibre unit.



One of the comb's optical assemblies that will feed light into the spatial light modulator (SML) to flatten the spectral response..

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https://saltastro.blogspot.com/2016/04/a-laser-frequency-comb-at-salt.html

https://saltastro.blogspot.com/2016/04/getting-lfc-set-up.html

https://saltastro.blogspot.com/2016/04/so-how-do-these-things-work.html

https://saltastro.blogspot.com/2016/04/a-great-analogy-to-explain-lfc.html

https://saltastro.blogspot.com/2016/05/first-light-on-sky-observations-with-lfc.html

Lisa Crause.--

timDIMM upgrade

In the second half of June, former SALT Astronomer, Dr. Timothy Pickering, visited Sutherland to perform some hardware upgrades to the seeing monitor system, timDIMM. The most significant upgrade was to replace the camera used to measure the seeing. The new CMOS camera features significantly less noise (2 e^- vs > 25 e^-), faster readout (300 frames/sec with a 400x400 region-of-interest), greater dynamic range (12-bit vs 8-bit), and higher quantum efficiency (>80% peak vs ~40%). The new camera also uses a standard, readily available USB3 interface instead of the now-obsolete IEEE1394 interface the previous camera used. A second CMOS camera was added to the system as well to work as an acquisition camera along with a new 50mm guide scope.

Upon arriving in Sutherland (almost a week later than originally planned thanks to inclement weather), the new cameras and finder scope were easily attached and ready to test. Unfortunately, once we got on-sky it was apparent that the timDIMM's mount was not very healthy and its tracking performance was quite poor. It was also apparent that the field-of-view for the seeing camera was limited by the aperture within the MASS-DIMM instrument rather than by the camera itself.

Setting up to test out new cameras and new telescope control software.

SALT engineer Nico van der Merwe took on the task of taking the mount apart to clean and re-lube the bearings as well as fix some slight damage to the declination bearing race. The declination axis worked significantly better after this work. The right ascension axis was also noticeably improved, but the tracking performance is still degraded. This problem can be mitigated by a wider field-of-view, restricting the system to only use southerly targets, and limiting seeing measurements to ~15 seconds.

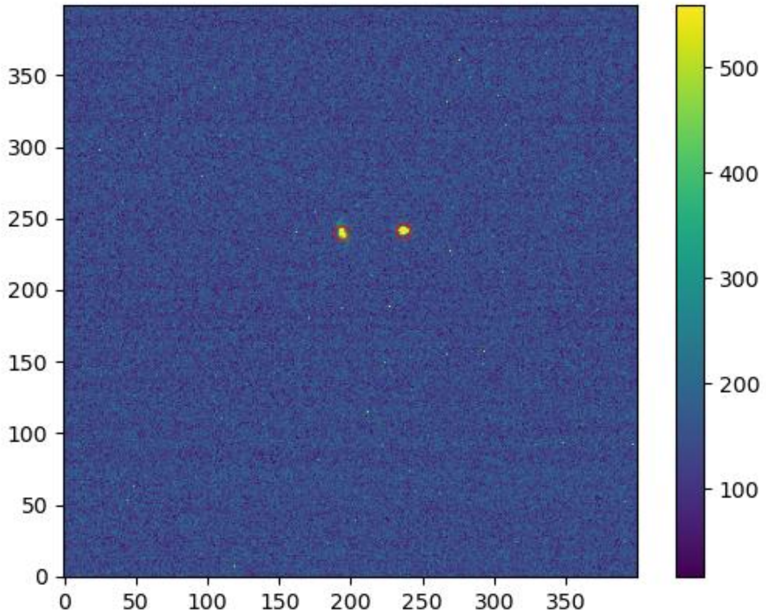
To achieve the wider field-of-view, the MASS-DIMM instrument was removed and the old DIMM mask was installed on the front of the telescope. This has added benefits of reducing the weight of the system (and thus the burden on the mount) and removing a heavy cable wrap that was no longer needed. This cable wrap was likely snagging the power cable for the mount on occasion which would cause a power glitch resulting in the mount losing its bearings. The USB cables for the new cameras are significantly lighter and hang further back so they will no longer interfere with the mount's power input.

After some final manual interventions by Nico to align the DIMM mask and the acquisition scope, we were finally able to do some proper on-sky testing with the new configuration. Unfortunately, thanks to the weather this didn't happen until Tim's last night before his return flight home. In spite of that, we did manage to learn or verify several key things:

The telescope with the new seeing camera at the bottom and new acquisition camera to the right (both in red).

Nico (right) and Tim (left) working outside in 4 C conditions with 70 km/h winds to make sure the new ox wagon interface works properly.

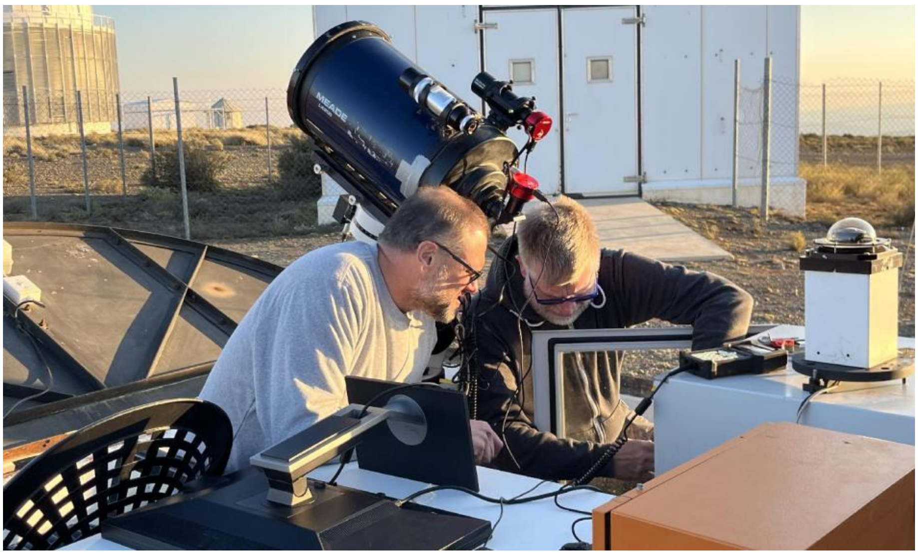
- Useful seeing data can be acquired using stars as faint as 3rd magnitude with 1 ms exposures. To avoid saturation, 1 ms exposure is appropriate for 1st to 3rd mag and 0.5 ms exposures should be used for stars brighter than 1st mag.
- The new acquistion scope+ camera worked very well for accurately acquiring targets. The "Align" function in KStars was used to acquire images, measure their astrometry, and then update/recalibrate the mount based on the solution. This function iterates until the solution matches the pointing to within 20" which would place the target well within the inner 400x400 pixel region of the seeing camera. The first pointing took several iterations to converge, but subsequent pointings only required 1 – 3.
- The software to interface with the ox wagon was updated to Python 3 and successfully migrated to a new computer.
- The tracking issues hinder the ability to observe northern targets, but are much less of an issue for stars south of –30 deg declination. Such targets largely stayed within the inner 400x400 center of the seeing camera. Moving this region-of-interest between measurements and limiting measurements to 15 seconds in duration can probably push this declination limit to –10 deg or even further north. However, with the much fainter limiting magnitude, this may not be necessary.



Example 1 ms exposure of a 2.95 mag star with the new camera and old DIMM mask. This is the 400x400 region at the center of the detector. The full detector size is 1608x1104.

There is still software work to be done to finish the job to fully integrate seeing measurements into the KStars control and Ekos scheduling systems. The hope is to have this done and timDIMM running in a fully automated fashion sometime in August 2023.

Tim Pickering.--



"Science Highlights from SALT"

After several years of only workshops and mini-meetings, the SALT community gathered again for a science conference, this time hosted by the Nicolas Copernicus Astronomical Center (CAMK) in Warsaw, Poland, from 1 – 3 June 2023. The conference followed directly after the 53rd SALT board meeting, and included approximately 60 participants representing all the SALT partners, with Poland and South Africa having the most participants, and others coming from the USA, UK, India, Germany, Thailand, and Italy.

A very wide array of topics was covered in 38 excellent talks and six posters, highlighting some of the fascinating questions that have been explored using SALT over the past few years. Interesting results and ongoing projects on all sorts of stars and transient phenomena, characterising exoplanet hosts, multiple stellar systems, AGN and galaxies in clusters were presented.

At the start of the conference, Marek Sarna was awarded the CAMK PAN medal in recognition of his leading role in realising Polish participation in the SALT project. We thank him for his commitment and many valuable contributions as a SALT board member over the years.

Thank you to Joanna Mikołajewska and the local and scientific organising committees for putting together an inspiring and enjoyable conference! As Lisa Crause reflected, "There was a real sense of how much SALT has matured over the six years since the previous conference in Poland, which is most heartening to see." We look forward to seeing what the next few years hold for SALT!

Panel discussion with Lisa Crause, Lee Townsend, Petri Väisänen, and Encarni Romero Colmenero (from left to right).

Marek Sarna receiving his award.

And here are some photos from evenings out in Warsaw.

Jack Hughes (Rutgers University) and Brian Chaboyer (Dartmouth College, SALT board chair)

Gerald Handler, Lisa Crause and David Buckley

A cute car at the Italian restaurant where the conference dinner was held

Ros Skelton & Joanna Mikołajewska .--

MEET THE TEAM: Shamiel Adams

Software Engineer

Hello everyone,

I graduated in 1999 with a BSC Engineering (Electrical). From 2000 to 2002 I developed GUI client interface using C++ MFC (Microsoft Foundation Classes) and traditional C windows 32 bit programming. Thereafter I completed my MSc Engineering (Electrical) 2005 with full dissertation dealing with fast processing SAR (Synthetic Aperture Radar) images in the time domain.

I was recruited as trainee at Sunspace and received high level top-down perspective in the fields of Attitude Determination & Control, Command & Data Handling and Satellite Software. Thereafter I was appointed to the Attitude Determination & Control System Team. A few highlight at Sunspace were performing a brief study on auto focusing using Cepstrum, upgrading a CCD Star Tracker harness between front end electronics and processing board from analogue to digital LVDS interface and prototype development of a portable Helmholtz coil system.

Sunspace was acquired and became Denel Spaceteq. I started to do the in-house development of Star Tracker Head using CMOS image with Space Wire communication.

I worked in the software team from 2017 to develop application flight software. A few highlights were:

- Integrating Star Tracker processing software with a procured Star Tracker Camera,
- Developed cross platform web based Star Tracker Tester/Visualiser, using ASP.Net Core, SignalR and D3,
- Implemented telemetry logger and accompanying telemetry decoder for satellite CAN bus and ground MQTT bus.
- Maintain Vagrant provisioned Fedora boxes on VirtualBox for development.
- Ported Task Scheduler from Sumbandila project to EOSat1 project.
- Prototype non-linear least square using Sympy for optical correction

I joined as a SALT Software Engineer, in Cape Town in March 2022, reporting to Janus. At present, I am working to help commission NDET software for NIR and on the RSS detector upgrade software for PDET. Other activities include general software operational support for SALT team in Sutherland.

There is a lot to learn at SALT and I am still familiarising myself with all the systems and software developed.

Kind Regards,

Shamiel

SALT SCIENCE PAPERS

April 2023 – July 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.

- Imbrogno, M., Israel, G. L., Rodríguez Castillo, G. A., et al. 07/2023: Discovery of a magnetar candidate X-ray pulsar in the Large Magellanic Cloud, MNRAS.tmp -- https://ui.adsabs.harvard.edu/abs/2023MNRAS.tmp.2074I
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