NRF National Research Foundation | SAAO South African Astronomical Observatory

SAAO ANNUAL REVIEW

2022 | 2023

SAAONEWS SAAO_ASTRO SAAO SALTSAAO

SOUTH AFRICAN ASTRONOMICAL OBSERVATORY

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SAAONEWS SAAO_ASTRO SAAO SALTSAAO

SOUTH AFRICAN ASTRONOMICAL OBSERVATORY

CONTENTS

SAAO 2023

3D - Three Dimensional

A

AAVSO - American Association of Variable Star Observers
ADASS - Astronomical Data Analysis Software and Systems Conference
AERAP - African-European Radio Astronomy Platform
AfAS - African Astronomical Society
AGN - Active Galactic Nucleus
ALMA - Atacama Large Millimeter/ sub-millimeter Array
APA - African Planetarium Association
APASS -The AAVSO Photometric All-Sky Survey
ASSAP - African Science Stars Awareness Publication
ATLAS - Asteroid Terrestrial-Impact Last Alert System

B

BCG - Brightest Cluster Galaxies
BiSON - Birmingham Solar Oscillations Network
BITDN - BRICS Intelligent Telescope and Data Network
BRICS - Brazil-Russia-India-China-South Africa

C

CAD - Computer-Aided Design CCD - Charge-Coupled Device CEO - Chief Executive Officer
CERN - European Council for Nuclear Research
CMOS/sCMOS (scientific) - Complementary Metal Oxide Semiconductors
CNC - Computer Numerically Controlled
CSIR - Council for Scientific and Industrial Research

D

DSI - Department of Science and Innovation

E

EDM - Electrical Discharge Machining
ESO - European Southern Observatory

F

FRD - Foundation for Research Development, later NRF

G

GA - General Assembly

H

HESS - High Energy Stereoscopic System
HMI - Human Machine Interface
HRS - High-Resolution Spectrograph
HST - Hubble Space Telescope
HWU - Heriot-Watt University

I

IAU - International Astronomical Union
IDSAC - IUCAA Digital Sampler Array Controller
IFU - Integral-Field Units
INAF - National Institute for Astrophysics, Italy
IO/AIO - (African) Intelligent Observatory
IRSF - InfraRed Survey Facility
IT - Information Technology
IUCAA - Inter-University Centre for Astronomy and Astrophysics

J

JWST - James Webb Space Telescope

K

KELT-South - Kilodegree Extremely Little Telescope
KMTNet - Korea Microlensing Telescope Network

L

LADUMA - Looking At the Distant Universe with the MeerKAT Array
LCO - Las Cumbres Observatory
LFC - Laser Frequency Comb
LIRGs - Luminous Infra-Red Galaxies LJMU - Liverpool John Moores University LMC - Large Magellanic Cloud
LSST - Legacy Survey of Space and Time

M

MASTER - Mobile Astronomical System of the TElescope-Robots Network
MaxE - Maximum Efficiency spectrograph
MeerKAT - Karoo Array Telescope
MIT - Massachusetts Institute of Technology
MNRAS - Monthly Notices of the Royal Astronomical Society
MONET - MOnitoring NEtwork of Telescopes
MPE - Max Planck Institute for Extraterrestrial Physics
MSc - Masters of Science
MSU - Michigan State University

ACRONYMS/ABBREVIATIONS

N

NAOJ - National Astronomical Observatory of Japan
NASA - National Aeronautics and Space Administration
NASSP - National Astrophysics and Space Science Program
NEO - Near-Earth Objects
NGC - New General Catalog
NGTS - Next-Generation Transit Survey
NIR - Near-Infrared
NRF - National Research Foundation
NSTF - National Science and Technology Forum

O

OAD - Office of Astronomy for Development
OGLE - Optical Gravitational Lensing Experiment

P

PAC - Postgraduate Advisory Committee
PhD - Doctor of Philosophy
PI - Principal Investigator
PRIME - PRime focus Infrared Microlensing Experiment

Q

QE - Quantum Efficiency

R

ROS - Remote Observing Station
RSS - Robert Stobie Spectrograph

S

SAAO - South African Astronomical Observatory
SAASTA - South Africa Agency for Science and Technology Advancement
SALT - Southern African Large Telescope
SANSA - South African National Space Agency
SARAO - South African Radio Astronomy Observatory
SCBP - SALT Collateral Benefits Programme
SDSS - Sloan Digital Sky Survey
SDSU - San Diego State University Astronomy Department
SKA - Square Kilometre Array
SHOC - Sutherland High-speed Optical Camera
SIRIUS- Simultaneous 3-colour InfraRed Imager for Unbiased Survey
SMC - Small Magellanic Cloud
SMI - Slitmask IFU
SNR - Signal-to-Noise Ratio
SOFIA - Stratospheric Observatory for Infrared Astronomy
SpUpNIC - Spectrograph Upgrade Newly- Improved Cassegrain
SUNBIRD - SUperNovae and starBurst in the InfraReD
SuperWASP - Super Wide Angle Search for Planets

T

TESS - Transiting Exoplanet Survey Satellite
TNS - Transient Name Server UCT - University of Cape Town UK - United Kingdom

U

UM - University of Miami
USA/US - United States of America
UV - Ultraviolet

V

VIS - Visible

W

WALOP - Wide Area Linear Optical Polarimeters
WISE - Wide-field Infrared Survey Explorer

Z

ZTF - Zwicky Transient Facility

MESSAGE FROM THE SAAO DIRECTOR

DEAR READER, AND DEAR SAAO & SALT TEAM,

It is my pleasure to present the Annual Report of the South African Astronomical Observatory for the year April 2022 through to March 2023. During this year, the country and the world finally were able to move forward from the COVID-19 pandemic, and at an organisational level, we gradually returned to "normal" operations. However, while the pandemic period appears quite surreal now, it also remains painful for many of us due to the losses experienced, and my heart goes out to all those readers who experienced tragedy close by.

Nevertheless, the SAAO staff showed incredible resilience and dedication through those difficult times, including adapting to new ways of working, which I hope stay with us as we have learned to be more agile and flexible while maintaining efficiency. Thus, first of all, I want to extend my heartfelt gratitude to each and every one of you for your unwavering commitment during those trying times, and since.

There were many highlights and notable achievements during this period, that you can read about in this beautiful Annual Report, and of which the Observatory can be very proud. On the science front, a noteworthy refereed publication rate by SAAO staff in prestigious journals returned to pre-pandemic levels (138 refereed papers, to be exact). These publications demonstrate our commitment to cutting-edge research and our role in the global astronomy community. Science highlights include super-hot stars observed with SALT, the "Peekaboo galaxy", exo-planets, gamma-ray bursts, and more, continuing to push the boundaries of knowledge in the field.

Our dedication to training future generations of astronomers is exemplified by the successful graduation of 2 PhD and 4 MSc students supervised by SAAO staff. By nurturing young talent, we ensure that the legacy of SAAO continues to shine. In addition, we develop talent and skills through investments in other student support, training workshops, job shadow programs, hackathons, and other initiatives, also together with other hosted and/or collaborative entities, such as the Office of Astronomy for Development (OAD), the African Astronomical Society (AfAS), and the BRICS Astronomy Group.

Regarding continental and global connections, a highlight of the reporting period was our participation in the *IAU General Assembly* in Busan, South Korea, in August 2022. The conference was one to remember not only for its great science content but especially due to the phenomenal vibe the whole *African delegation* demonstrated there. I was very proud to have had the opportunity to be part of that – the joyful, colourful, innovative, interactive presence we had all around, especially at the SAAO, SALT, AfAS, GA2024, and OAD booths. It is exciting to be looking forward to the next General Assembly, hosted by us here in Cape Town, in 2024.

In addition, SAAO-based personnel were in the driving seat of organising the third annual conference of AfAS in March 2023. In a welcome sign of growth of the community, this was held at Wits, in Johannesburg, the continental AfAS meeting happening for the first time outside of Cape Town. Finally, SAAO also called together a national Astronomy Town meeting in 2022 to discuss the status and strategy of South African astronomy, an event that will happen annually henceforth.

The highlight of our telescope operations in this period is the extraordinary progress in the *Intelligent Observatory (IO)* project to enhance our efficiency by modernising the SAAO operational model with a large step, not only incrementally. The IO team has been very innovative in developing agile and responsive systems for this to be possible. The significant milestones in this long-term IO vision were reached in particular with our Lesedi telescope and its *Mookodi* imaging-spectrograph, which demonstrated *fully autonomous* operations for weeks on end. Not only does the telescope operate without human intervention following some pre-described program, but it actually is dynamically able to also make its own schedule by e.g. "listening" to international alert streams of interesting new astrophysical targets of opportunity, observed elsewhere.

The IO project is not the only demonstrator of SAAO's commitment to innovation, but there has also been significant progress in other technology projects, as elaborated in the Review, such as first-light achieved with the new NIRWALS instrument on SALT, and progress in new SALT/RSS Detector packages, an SAAO-built Integral Field Unit also for SALT, and the WALOP instrument for the SAAO 1m telescope.

As an individual event, perhaps the most globally visible one was our role in the NASA DART mission in 2022. Our astronomers and telescopes obtained exquisite "front row" observations[1] of the asteroid impact, which for the first time demonstrated *planetary defence* (no less) techniques, to stave off potentially catastrophic asteroid or comet impacts on Earth.

Lastly, it was very gratifying to be able to return to public engagement activities after the pandemic period. It is our sincere hope that SAAO's dedication to public engagement through Open Nights, school outreach programs and teacher workshops, various exhibitions, the AstroQuiz, as well as community outreach programs in Sutherland in particular, inspire both young and older minds to foster a deeper appreciation for the cosmos. The forthcoming opening of the new Cape Town Visitors Centre for the public in 2023/2024 is another exciting development, which will showcase African astronomy heritage as well as SAAO's research.

The SAAO's mission is to advance astronomy and to inspire society with the wonders of the universe. Moreover, I truly wish that when reaching for the stars and exploring new horizons, we also encourage appreciation for life, and specifically *life* together, on this planet that we all share.

I would like to again thank every member of the SAAO team for your hard work, passion, and commitment that made all of these activities and achievements described in this Annual Review possible.

Sincerely,

Prof. Petri Väisänen

[1] *https://en.wikipedia.org/wiki/Double_Asteroid_Redirection_Test#/media/File:DART-impact-SAAO-Lesedi-Mookodi.gif*

ABOUT SAAO

ABOUT SAAO
BACKGROUND

The South African Astronomical Observatory (SAAO) operates as a business unit of the National Research Foundation (NRF) and serves as a National Research Facility under the jurisdiction of the Department of Science and Innovation (DSI).

It holds the distinction of being the national center for optical and infrared astronomy in South Africa. Moreover, the SAAO stands as the foremost establishment for optical astronomy across the African continent and bears majority ownership and operational responsibility for the Southern African Large Telescope (SALT), the largest optical telescope in the southern hemisphere.

The SAAO plays a crucial role in offering state-of-the-art ground-based observational facilities to astronomers both within the nation and around the globe. Additionally, it conducts cutting-edge astronomical research through its own team of expert researchers.

Situated within the Two Rivers Urban Park in Cape Town's Observatory suburb, the SAAO's headquarters are located at the confluence of the Black and Liesbeek Rivers. Tracing its roots back to 1820 when the authorisation for its establishment, then known as the Royal Observatory Cape of Good Hope, was granted, this observatory represents one of Cape Town's oldest enduring structures. Recognizing its historical significance, the Observatory was declared a National Heritage Site in 2018. Today, some of the historical telescopes in Cape Town continue to be utilised for outreach programs and public events.

The Cape Town site stands as one of the last remaining areas near the city center where the original local ecology has been preserved. The lower-lying regions are periodically subject to flooding and provide a diverse habitat for a wide array of bird and animal species, as well as a variety of flowering bulbous plants. Moreover, this locale serves as the northern boundary for the endangered Western Leopard Toad (Amietophrynus pantherinus) and represents the sole remaining habitat for the rare iris species, Moraea Aristata.

Due to the challenges posed by light and air pollution in the city, research observations are conducted at an observing site located 15 km from the small town of Sutherland in the Northern Cape. This site, situated on a plateau 1,800 meters above sea level and distanced from Cape Town's urban lights, houses 24 telescopes of varying sizes and configurations. Some of these telescopes are owned by the SAAO, while others are hosted on behalf of international research institutes. This collection of telescopes offers astronomers from South Africa and across the globe access to exceptionally dark skies. The site's strategic positioning in longitude between other prominent optical observatories in the southern hemisphere, such as those in Chile and Australia, enables continuous coverage for time-critical observations.

The SAAO fulfills a vital role in the National System of Innovation (NSI) through its foundational research, provision of research infrastructure for astronomers affiliated with South African universities, and development of innovative technologies for astronomical instrumentation.

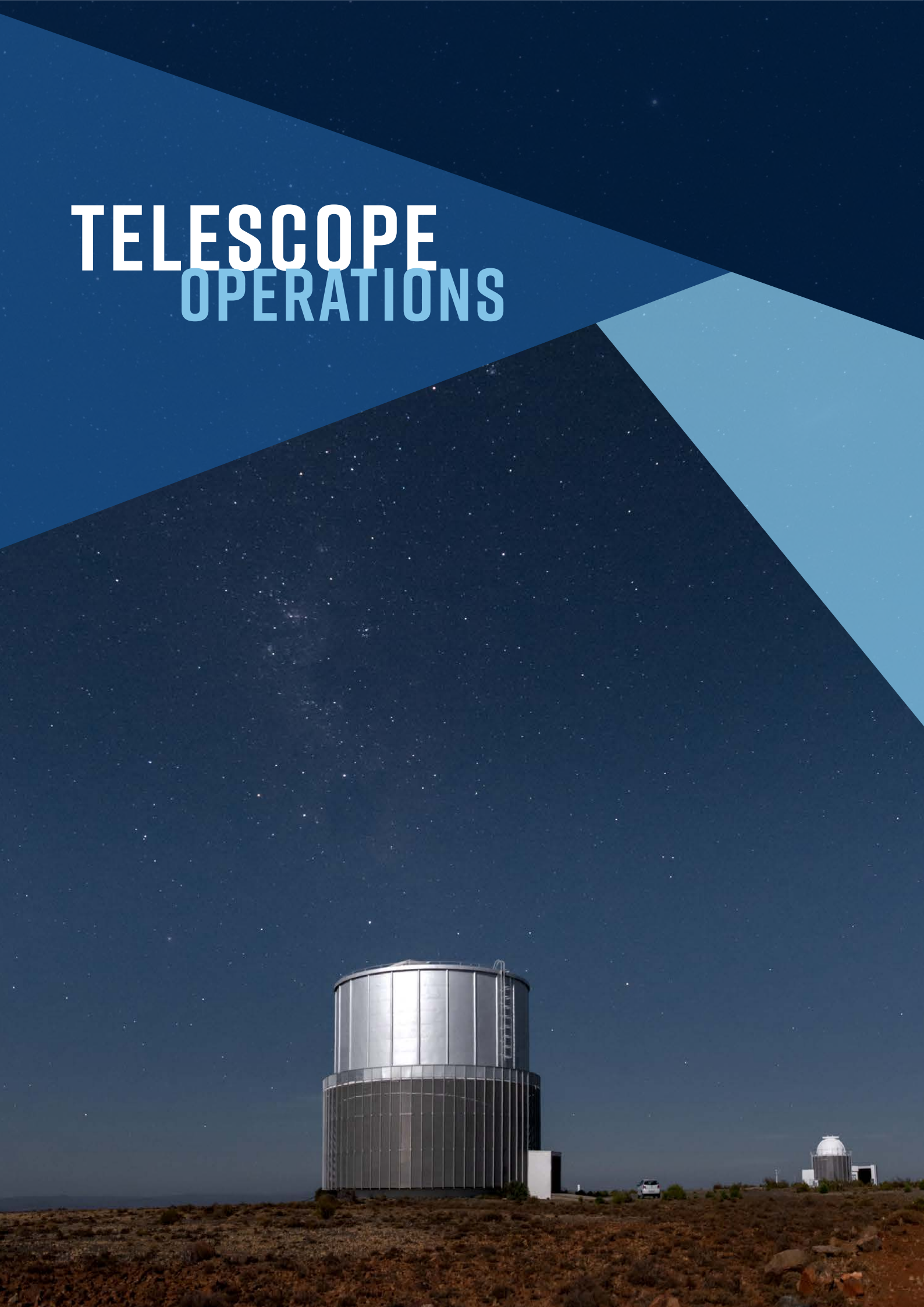
SAAO astronomers actively engage in a wide range of international research projects. Dissemination of their research findings through publications and conference presentations serves to drive innovation both within the nation and worldwide. Moreover, the SAAO assumes responsibility for guiding numerous post-graduate students in their educational pursuits. Graduates trained at the SAAO have gone on to become esteemed researchers and educators, leaving their mark not only in South Africa but also across the African continent.

To further enrich Southern Africa's interest in and understanding of astronomy

and astrophysics, the SAAO shares its research findings and discoveries while actively participating in outreach activities. Through these efforts, the SAAO endeavors to inspire and engage citizens, fostering enthusiasm for the fields of physics and astronomy. Its overarching goal is to sow the seeds of innovation in future generations of South Africans. The SAAO proudly hosts the Office of Astronomy for Development (OAD) of the International Astronomical Union (IAU), which coordinates projects worldwide aimed at leveraging the transformative power of astronomy to improve people's lives.

In addition, the SAAO serves as the secretariat of the African Astronomical Society (AfAS), a pan-African professional society of astronomers. As a not-for-profit company registered in South Africa, AfAS aspires to create and support a globally competitive and collaborative astronomy community within Africa. Its mission is to be the authoritative voice of astronomy on the continent and contribute to addressing the challenges faced by Africa through the promotion and advancement of astronomical pursuits. A primary objective of AfAS involves fostering the development of astronomy and human capacity throughout the African continent by cultivating a vibrant and active society. At present, AfAS primarily receives funding from the Department of Science and Innovation (DSI) in South Africa.

TELESCOPE OPERATIONS



SAAO

TELESCOPE OPERATIONS

SAAO TELESCOPES

SALT
(SOUTHERN AFRICAN LARGE TELESCOPE)

Size: 9 x 11 m
Instruments: Spectrographs (low and high resolution), CCD camera, Spectro-polarimeter.
Start of science operations: 2011

1.9-METRE

Size: 1.9 m
Instruments: Spectrographs, CCD cameras, Polarimeter Spectrographs, CCD cameras, Polarimeter
Start of science operations: 1938-1948

1.0-METRE

Size: 1.0 m
Instruments: CCD cameras
Start of science operations: 1964

LESEDI

Size: 1.0 m
Instruments: Low-resolution imaging spectrograph, wide-field camera
First light: 2019

ACT
(ALAN COUSINS TELESCOPE)

Size: 0.75 m
Instruments: Photometer
Start of science operations: 1999

DIMM

Instruments: Sky monitor; part of SALT
Start of science operations:1995

CO-OWNED FACILITIES

NEW!

PRIME
(PRIME FOCUS REFLECTOR TELESCOPE)

Size: 1.8 m
Owner: SAAO, University of Osaka, Astro-Biology Centre of Tokyo, NASA's Goddard Space Flight Centre, University of Maryland.
Description: A wide FOV 1.8m telescope with the world largest class NIR camera to perform world's first NIR microlensing surveys for exoplanets. The telescope is designed to perform world's first NIR (JH-band) microlensing surveys for exoplanets in galactic center to dramatically increase detections of exoplanets.

IRSF
(INFRARED SURVEY FACILITY)

Size: 1.4 m
Owner: Nagoya Univ, Kyoto Univ, NAOJ (Japan), and SAAO
Description: IRSF has been a fruitful collaboration between Japan and SAAO since 2000 and offers a near-infrared camera (SIRIUS) and polarimeter (SIRPOL).

MeerLICHT

Size: 0.65 m
Owner: Six institutes in South Africa, the Netherlands and the United Kingdom
Description: MeerLICHT -- Dutch for 'MORE LIGHT' -- is fully robotic and provides a simultaneous, optical view of the radio sky as observed by MeerKAT to help identify and classify transient events.

BISON
(BIRMINGHAM SOLAR OSCILLATIONS NETWORK)

Size: 0.5 m
Owner: Birmingham University (UK) and SAAO
Description: BiSON is a cooperative programme between SAAO and Birmingham University, UK, to study the 5-minute oscillations of the Sun. Its Sutherland station is one of six networked solar telescopes spread around the world.

KELT-SOUTH
(KILODEGREE EXTREMELY LITTLE TELESCOPE)

Size: 4.2 cm / 7.1 cm, telephoto lenses
Owner: Ohio State University, Vanderbilt University, Lehigh University, SAAO
Description: KELT consists of two robotic telescopes: KELT-North in Arizona, USA, and KELT-South at Sutherland. They are conducting a survey for transiting extrasolar planets.

HOSTED FACILITIES

KMTNET
(KOREA MICROLENSING TELESCOPE NETWORK)

Size: 1.6 m
Owner: Korean Astronomy and Space Science Institute (KASI)
Description: KMTNet is a Korean network of three identical 1.6-m telescopes situated in the southern hemisphere (Chile, South Africa, and Australia), conducting a wide-field photometric survey. The network's main scientific goal is to discover earth-mass planets using the gravitational microlensing technique.

MONET
(MONITORING NETWORK OF TELESCOPES)

Size: 1.2 m
Owner: University of Göttingen, Germany
Description: MONET consists of two fully automatic telescopes located at the observatory sites of partner institutions in Texas and South Africa. A large fraction of observing time is available to schools.

LCO
(LAS CUMBRES OBSERVATORY)

Size: 3 x 1.0 m and 1 x 0.4 m
Owner: Las Cumbres Observatory
Description: The Las Cumbres Observatory is run by a private operating foundation; it consists of a global network of telescopes and operates as a single facility. LCO is used for professional research and citizen investigations. Sutherland is the location of three 1-metre and one 0.4-metre telescopes.

SOLARIS-1 AND SOLARIS-2

Size: 2 x 0.5 m
Owner: Poland
Description: Solaris is a Polish scientific initiative to open a new frontier in the hunt for extrasolar planets. It consists of a global network of fully autonomous telescopes: two at SAAO and one each in Australia and in Argentina.

HOSTED FACILITIES

OSR
(OPTICAL SPACE RESEARCH)

Size: 0.5 m
Owner: SANSA, DLR (the German Aerospace Centre)
Description: The OSR laboratory is a space debris tracking telescope (part of the Small Aperture Robotic Telescope Network, or SMARTnet), to enable activation of collision-avoidance measures, to ensure the safe operation of satellites.

MASTER-SAAO
(MOBILE ASTRONOMICAL SYSTEM OF THE TELESCOPE-ROBOTS NETWORK)

Size: 2 x 0.4 m
Owner: MASTER-Net
Description: MASTER-Net is a network of optical transient alert twin-telescopes distributed in longitude over Russia, Argentina and South Africa (MASTER-SAAO). It is a fast survey system, covering more than 2000 square-degrees of sky per night.

ASAS-SN
(ALL-SKY AUTOMATED SURVEY FOR SUPERNOVAE)

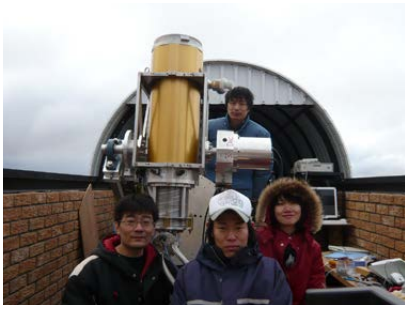
Size: 0.4 m
Owner: Las Cumbres Observatory, Ohio State University
Description: The LCO's Aqawan hut hosts both the ASAS-SN as well as the 0.4-m LCO telescope. The network comprises of five ASAS-SN telescopes.

XAMIDIMURA

Size: 2 x 0.4 m
Owner: Keele University, UK
Description: Xamidimura (meaning "Eyes of the Lion") is a new installation in the enclosure formerly housing SuperWASP, dedicated to following up eclipsing binary discoveries.

HOSTED FACILITIES

WFTC II



Size: 2 x 0.5 m
Owner: Nagoya Univ, Kyoto Univ, NAOJ (National Astronomical Observatory of Japan)
Description: WFTC II is a special infrared telescope whose interior is under vacuum and cooled to cryogenic temperatures. It has not been used much in recent years. The roll-off roof building was named Sumi-hut for the Sumitomo Foundation that supplied funding.

bRing PROJECT

(ß PIC B RING)

Size: 2 x 2.4 cm f/1.4 wide field lenses
Owner: University of Rochester, USA; NASA Jet Propulsion Laboratory; Leiden University, Netherlands
Description: The bRing experiment consists of a twin/two-camera telescope, monitoring the bright star β Pictoris for signs of obscuration from circumplanetary dust associated with the young gas giant exoplanet β Pic b.

ASTMON

(ALL-SKY MONITOR)

Size: 2 fish-eye lenses
Owner:
Description: All-Sky Monitor; used to determine the sky brightness in magnitudes.

SOUTH AFRICAN NATIONAL SPACE AGENCY

Owner: SANSA
Description: The SANSA container comprises several instruments (airglow imager, night-vision video cameras, extremely low-frequency receiver, mesospheric temperature mapper and satellite-based augmentation system receiver) to study the Earth's atmosphere and ionosphere, including research into how sprites are triggered and their effects on the upper atmosphere.

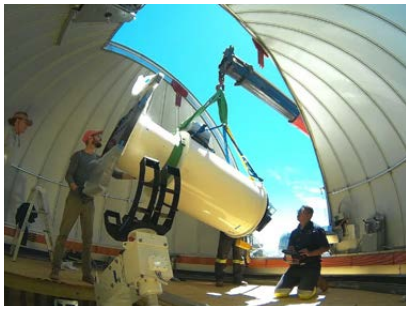
SAGOS

(SOUTH AFRICAN GEODYNAMIC OBSERVATORY SUTHERLAND)

Owner: German Research Centre for Geosciences (GFZ)
Description: The SAGOS seismograph is a superconducting gravimeter providing continuous high-resolution monitoring of changes in the Earth's gravity field.

ATLAS-STH

(ASTEROID TERRESTRIAL-IMPACT LAST ALERT SYSTEM - SUTHERLAND)



Size: 0.5 m
Owner: University of Hawaii Institute for Astronomy
Description: The Sutherland node of the four-telescope ATLAS system that surveys for hazardous near-Earth asteroids. The system also detects and reports many transient objects to the Transient Name Server (TNS).

TELESCOPE OPERATIONS REPORT

Throughout the financial year spanning from April 2022 to March 2023, the telescopes operated by the South African Astronomical Observatory (SAAO) have demonstrated exceptional efficiency, with an average technical downtime of only 1.9% per telescope. To enhance usability and safeguard the telescopes during observations, operational protocols, software watchdogs, and web interfaces have been implemented. A state-of-the-art Remote Observing Station (ROS) has been constructed at the Cape Town site to align with the SAAO's Intelligent Observatory (IO) philosophy. This facility, which facilitates convenient and well-equipped access to the telescopes, is now extensively utilised by both South African and international observers. Notably, experienced international telescope users have successfully conducted remote observations from their respective institutes, particularly those from the United Kingdom. Operations have returned to a state of near normality, with several national and overseas telescope users choosing to observe from Sutherland. Technical teams from hosted facilities have also visited Sutherland to work on their respective instruments, and all telescopes, including hosted ones, have resumed operations in Sutherland following the disruptions caused by the Covid-19 pandemic.

Several newly installed telescopes in Sutherland, such as the Asteroid Terrestrial-impact Last Alert System (ATLAS) and the PRime focus Infrared Microlensing Experiment (PRIME), have been operational for some time. ATLAS, in particular, has played a pivotal role in significant observations and discoveries related to Near-Earth Asteroids. The commissioning of the main imaging instrument for PRIME is still underway. Furthermore, efforts are underway to enable remote operations of the InfraRed Survey Facility (IRSF) from both Japan and South Africa, with successful remote operations from the SAAO in Cape Town already demonstrated.

Lesedi now offers the option to observe in a queue schedule mode, wherein users submit applications through the Observatory Control System (OCS) and observations are autonomously scheduled and executed. Currently, the OCS functions with Mookodi, one of the two instruments on Lesedi. The commissioning of Sibonise, a wide-field camera developed in collaboration with the Inter-University Centre for Astronomy and Astrophysics (IUCAA), on the other Nasmyth port of Lesedi is also progressing, having already produced remarkable images.

In terms of challenges faced during the period, the resignation of two mechanical technicians in Sutherland within a short time frame resulted in a one-month period during which the Telescope Operations (TOPS) division lacked a mechanical technician. However, one technician has been employed, and the recruitment process for the second mechanical technician is nearing completion. Additionally, there have been issues with the wind blinds on the 1.9m and 1.0m telescopes, which are currently non-functional. Plans are underway to address this problem. Furthermore, leaks have been detected in the domes of the 1.9m telescope, Lesedi, MeerLICHT, and PRIME. Although attempts to seal the leaks on PRIME have proven unsuccessful, plans are being finalised to engage a service provider to waterproof the domes of the 1.9m telescope, Lesedi, and MeerLICHT.

On the human resources front, a restructuring of technical operations in Sutherland has taken place. Both mechanical and electronics technicians are now part of the TOPS division, with Avhapfani Mulaudzi assuming the role of technical lead technician at Sutherland. In this capacity, Mulaudzi is responsible for coordinating and leading all technical efforts within TOPS in Sutherland, reporting directly to the head of TOPS (previously reporting to the head of Instrumentation).

- Ramatholo Sefako

TO ENHANCE USABILITY AND SAFEGUARD THE TELESCOPES DURING OBSERVATIONS, OPERATIONAL PROTOCOLS, SOFTWARE WATCHDOGS, AND **WEB INTERFACES HAVE BEEN IMPLEMENTED.**

TELESCOPE HIGHLIGHTS

PRIME FIRST LIGHT AND FIRST SCIENCE

After the successful delivery of the PRIME science camera by NASA-Goddard Space Flight Centre in late September, a joint team from NASA and Osaka University embarked on a journey to Sutherland for testing, installation, and the commencement of on-sky commissioning. However, upon arrival, they encountered an immediate setback. It was discovered that during transportation from the United States, an electronic component had become detached from one of the four infrared arrays, rendering that specific array temporarily inoperable.

Despite this initial hurdle, significant progress was made. The first light with the new camera on PRIME was achieved on October 8th, followed by a remarkable milestone on October 9th, when the first scientific result was obtained. Serendipitously, the team discovered the brightest Gamma Ray Burst ever detected in gamma rays on October 9th. The afterglow of this gamma ray burst was observed using various telescopes, both ground-based and space-based. Among them, PRIME played a crucial role by providing the first infrared measurements of this astronomical event, approximately 4.7 hours after its discovery.

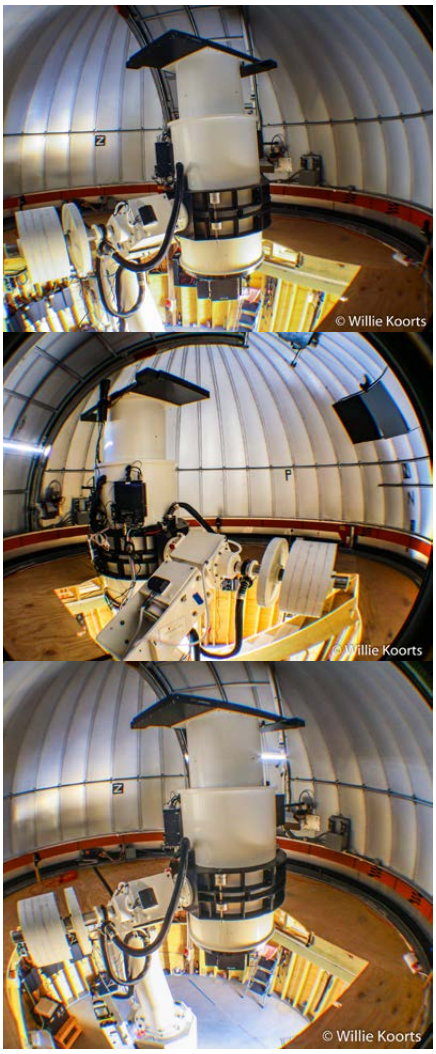
The GRB was detected with a brightness of H = 12.2 (refer to the accompanying image on the right). This groundbreaking observation stands as the first scientific achievement from PRIME, impressively realised only a day after the installation of the main camera. This accomplishment signifies a major milestone and paves the way for exciting future discoveries and results to unfold.

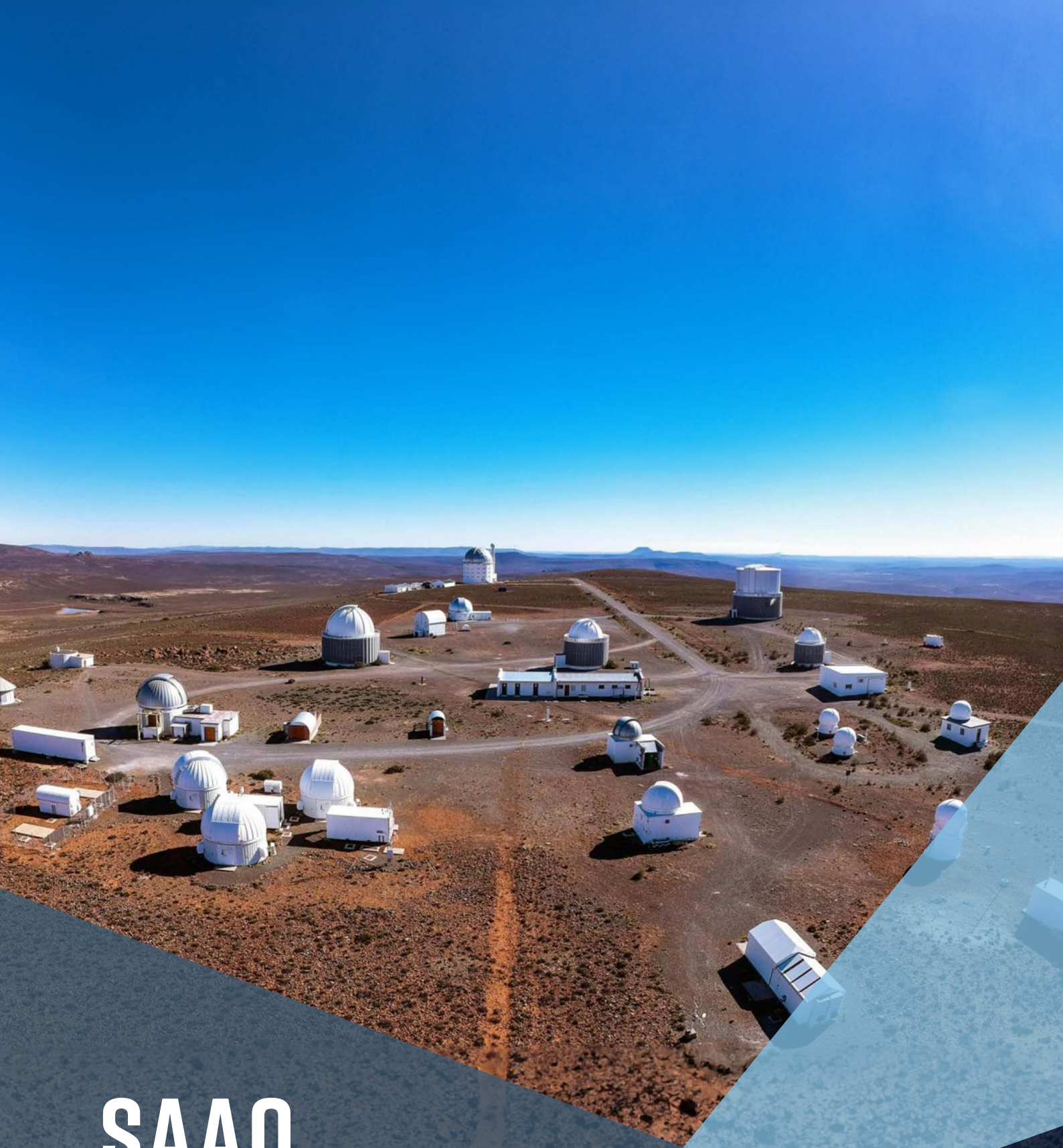
ATLAS SUTHERLAND MAKES AN IMPACT

ATLAS-Sutherland, which was installed and had its first light in December 2021, is part of a four-telescope network designed for the discovery of near-Earth asteroids (NEAs). Despite a temporary setback caused by contamination in the camera's cooling line in May, the system has performed well throughout the year. Since the beginning of this year, ATLAS-Sutherland has already discovered 25 new NEAs, comprising 4 Atens, 7 Amors, and 14 Apollos.

Notably, one of the discovered NEAs has been classified as potentially hazardous (PHA). In addition to NEAs, ATLAS-Sutherland has also detected one new comet and provided astrometry and photometry data for tens of thousands of known asteroids and comets, aiding in refining their orbits. Comparatively, the ATLAS unit at El Sauce Observatory in Chile, installed around the same time, has discovered 21 NEAs and 2 comets. Despite experiencing a one-month downtime in Sutherland and Chile having generally better observing weather conditions, Sutherland has surpassed Chile in terms of discovery numbers.

Moreover, ATLAS-Sutherland has contributed significantly to transient astronomy by reporting thousands of non-Solar System transients to the publicly available Transient Name Server (TNS). Many of these transients are followed up by transient research groups at the South African Astronomical Observatory (SAAO) using other telescopes in Sutherland. The ATLAS program as a whole has made a substantial impact in this field and currently ranks among the top five contenders in terms of the number of discoveries reported to the TNS.





SAAO INSTRUMENTATION

THE SAAO **INSTRUMENT WORKSHOP**

The process of transforming ideas and concepts into tangible and precise scientific instruments is an essential aspect of astronomical and scientific instrument development. The SAAO houses a facility that excels in producing components and instruments with exceptional precision, surpassing the capabilities of conventional manufacturing techniques.

At the SAAO machine shop, unique facilities are available for electrical discharge machining (EDM), utilising both plunge and wire techniques. EDM involves the use of electrical sparks to meticulously erode material, achieving remarkable precision in the process. Additionally, the machine shop offers computer numerically controlled (CNC) mills, lathes, and other equipment, including a precision measurement arm capable of verifying component dimensions with accuracy down to two micrometres.

In support of scientific and research endeavours over the years, the SAAO workshop has played a pivotal role in manufacturing an array of remarkable components. These components have contributed to the initiatives of various units within the National Research Foundation (NRF) as well as collaborations with esteemed international organisations such as the Inter-University Centre for Astronomy and Astrophysics (IUCAA), the European Council for Nuclear Research (CERN), the Square Kilometre Array Observatory (SKAO), and iThemba Labs.

- Hitesh Gajjar

INSTRUMENTATION **HIGHLIGHTS**

RSS DETECTORS

The SAAO has been actively working on the development projects for the Robert Stobie Spectrograph (RSS) at the Southern African Large Telescope (SALT). These projects involve the delivery of two new detectors: the upgrade of the existing RSS detector (RSS Vis) and the introduction of a new Red Arm to work in conjunction with RSS Vis, known as RSS Dual.

Considerable efforts have been dedicated to optimizing the performance of the controller and charge-coupled device (CCD) combination proposed for RSS. A significant milestone was achieved with the visit of Bhushan Joshi from the Inter-University Centre for Astronomy and Astrophysics (IUCAA) in March 2023. His visit led to crucial changes in the configuration of the controller unit used in the Sibonise instrument.

The appointment of Kgomotso Makolomakwe as an electronics engineer in the instrumentation department has played a pivotal role in the development of the detector control system. The hardware for this system will predominantly rely on programmable logic controllers (PLCs). The detector control system monitors and controls various aspects such as temperatures, camera shutter operation, vacuum control through an ion pump, and overall coordination of different components of the detector system apart from the CCD itself. Working in collaboration with SALT control engineers, Kgomotso has devised a PLC architecture that minimizes the mass and heat load on the payload while ensuring redundant control of both RSS Vis and Red.

Significant attention has been given to the optical aspects of the projects. This includes specifying and identifying suitable vendors for the RSS Vis field flattener lens, which also serves as the cryostat window. Thermal and structural analyses were conducted in preparation for the RSS Red Optical Preliminary Design Review (PDR) held in November 2022. Additionally, the design of test hardware has been underway to address specific questions regarding the behavior of the blank material.

These collective efforts reflect the SAAO's commitment to advancing the capabilities and performance of the RSS at SALT, ensuring the delivery of enhanced detectors and contributing to the overall success of astronomical observations and research conducted at the facility.

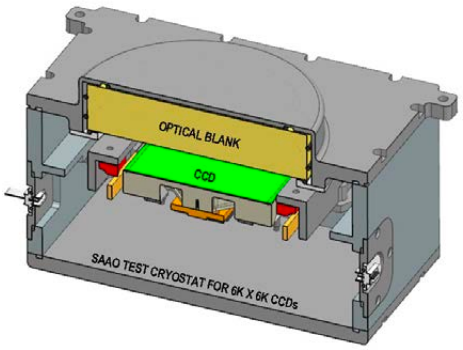


Figure: General arrangement of test setup for measuring baseline activity of the blank material for the RSS Red field flattener.

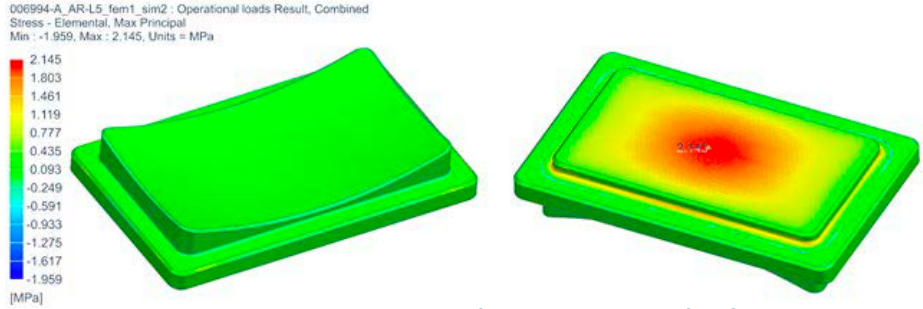
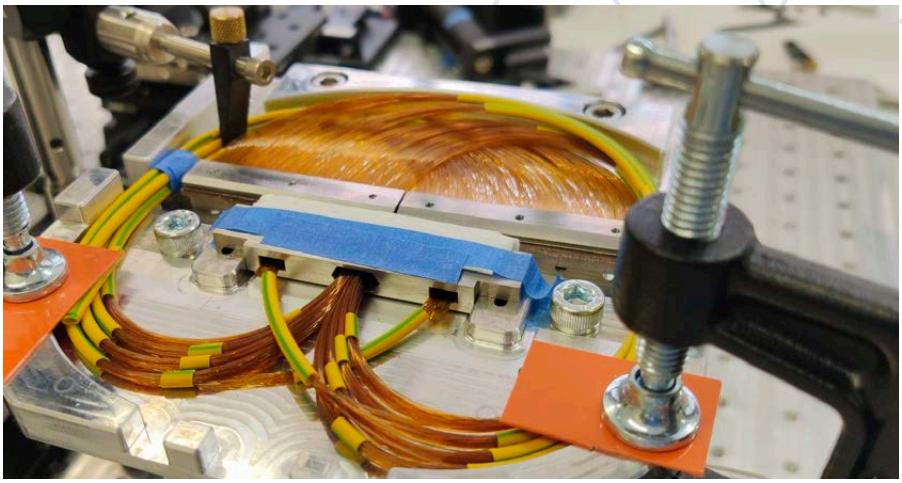


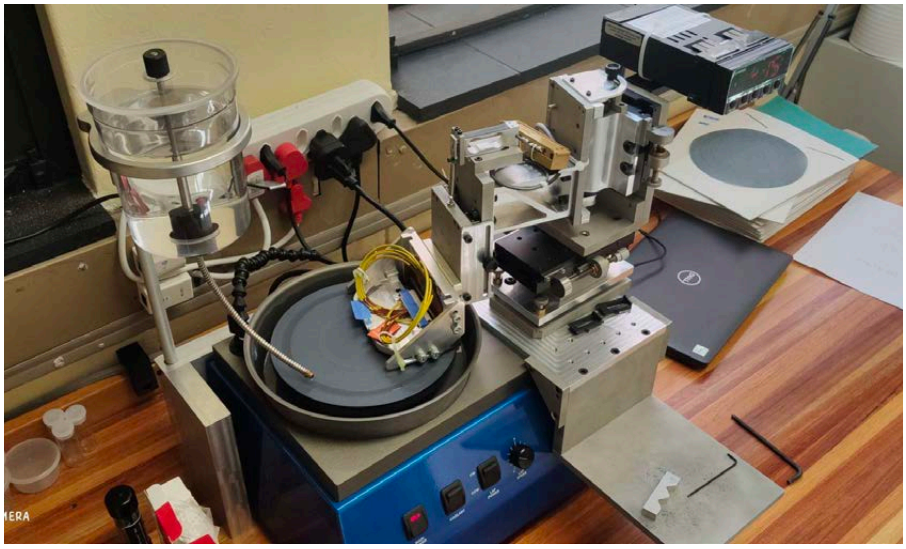
Figure: Analysis of stress distribution in field flattener subject to temperature variation and vacuum

SALT IFU (INTEGRAL FIELD UNITS)

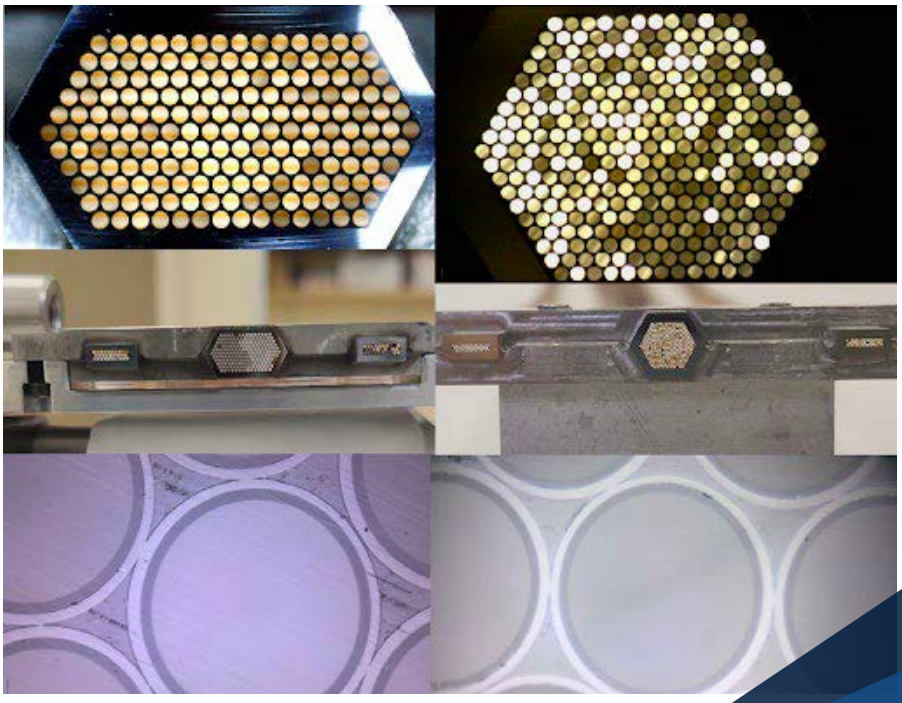
The SAAO is currently constructing two fiber integral field units (IFUs) in its fiber-lab for the visible arm of the Robert Stobie Spectrograph (RSS). Furthermore, a collaboration with the University of Wisconsin/Washburn Laboratory is underway to develop a third IFU. Once the second, red RSS beam becomes operational, all RSS IFUs will be able to simultaneously feed both beams. Each IFU is compatible with various gratings and camera angles available for other spectroscopic modes.



The fiber IFUs have different fiber diameters: 200, 300, and 400 micrometers. These IFUs consist of 179, 246, and 309 spatial elements, respectively, covering an extended hexagonal footprint on the sky. The spatial coverage on the sky for each fiber diameter is as follows: 18x23, 19x35, and 21x44 square arcseconds. Each individual fiber collects light through a circular aperture with a diameter of 0.9, 1.35, and 1.8 arcseconds for the 200, 300, and 400 micrometer fibers, respectively. The hexagonal arrangement of the fibers achieves a fill-factor of approximately 60%. This fill-factor results from the hexagonal packing and the required center-to-center spacing of 240, 370, and 480 millimeters (corresponding to 1.06, 1.65, and 2.14 arcseconds) to accommodate the fiber clad and buffer. To achieve full spatial coverage, users can employ dithering techniques to position the array at three defined locations on the sky.



The elongated hexagonal shape of the IFUs, known as the Spectral Mapping Instrument (SMI), is particularly advantageous for observing galaxies at various inclination angles. It enables mapping of extended objects ranging from Galactic HII regions to merging and interacting galaxies, as well as galaxy cluster cores and strongly lensed galaxies. Additionally, the SMIs are effective for low surface brightness observations, serving as a photon bucket to enhance the detection of faint astronomical sources.



INSTRUMENT SELECTOR

The Instrument Selector project was conceived out of the vision and mission of the Intelligent Observatory (IO) program at the South African Astronomical Observatory (SAAO). One of the goals of the IO program is to move towards a highly robotic and autonomous operational scheme. To this end, concerted effort is being made to implement robotic control on all new and existing instruments and telescopes at SAAO.

The 1.9m telescope currently supports the mounting of one instrument at a time on the Cassegrain port, and instrument changes are effected by daytime personnel who physically unmount and replace instruments as required. To minimise technical load, instrument changes are only performed once a week and as such, observations are limited to science cases supported by the instrument on the telescope in a given week.

The primary goal of the Instrument Selector project was to develop a means by which more instruments are available on the telescope at any one time, and whereby an instrument can be switched to active use without manual intervention. This improves operational efficiency by making daily (as opposed to weekly) scheduled rotas possible. It also better serves certain sciences, such as transient astronomy, by making rapid follow-up observations possible through quick, seamless and autonomous instrument changes.

Another significant advantage of the Instrument Selector, and the implementation of daily scheduled rotas, is that it will reduce the number of manual instrument changes performed per year. More importantly, the Instrument Selector would allow the observer (rather than daytime technicians) to make an instrument change during the course of a night, potentially allowing hundreds of changes per year.

The three instruments in regular use on the 1.9m telescope are the SHOC high speed imager, the SpUpNIC spectrograph, and the HiPPO polarimeter. The operational concept behind the Instrument Selector from a user perspective is to always have two of these instruments available on the telescope, and to be able to select between them at the push of a button. One of the instruments will always be the high-speed imager SHOC, and as such the available combinations will be SpUpNIC/SHOC or HiPPO/SHOC.

The operational concept of the Instrument Selector from a site operations perspective is thus: regular manual instrument changes will still be required to change between SpUpNIC and HiPPO. However, when one of those are mounted, a newly designed acquisition and auto-guiding system will be mounted to the acquisition box which will incorporate the SHOC fast imager and filters. The light can be diverted to either the primary instrument (SpUpNIC or HiPPO) or the secondary SHOC instrument by a new actuated fold mirror inside the acquisition box) (Figure1). Both the primary instrument and the secondary instrument will use the same guiding system, which is fed by light from the annulus mirror in the acquisition box (also referred to as an Offset Guiding Mirror, or OGM).

The guiding system, focal reducer optics, filter mechanism and SHOC is incorporated into a migratable package (Figure 2)which will be moved between and interfaced with whichever primary instrument is available on the telescope at the time.

The components for the Instrument Selector are currently being machined in the SAAO workshop and assembly and integration is on par for 3rd quarter of 2023.

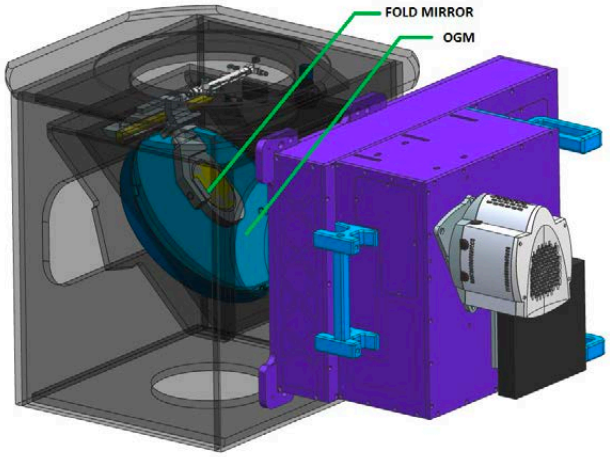


Figure: Instrument components 1

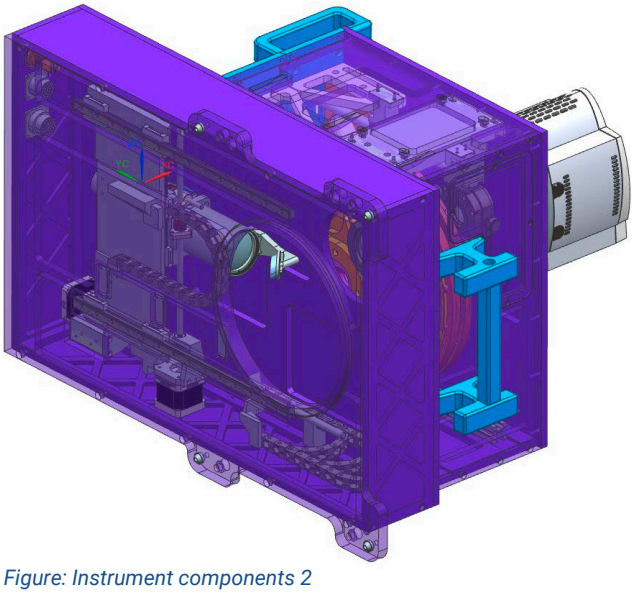
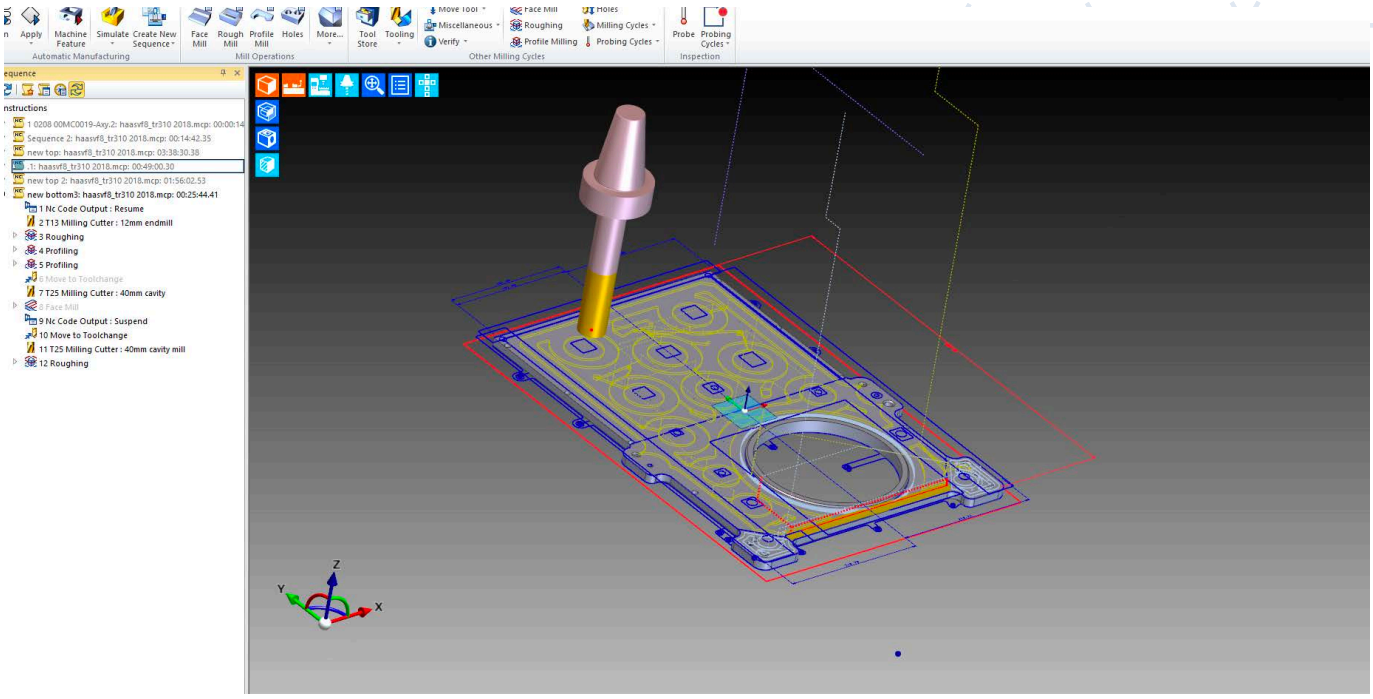
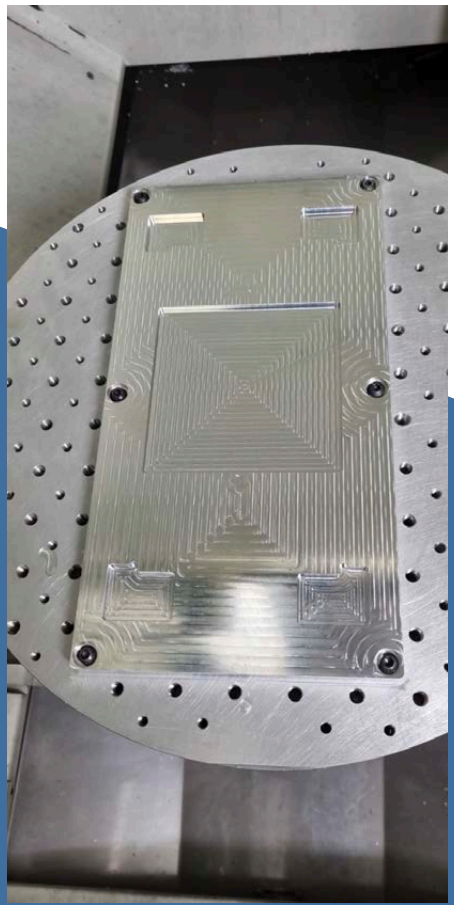
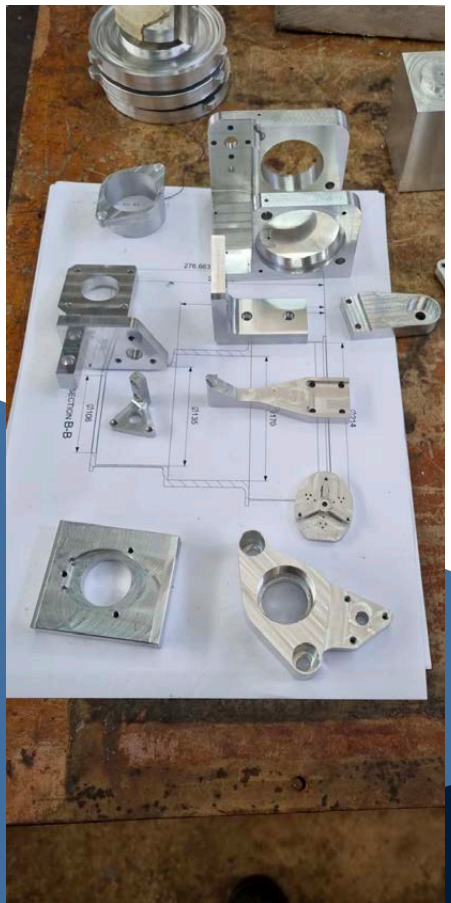


Figure: Instrument components 2

INSTRUMENT SELECTOR







WALOP

The WALOP-South instrument is one of the two WALOPs being developed by IUCAA in collaboration with SAAO to function as the workhorse instrument for the upcoming PASIPHAE program.

The assembly of the Wide-Area Linear Optical Polarimeter (WALOP)-South instrument, to be mounted on the old 1m SAAO telescope at Sutherland, is underway at the instrumentation laboratory of the Inter-University Center for Astronomy and Astrophysics (IUCAA), Pune, India.

The PASIPHAE program aims to create the first large optical polarimetry map of the sky, enabling astronomers to pursue long standing puzzles on the physics of the dust and magnetic fields permeating in the interstellar medium, which together influence almost all processes in our and other galaxies.

WALOP is being designed to obtain polarimetric accuracy of 0.1 % over an unprecedented large field of view of 35-by-35 arcminutes (diameter of the full-Moon is 30 arcminutes), making it a unique polarimeter. The instrument is in advanced phases of assembly and is scheduled for commissioning in the later part of 2023.

The overall instrument schematic is shown in the Figure below.

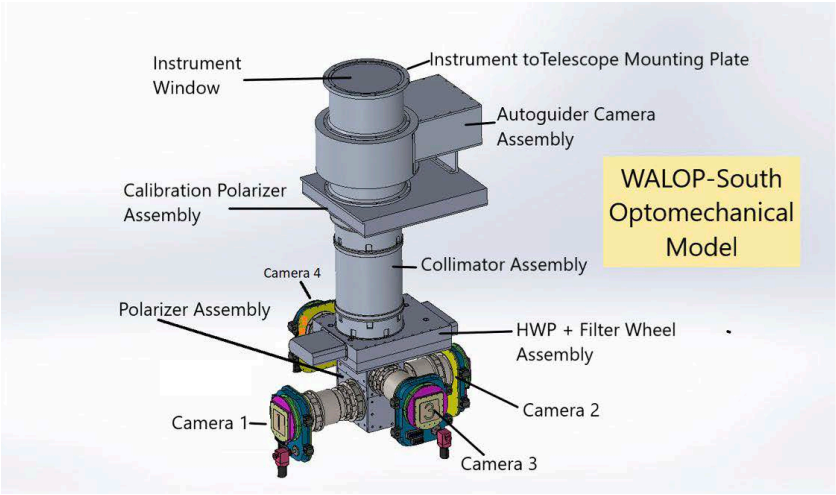


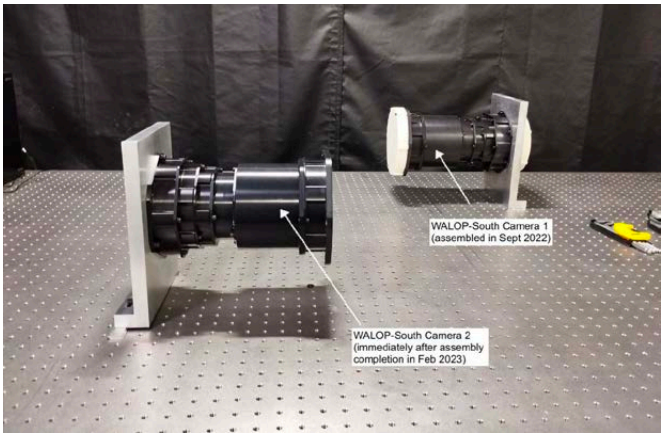
Figure: Left: The overall opto-mechanical model of the WALOP-South instrument, without electrical connectors and control boxes mounted. The various major subsystems in the model have been marked. Right: The overall opto-mechanical model of the WALOP-South instrument mounted inside its truss structure.

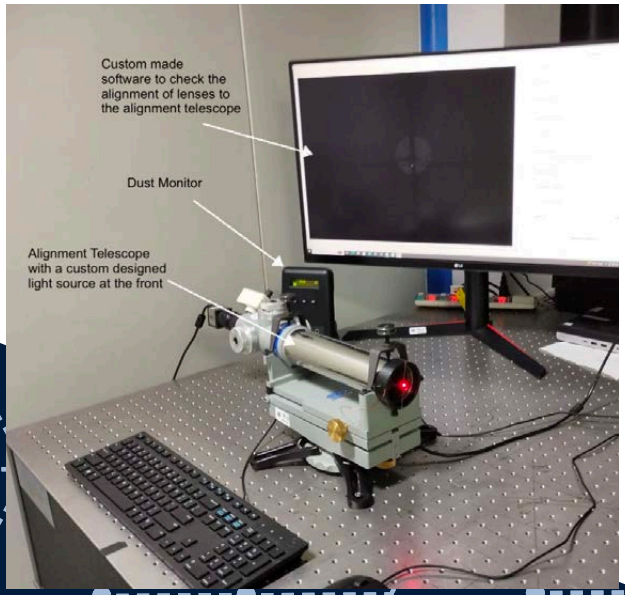
WALOP

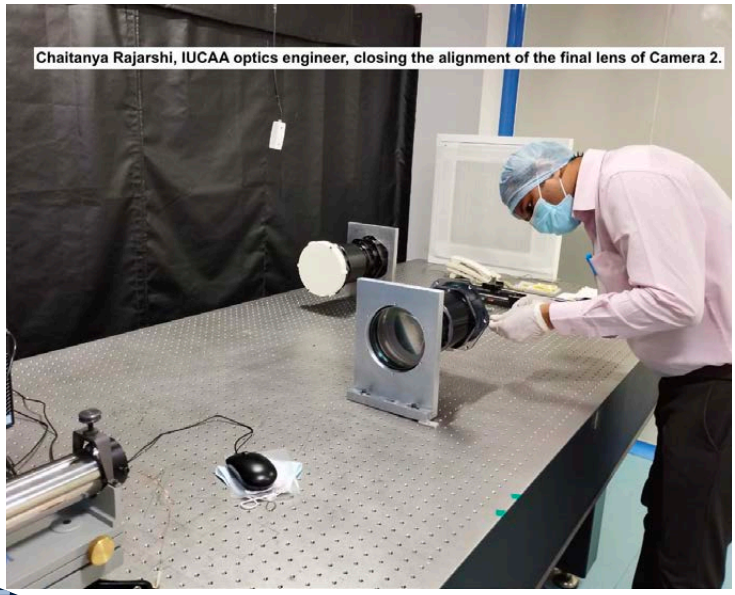
To achieve the challenging optical and polarimetric performance goals of the instrument, the optical assemblies of the instrument (including four cameras and a collimator) need to be aligned within accuracy of 20 to 50 micrometres. To meet this goal, the SAAO workshop is fabricating the lens mounts of the instrument to accuracies better than 20 micrometres. What makes the fabrication of the components challenging is their large dimensions: some of the components are as big as 35 cm in diameter. Obtaining these accuracies over such large spatial dimensions entails high end machining tool and jig development, innovative methodology development through an iterative learning process and a very strict quality control at each step of machining.

CURRENT STATUS: Two of the four cameras of WALOP-South have been assembled with the optics. The most challenging subassembly to fabricate, the collimator assembly, has been successfully fabricated by the SAAO workshop and the parts will be shipped to IUCAA for the optical assembly work. Fabrication of the remaining two camera mounts is ongoing. Apart from these, the remaining components with less stringent tolerances have been fabricated in India. The other sub-assemblies (besides camera and collimator) such as the polariser assembly which forms the heart and brain of the instrument, filter mechanism, and calibrator unit are under assembly in IUCAA.

The figure below shows the fabricated components for one of the cameras and the assembled barrel in the IUCAA with optics mounted on it.



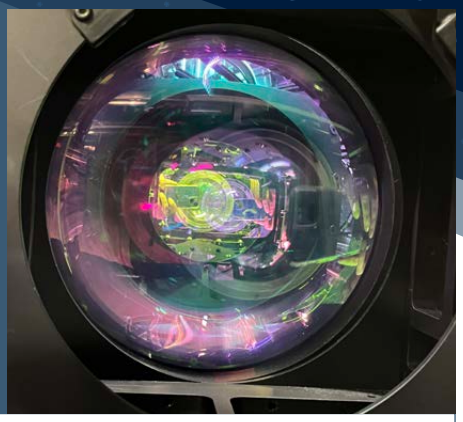


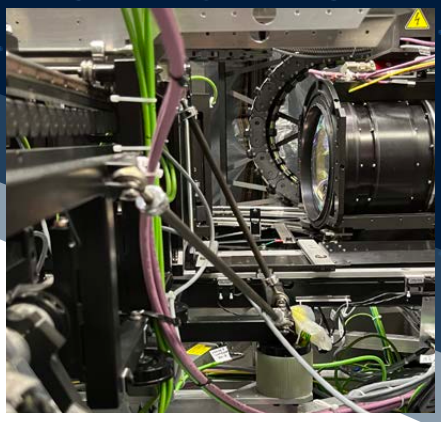


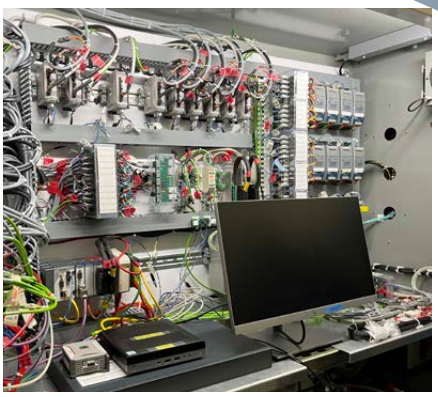
The two additional figures show the alignment setup.

FIRST LIGHT FOR SALT'S **NEW INSTRUMENT: NIRWALS***

*NEAR INFRARED WASHBURN ASTRONOMICAL LABS SPECTROGRAPH







The evening of 7 July 2022, SALT celebrated First-Light of the NIRWALS instrument. It is the first new instrument since the HRS was installed in 2013. NIRWALS is a standalone integral field spectrograph, fed by a fibre bundle that resides inside a cold enclosure in the spectrometer room, next to the HRS enclosure. It was developed and built by the Washburn Astronomical Laboratories of the University of Wisconsin-Madison's Astronomy Department, with Marsha Wolf (UW) as the PI. It is going to be a great addition to the existing suite of instruments and will extend SALT's capabilities into the near-infrared (NIR).

SCIENCE DRIVERS

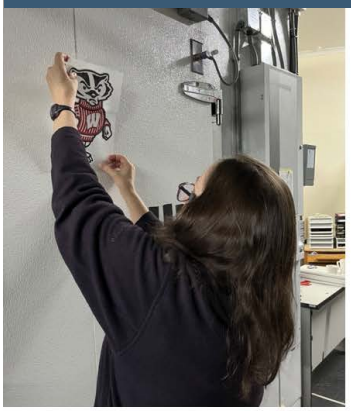
NIRWALS will paint a clearer picture of if and how AGN have regulated the star formation histories of galaxies. While the optical spectra using Robert Stobie Spectrograph (RSS) give information on the star formation histories of the galaxies and the ionisation state of the gas (indicating the presence of an AGN and its extent), the NIR spectra will give information on shocks in the gas from AGN outflows, past supernovae, and the very youngest stellar populations. The combined data will answer questions on where and when stars formed in a galaxy, where AGNs ionise the gas, if and where there were outflows from the AGN, and where star formation was shut down in the galaxies (e.g., was it along the AGN outflows?). Furthermore, NIRWALS will allow the comparison of light signals from galaxies at high redshifts to galaxies nearby that have been observed with RSS-VIS. And since NIR wavelengths can easily penetrate dust, NIRWALS can be used to study dusty star-forming galaxies. The IFU is necessary to isolate the different galaxy components and get simultaneous spectra of the different regions, including the faint outer parts for which SALT's large aperture is particularly suited.

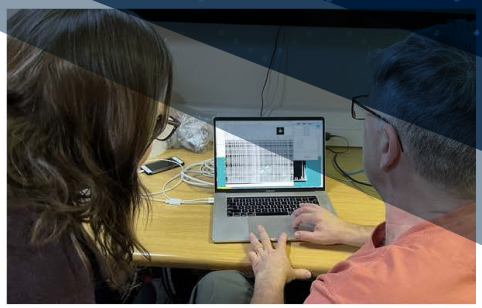
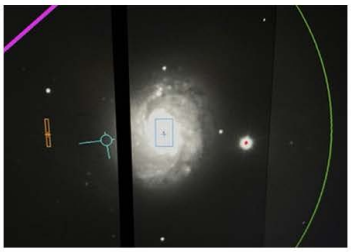
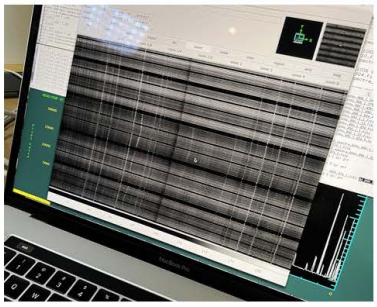
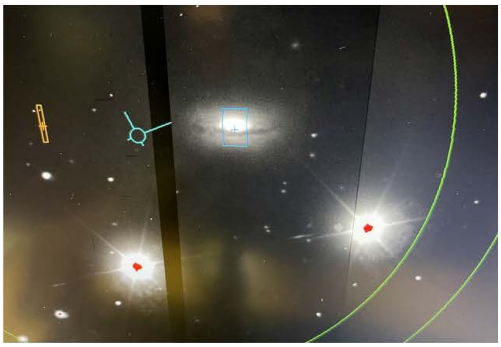
SPECIFICATIONS

NIRWALS provides medium resolution spectroscopy at R = 2000 – 5000 over the wavelength range of 800 – 1700 nm. Its integral field unit (IFU) is an elongated hexagonal bundle of 212 fibres, each of which subtends 1.3 arcsec on the sky, approximately matching the median site seeing. The IFU's on-sky dimensions of 29 x 18 arcsec are ideally suited for resolving nearby galaxies. A separate 36-fibre sky bundle simultaneously samples the sky. It can be adjusted to distances ranging from 45 – 145 arcsec from the object IFU, with a gimbaled jaw in the fibre instrument feed (FIF) that maintains telecentricity and common field angles for the object and sky bundles. Sky fibres are interleaved with object fibres along the 8-arcmin long spectrograph slit for optimising sky subtraction. The spectrograph is cooled to -40 C in an enclosure beneath the telescope, with the cryogenic dewar inside this enclosure operating at 120 K via a separate closed-cycle cooler. The spectrograph used volume phase holographic gratings with an articulated camera, similar to the RSS, for setup versatility. The spectrograph has been fully tested in the laboratory at the University of Wisconsin and is currently being commissioned on SALT.

Wavelength Coverage	800 - 1700 nm
Spectral Resolution (R)	2000 - 5000
Peak Predicted Throughput	0.40
Number Of Fibres In Ifu	212
Ifu Field Of View On-Sky	18 x 29 arcsec
Fibre Size On-Sky	1.33 arcsec
Number Of Fibres In Sky Bundle	36
Sky Bundle Field Of View On-Sky	4 x 29 arcsec
Adjustable Sky Bundle Distance From Ifu	45 - 145 arcsec

FIRST LIGHT FOR SALT'S **NEW INSTRUMENT: NIRWALS***



THE LASER FREQUENCY COMB (LFC)

During a busy period in early 2023, Lisa Crause, an Astronomer at SAAO, was joined by Richard McCracken from Scotland's Heriot-Watt University (HWU) on a trip to SALT in Sutherland. The very short trip was intended to help Lisa and Richard identify any issues that could possibly impact the integration and installation of the LFC.

Richard McCracken is a laser physicist and the project lead for the LFC that is currently under development for SALT's high-resolution spectrograph (HRS). The comb is a precision calibration device that will equip the HRS for very demanding radial velocity studies, such as those used to search for and characterise exoplanets. LFCs tend to be prohibitively expensive and dauntingly complicated. However, this collaboration with HWU was a fantastic opportunity to learn about and help develop a state-of-the-art system that's tailored to suit SALT's HRS.

All the components required were diligently ordered and delivered from suppliers, or manufactured by SAAO's in-house workshop. A few minor issues were identified and addressed along the way and one component (an acousto-optic modulator unit) was found to be unsuitable, so an alternative (an electro-optic modulator) was ordered.

The timing of this short visit was ideal, as interns got to spend some time with Richard and engage with the LFC hardware. Overall, SAAO looks forward to the integration and installation of the LFC scheduled for the 2nd half of 2023.

THE INTELLIGENT OBSERVERTORY (IO)

THE **INTELLIGENT** OBSERVATORY (IO)

The South African Astronomical Observatory (SAAO) has embarked on an ambitious initiative to upgrade its telescopes, instruments, and data analysis capabilities, facilitating their intelligent integration and seamless coordination. This endeavour aims not only to improve efficiency and agility but also to unlock exciting scientific possibilities within the realms of multi-messenger and time-domain astronomy.

The program encompasses hardware enhancements enabling autonomous operations, complemented by the development of sophisticated software solutions. Intelligent algorithms have been meticulously crafted to promptly and autonomously respond to real-time alerts from telescopes worldwide and space-based observatories. Overseeing this sophisticated framework is the Observatory Control System (OCS), actively managing the observing queue in real-time.

- Stephen Potter

FOCUS ON THE 1M LESEDI TELESCOPE AND THE MOOKODI IMAGER/ SPECTROGRAPH INSTRUMENT DURING 2022/23

During 2022/23 the IO team focussed on the objective to make the 1m Lesedi telescope plus its Mookodi instrument fully autonomous. The IO team had already previously developed a software framework that resulted in the deployment of a Web user interface for the telescope.

The next step was to use the framework to enable control of the telescope through scripts. In parallel, after the delivery of the Mookodi instrument at the end of 2021, the IO team developed a software framework that permitted its Mookodi's operation through a Web user interface and also emanating in "scripting" capabilities during 2022. Lesedi and Mookodi were used in this hybrid mode of operating either via the user web GUIs or executing scripts from the command line.

Through 2022 the IO team continued to develop the software framework to seamlessly integrate the Lesedi and Mookodi. By mid 2022 the framework was sufficiently developed to enable a full nights set of observations to be defined through the creation and execution of scripts.

AUTOMATION OF LESEDI AND MOOKODI SOFTWARE DEVELOPMENT

To enable full scripting functionality, autonomous software was developed to take care of:

- the telescope focus (function of filter and temperature)
- the pre-calculation of guide star coordinates using a local installation of the APASS catalogue
- autoguiding
- the fine pointing of the telescope to put target coordinates (and therefore the automatic calculation of the WCS) and any detector pixel coordinates
- the fine pointing of the telescope to put target coordinates at the location of the slit for spectroscopy
- an optional additional fine pointing of the telescope that uses the acquisition image to move the nearest point source to the specified pixel coordinates or slit position
- observing non-sidereal objects (near-real-time coordinates calculated using supplied orbital parameters)

OBSERVATORY CONTROL SYSTEM

To produce a fully-featured and maintainable (OCS) is an expensive undertaking. Fortunately the Las Cumbres Observatory successfully operates a network of 20+ robotic telescopes around the world, driven entirely by APIs and they have bundled up and open-sourced their software (https://observatorycontrolsystem.github.io/). The IO team have installed, deployed and configured LCO's OCS for the Lesedi and Mookodi instrument.

As of May 2023, with the OCS astronomers can:

- Submit requests to observe a target(s), track the states of those requests, and cancel requests if their needs have changed
- View information about their past and current requests, proposals
- Programmatically submit observation requests

Observatories can:

- Define trimesters
- Manage users and proposals who are able to submit requests
- Requests and queue scheduled according to criteria such as visibility, priority, target of opportunity etc.

BY THE END OF 2022 THE OCS HAS BEEN SEAMLESSLY INTEGRATED WITH THE AUTOMATED SCRIPTING FRAMEWORK OF THE LESEDI TELESCOPE AND MOOKODI. AT THE END OF APRIL 2023, LESEDI WITH MOOKODI COMPLETED A FULL TRIMESTER OF AUTOMATED OBSERVATIONS AS MANAGED BY THE OCS.

ADDITIONAL SOFTWARE SERVICES

Additional Web based software tools have been deployed:

- Quick-look spectroscopy. This tool produces wave-length and flux calibrated spectroscopy. Drop down menus not only permit quick-look reductions in live-observations but also any observations in the archive.
- Quick-look photometry. Will produce live light curves or from any data set in the archive.
- A live graphical view of the schedule.

SCIENCE HIGHLIGHTS

SINCE THE DEPLOYMENT OF FULL AUTOMATION OF LESEDI PLUS MOOKODI, THERE ARE NEW SCIENCE OPPORTUNITIES THAT HAVE NOT BEEN POSSIBLE THROUGH THE TRADITIONAL TIME ALLOCATION PROCESS. HERE ARE SOME HIGHLIGHTS:

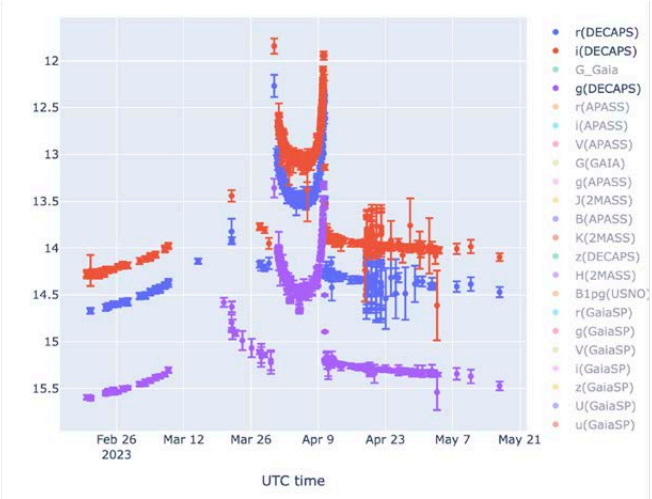
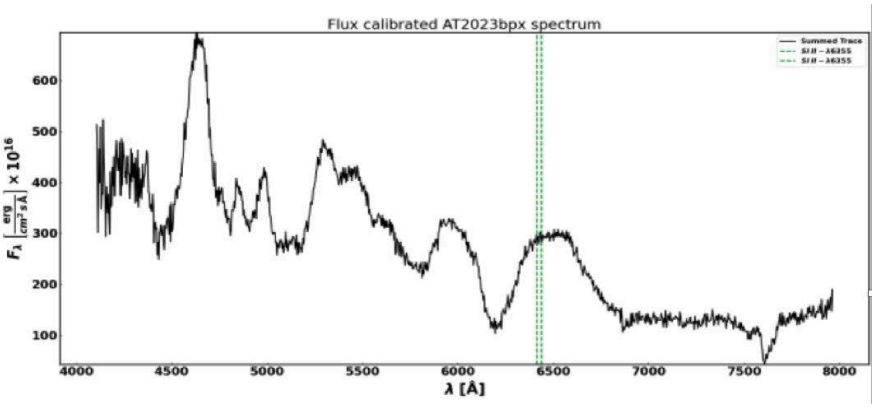


Figure 1. G'R'I' filtered (purple, blue, red) observations of a microlensing event originally alerted by the Gaia facility. Individual data points from across the globe including Lesedi. The lens itself is thought to be a binary system.



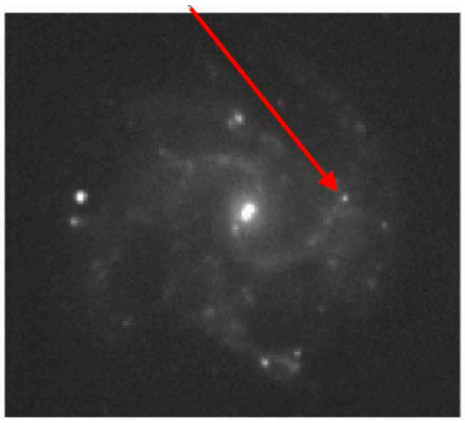


Figure 2. Top shows Mookodi spectrum identifying a type Ia supernova. Bottom shows Mookodi imaging of a supernova during photometric followup.

- ~15 newly discovered and close approaching Near Earth Asteroids - by autonomously responding to alerts
- Double Asteroid Redirection Test (DART) impact and its corresponding plume was seen by using the Mookodi instrument the Lesedi telescope. (see animation on https://en.wikipedia.org/wiki/Double_Asteroid_Redirection_Test) and Fig 3.
- Identification of radio stars from the MeerKAT Galactic Plane Point Sources. Mookodi plus Lesedi ideal for identifying H Alpha emission sources
- Rapid classification of MeerLicht sources. Specific examples include the spectroscopic identification of SN and imaging for followup photometry (e.g. Fig 2.)
- Optical monitoring of gaia microlensing sources (e.g. Fig 1.)
- Detailed multi wavelength followup of new unique sources (e.g. Fig 4.)
- autonomously responding to GRB alerts through the OCS.

WHAT'S NEXT?

The IO main goals for the next year will involve:

- the integration of additional telescopes into the OCS. Particularly new facilities such as the PRIME telescope.
- the deployment of a instrument selector port onto the 74 inch telescope
- the integration of the 74 inch telescope into the OCS
- commissioning and then the integration of the Sibonise instrument for Lesedi onto the OCS.

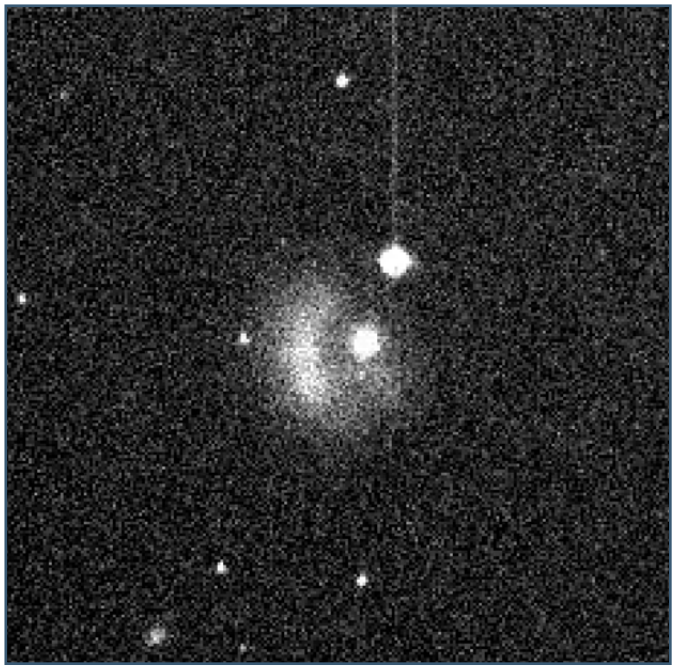


Figure 3. DART impact and its corresponding plume as seen by using the Mookodi instrument on the Lesedi telescope. See animation (https://en.wikipedia.org/wiki/Double_Asteroid_Redirection_Test)

Mookodi image of ngc4535.

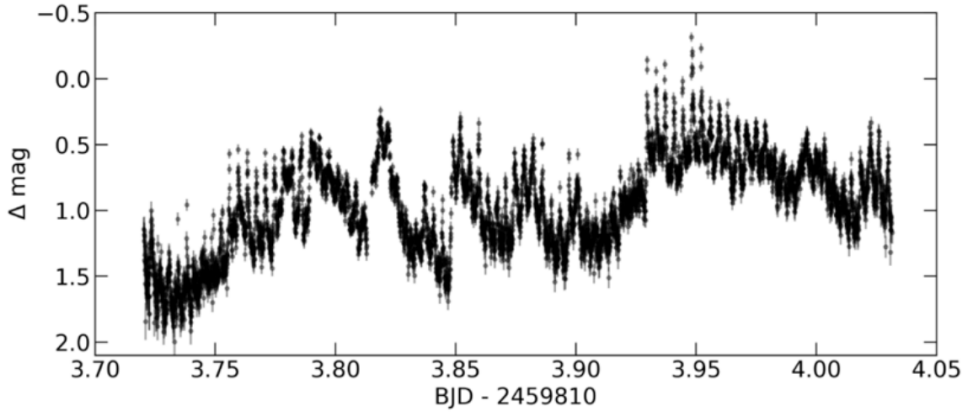
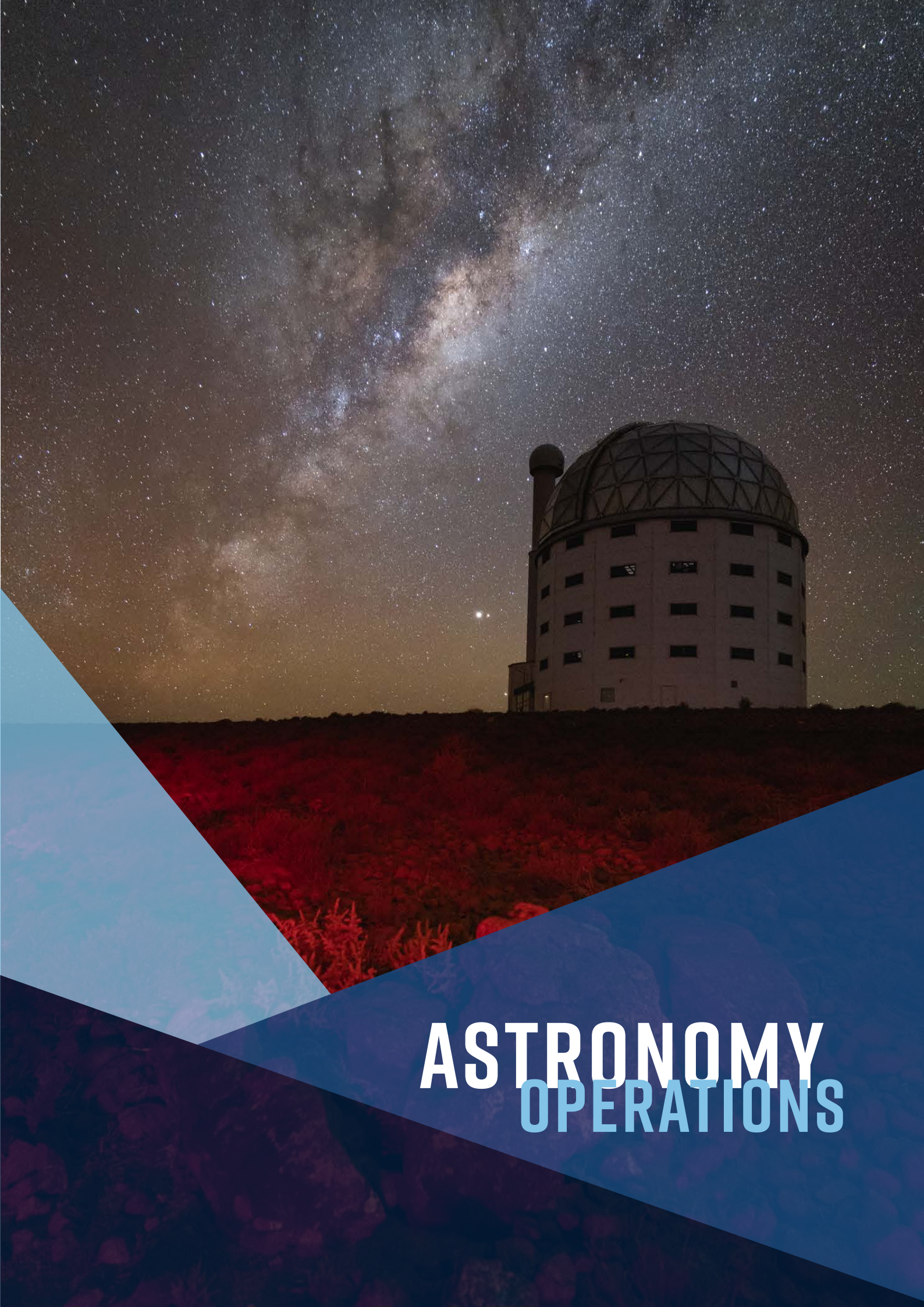


Figure 4. Mookodi high-speed photometry showing 5.3-minute pulses and flares on this newly discovered pulsing white dwarf on a binary system. The pulses have been detected from radio-Xray. SALT FT spectroscopy and high-speed photo-polarimetry with HIPPO on the 74inch telescope also show the pulses. Now accepted in Nature Astronomy as part of a multiwavelength campaign.



ASTRONOMY OPERATIONS

OVERVIEW BY THE HEAD OF RESEARCH

The past year marked a significant milestone as Covid-19 restrictions were gradually lifted, allowing for a resumption of in-person research activities at SAAO. Colloquia, skills transfer sessions for students, face-to-face teaching, and conferences were once again part of our research landscape.

In 2022, SAAO researchers made notable contributions to the scientific community by publishing 138 papers in esteemed peer-reviewed journals. Moreover, we proudly celebrated the achievements of our students, with three Masters students and two PhD students who were supervised by SAAO researchers successfully earning their degrees.

Throughout the year, SAAO hosted a total of sixteen colloquia, adapting to changing circumstances by offering a mix of hybrid, fully online, and fully in-person formats. These events provided valuable platforms for scientific exchange and collaboration. In November 2022, we introduced a visitor's programme, inviting esteemed researchers, instrumentation specialists, and individuals with exceptional skills to spend time at SAAO. This programme serves as a catalyst for initiating and nurturing strong international collaborations, fostering knowledge exchange and advancing our collective understanding of the universe.

A significant event took place in September 2022 when SAAO organised and hosted the Astronomy Town Meeting. This gathering provided a crucial opportunity to assess the current state of the South African astronomy landscape. The meeting yielded valuable operational and strategic outcomes, leading to the establishment of the Astronomy Community Task Team (ACTT). The ACTT assumes the important role of coordinating efforts within the South African astronomy community and serving as a liaison with funders and policymakers on behalf of our community. As an observatory dedicated to providing research infrastructure to the South African and international astronomy communities, our research efforts inform the provision, design, and construction of these platforms. Furthermore, our active research projects create an environment that nurtures the growth of the next generation of researchers and instrument builders, who will continue to advance and utilise these cutting-edge facilities for future scientific discoveries.

RESEARCH GROUPS

EXTRAGALACTIC SCIENCE

Extragalactic Science at the South African Astronomical Observatory (SAAO) has been a focal point of research from April 2022 to March 2023. The SAAO actively investigates a wide range of extragalactic phenomena, encompassing various areas of interest such as star formation, super star clusters, active galactic nuclei (AGN), feedback processes in starbursts and AGN, ultra-diffuse galaxies, brightest cluster galaxy (BCG) evolution, galaxy mergers and disc assembly dynamics, baryon cycle in galaxy groups, and the transformation of galaxies from active to quiescent states.

To foster collaboration and stay abreast of recent developments, the extragalactic discussion group convenes fortnightly on Fridays. During these sessions, participants engage in comprehensive discussions covering recent literature findings, technological advancements, and scientific breakthroughs related to galaxies. The group comprises researchers from the University of Cape Town, University of the Western Cape, and North-West University, among other key collaborators and visitors.

In terms of academic accomplishments, 2022 saw Brian Bichang'a graduating with an MSc degree from the University of Cape Town. His thesis, titled "Three-Dimensional Structure of Edge-On Disk Galaxies in the COSMOS Field to z=0.5," was supervised by Prof. Matt Bershady. Additionally, in March 2023, Bynish Paul successfully defended his PhD thesis at the University of Johannesburg. His research focused on narrow-line Seyfert Galaxies and their role in the general model of Active Galactic Nuclei. Prof. Hartmut Winkler and Dr. Stephen Potter supervised Bynish throughout his doctoral studies.

Dr. Narges Hatamkhani, a member of the extragalactic group since mid-2022, has been undertaking a research project involving near-infrared and SALT (Southern African Large Telescope) observations of clusters in the Vela Supercluster. This supercluster, located behind the Zone of Avoidance, presents a unique opportunity to study partially obscured galactic structures.

The research highlight of the year was the discovery of a metal-poor dwarf galaxy concealed within the glare of a nearby star. Dr. Alexei Kniazev, among others, contributed to the characterisation of this galaxy, known as HIPASS J1131-31, using SALT observations. The spectral data obtained from SALT revealed remarkably low levels of chemical enrichment in the galaxy, offering valuable insights into the evolution of galaxies over cosmic timescales.

The extragalactic research conducted at the SAAO during this period has expanded our understanding of the universe, shedding light on the intricacies of galactic processes and providing significant contributions to the field of extragalactic science.

PLANETARY SCIENCE

Planetary Science at the South African Astronomical Observatory (SAAO) has been an active and professionally-driven research endeavor from April 2022 to March 2023. The SAAO's planetary science research group focuses primarily on the study of small bodies within the Solar System. Their investigations revolve around measuring the rotational periods and photometric colors of near-Earth and main-belt asteroids. Moreover, the group conducts similar color studies on centaurs through broadband photometry, while also conducting searches for comet-like activity.

The research group has utilised various instruments, including SALTICAM on the Southern African Large Telescope (SALT), SHOC on the 40- and 74-inch telescopes, and the recently commissioned Mookodi instrument on the 1-m Lesedi telescope. Mookodi, with its ability to perform high-cadence photometric imaging and low-resolution spectroscopy in robotic mode, has proven ideal for the group's near-Earth asteroid program, which necessitates rapid response capabilities. Thobekile Ngwane's MSc project focuses on this near-Earth asteroid program, serving as the primary research topic.

One of the notable highlights of the year was the group's participation in a global observing campaign to monitor the planned impact of NASA's DART spacecraft with asteroid Dimorphos in September 2022. The group's observations from Sutherland using Mookodi, including animations of the resultant plume, garnered widespread attention on social media and through global press releases. These observations contribute to a publication analysing the dynamics and composition of the plume. In March 2023, the group also participated in a planetary-defense exercise organised by the International Asteroid Warning Network (IAWN), involving the characterisation of the newly discovered close-approaching asteroid 2023 DZ2.

Anja Genade, a PhD student specializing in centaur research, has made significant contributions during the year and is nearing the completion of her degree. Notably, she has developed Python-based pipelines for SHOC and, particularly, SALTICAM. The SALTIPhot pipeline now enables the absolute photometric calibration of SALT data for the first time. Through her investigations using SALTICAM and SALTIPhot, she has achieved groundbreaking results in centaur research, including the discovery of an active centaur and accurate absolute photometric measurements for several centaurs. These findings highlight the remarkable potential of photometric research using SALT.

The SAAO's collaboration with the ATLAS group at the University of Hawaii has also been instrumental, with extensive use of the large ATLAS photometry dataset for various asteroid studies. Access to this data, not only for asteroid science but also for other research, has been made possible through the partnership with ATLAS, linked to the fully operational third node of the ATLAS network in Sutherland. In its first year, ATLAS-Sutherland discovered 28 near-Earth asteroids and one comet, further contributing to the group's research efforts.

STELLAR ASTROPHYSICS

The stellar astrophysics group at the South African Astronomical Observatory (SAAO) holds regular discussions organised by Kelebogile Gasealahwe. These meetings take place on alternate Thursdays at 4pm and Fridays at 11am, with a virtual format currently in use. Non-SAAO-based researchers are also welcome to join these discussions. For any inquiries or additional information, please contact bang@saao.ac.za.

The group's discussions encompass a wide range of topics within stellar and binary astrophysics, spanning from observational techniques to theoretical and computational astrophysics. The primary objective is to gain a deeper understanding of the processes that drive star formation and evolution.

Several notable students have graduated by submitting thesis work aligned with the field of stellar astrophysics. Tamara Lancaster received her Master's degree from the University of Cape Town for her research project titled "The broad spectral energy distributions of cataclysmic variables." Her work involved comparing the spectral energy distributions of different sub-types of cataclysmic variables using multiwavelength data obtained from various telescopes. Dr. Retha Pretorius and Prof. Patrick Woudt supervised her research.
Zwidofhelangani Khangale completed his PhD under the supervision of Prof. Patrick Woudt and Dr. Steve Potter. His thesis focused on various aspects of the eclipsing polar UZ Fornacis. The system was studied using simultaneous multiwavelength data from several SAAO telescopes, including high-speed photometry and phase-resolved spectroscopy. After completing his PhD, Zwidofhelangani joined the University of Cape Town as a SARAO postdoctoral fellow, working with Prof. Woudt on ThunderKAT related projects.

OVERVIEW BY THE HEAD OF RESEARCH

Katlego Ramalatswa was awarded his Master's degree with distinction in 2022 for his project titled "Multi-dimensional simulations of bow shocks of massive, high-velocity runaway stars." His work involved developing a framework in the PLUTO code that incorporated relevant, updated physics (such as radiative cooling) to simulate the interaction of stellar winds with the interstellar medium in both 2D and 3D. Katlego also conducted a comparative study of bow shocks from typical runaways, using analytical solutions and literature references, and investigated the formation and properties of bow shocks from high-velocity runaways moving through different phases of the interstellar medium and during various stages of stellar evolution. A/Prof. Shazrene Mohamed supervised his research.

The stellar astrophysics group has been involved in two significant projects:

1. The SALT Transients Programme: In the 2022/23 year, the SALT Transients Programme received a substantial fraction of observing time on the Southern African Large Telescope (SALT), generating diverse and intriguing results covering a wide range of objects, including both stellar and extragalactic phenomena. A key result from this program was the discovery of an extremely soft X-ray source in the Large Magellanic Cloud, where a white dwarf is accreting pure helium. The discovery was confirmed through the clear signature of helium emission lines observed in the SALT spectroscopy. This finding not only represents the first example of a long-predicted, rare type of accreting white dwarf but also holds broader astrophysical significance, as massive white dwarfs contribute to the generation of Type Ia supernovae, which are used as standard candles for measuring distances in the universe. SALT's observations were a follow-up to the accreting white dwarf initially discovered by the eROSITA team at X-ray wavelengths. David Buckley and Itumeleng Monageng from SAAO were involved in this work. This collaboration exemplifies the fruitful Memorandum of Understanding (MoU) between the German-led eROSITA consortium and the SALT transient collaboration.
2. The LSST Programme: David Buckley holds a prestigious position as a Vera C. Rubin Observatory Large Synoptic Survey Telescope (LSST) Affiliate PI. This appointment grants him and his team access to the Rubin Science Platform, full data rights for the survey (including simulated and real data once observations commence in 2024), software resources, and participation in various LSST science collaboration projects throughout the ten-year survey period. Sally Macfarlane joined the group in 2022 as a South African LSST postdoc and Rubin Junior Affiliate. She focuses on analising LSST time series data of transient and variable objects, as well as developing novel data visualization techniques. Other current Junior Affiliate team members include Itumeleng Monageng (high mass X-ray binaries), Hanno Marais (machine learning), Daniel Egbo (multiwavelength cross-matching), and Anke van Dyk (short spin period white dwarf binaries).

- Vanessa McBride

SCIENCE HIGHLIGHTS

PEEKABOO!

SALT AND HUBBLE COMBINE TO FIND A NEW DWARF GALAXY

A recent discovery by scientists utilising data from the Hubble Space Telescope (HST) and long-slit spectroscopy using the Southern African Large Telescope (SALT) has unveiled intriguing findings about the 'Peekaboo' dwarf galaxy (HIPASS J1131–31).

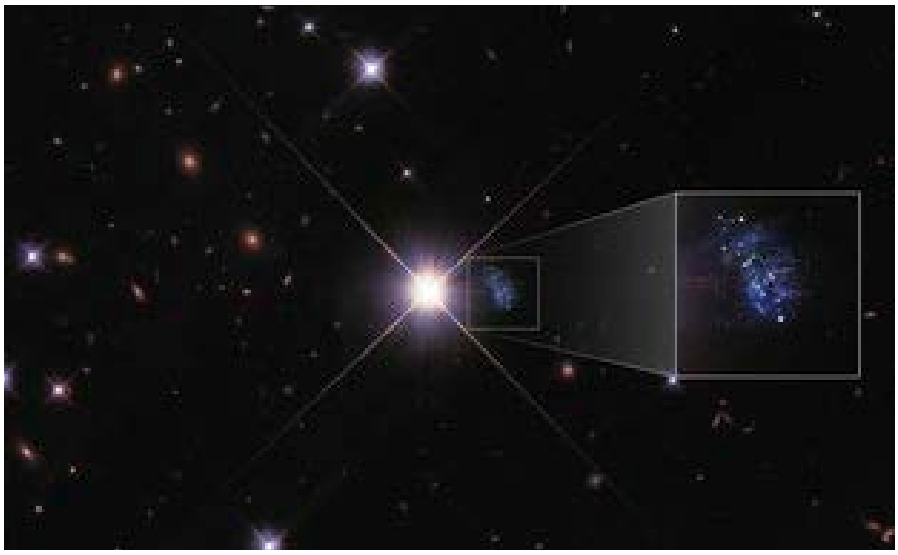
This discovery, detailed in a recently published paper in the Monthly Notices of the Royal Astronomical Society, involves collaborators including Alexei Kniazev from the South African Astronomical Observatory (SAAO).

The nickname 'Peekaboo' was given to this dwarf galaxy due to its peculiar nature of being hidden within the halo of a bright foreground star with a magnitude of 10.4. The dwarf galaxy's potential significance further justifies this nickname.

In the conventional understanding of galaxy formation, stars began forming approximately one billion years after the Big Bang, during a time when the universe was dense with cooled hydrogen and helium gas. While numerous groups of stars merged to create large galaxies, others formed small dwarf galaxies.

Over the course of more than 13 billion years since the Big Bang, the life cycle of stellar births and deaths has led to the transformation of primordial gas into heavier chemical elements present in the universe today. This process is most efficient in large galaxies but less prevalent in dwarf galaxies. One key aspect is that nearly all galaxies studied by astronomers contain old stars as a significant component.

However, there exists a small group of dwarf galaxies with common and puzzling characteristics. Firstly, these galaxies possess ten times more normal matter in the form of hydrogen and helium gas compared to stars, excluding the presence of enigmatic dark matter. Moreover, they exhibit the lowest fraction of heavier elements ever observed in galaxies. Most intriguingly, almost all the stars visible in HST images within these galaxies are less than one billion years old. This raises the question: Where are the 13-billion-year-old stars that are typically observed in almost all other galaxies?



NASA's Hubble Space Telescope captured a detailed image of the tiny galaxy HIPASS J1131–31, nicknamed the "Peekaboo Galaxy," despite its proximity to a bright foreground star. In addition to Hubble imagery, astronomers used the South African Large Telescope to collect detailed spectroscopic data on the galaxy's stars, which show it to be one of the least chemically enriched galaxies ever discovered in the local universe.
Credits: NASA, ESA, and Igor Karachentsev (SAO RAS); Image Processing: Alyssa Pagan (STScI)

The Peekaboo galaxy represents the closest example of these peculiar systems, making it exceptionally fascinating as it can be studied in greater detail. Its discovery was made through a search for hydrogen gas sources using the Parkes Radio Telescope in Australia.

The Doppler shift of the hydrogen spectral line indicated the presence of a nearby galaxy. Subsequently, the existence of Peekaboo was confirmed through HST imaging, revealing its proximity to a bright star located 15 arc seconds away.

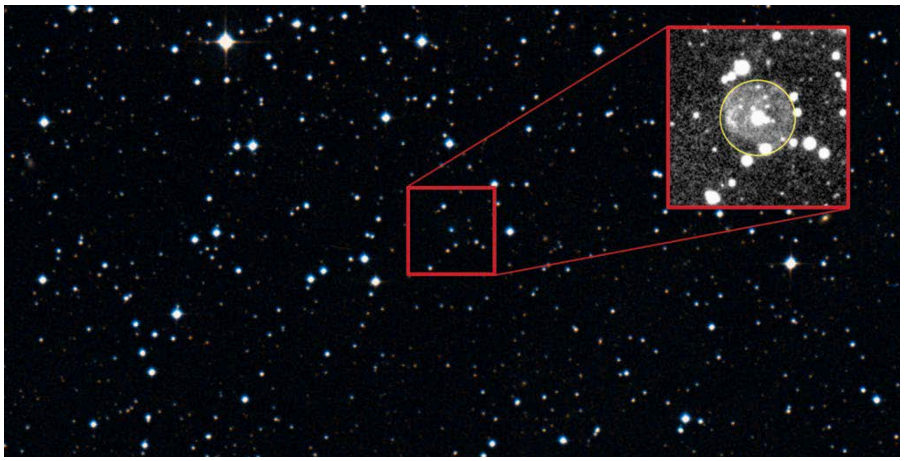
Further analysis conducted using SALT unveiled extremely low levels of chemical elements within this galaxy. Alexei Kniazev remarked, "A hundred years ago, this fast-moving foreground star would have obstructed the line of sight, rendering the Peekaboo galaxy entirely undetectable."

Although existing images of the Peekaboo galaxy are compromised by the glare from the bright star, more comprehensive images can be obtained by utilising appropriate masking techniques.

Future observations utilising the HST and James Webb Space Telescope (JWST) are expected to determine whether stars began forming early in the universe's history within Peekaboo, in accordance with galaxy formation theory, or if the galaxy contradicts this theory, thereby earning the classification of being 'young.'

Alexei Kniazev expressed, "We are going to continue our studies of this galaxy using SALT and expand our spectral analysis to gain a deeper understanding of Peekaboo's evolution."

SCIENTISTS UNVEIL EIGHT NEW SUPER-HOT STARS USING SOUTHERN AFRICAN LARGE TELESCOPE



Caption: A sky survey image centred on the newly-discovered O(H) star SALT J203959.5-034117 (J2039). Credit: Tom Watts (AOP), STScINASA, The Dark Energy Survey

In a significant breakthrough, an international team of astronomers has employed the Southern African Large Telescope (SALT), the largest single optical telescope in the southern hemisphere, to identify eight of the hottest stars ever observed in the universe. These stars possess surface temperatures exceeding 100,000 degrees and have been the subject of a study published in the Monthly Notices of the Royal Astronomical Society.

The research paper details the findings obtained through data collected using SALT, which boasts a mirror measuring 10m x 11m. By conducting a survey of helium-rich subdwarf stars, the team uncovered several extraordinarily hot white dwarf and pre-white dwarf stars. The most scorching among them boasts a surface temperature of a staggering 180,000 degrees Celsius, dwarfing the Sun's mere 5,800 degrees.

One of the identified stars serves as the central star of a recently discovered planetary nebula, which spans an impressive one light year in diameter.

Two others exhibit pulsations, signifying their variable nature. These stars are all in advanced stages of their life cycle and are fast approaching their transformation into white dwarf stars. Their extraordinarily high temperatures render each of these new discoveries more than one hundred times brighter than the Sun, an exceptional characteristic for white dwarfs.

White dwarfs, while similar in size to planet Earth, possess masses millions of times greater, approaching that of the Sun. They represent the densest stars composed of normal matter. Pre-white dwarfs, slightly larger in size, gradually shrink to become white dwarfs within a few thousand years.

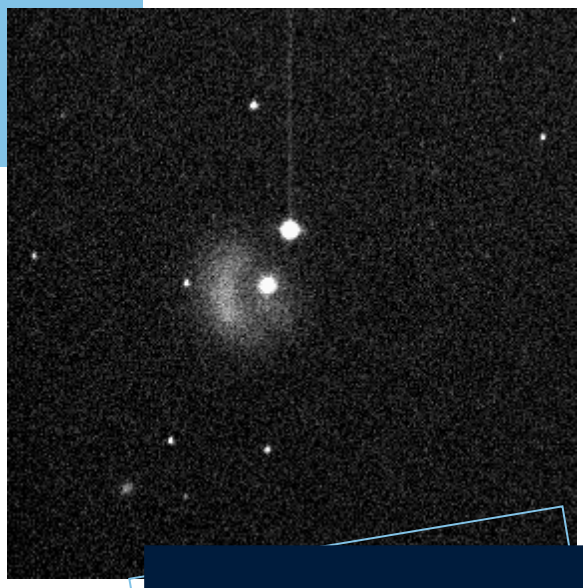
Simon Jeffery, the lead researcher from the Armagh Observatory and Planetarium, expresses, "Stars with effective temperatures of 100,000 degrees Celsius or higher are incredibly rare. It was a real surprise to find so many of these stars in our survey. These discoveries will help to increase our understanding of the late stages of stellar evolution, and they demonstrate that SALT is a fantastic telescope for our project." He adds, "Working with an experienced team has been exhilarating; their collective efforts enabled the discovery of these stars, the analysis of their atmospheres, and the identification of pulsations and a nebula in a remarkably short period."

Professor Klaus Werner from the University of Tuebingen, a co-author of the paper, shares, "I am proud to have contributed to this groundbreaking research. The revelation of eight intensely hot white dwarf and pre-white dwarf stars, along with a newly identified planetary nebula, is tremendously significant. We anticipate that these findings will illuminate fresh insights into the formation of our galaxy."

Dr. Itumeleng Monageng, representing the Department of Astronomy at the University of Cape Town and the South African Astronomical Observatory, comments, "Participating in this remarkable discovery has been an honour. The SALT survey of helium-rich hot subdwarfs aimed to explore evolutionary pathways among highly evolved star groups. It is captivating to have identified eight new extremely hot stars during this process, including one surrounded by a planetary nebula."

SAAO TELESCOPES WITNESS SUCCESSFUL **ASTEROID** REDIRECTION EXPERIMENT

Still Image showing the ejecta plume observed by Mookodi.
Image Credit: Nic Erasmus/SAAO



The National Aeronautics and Space Administration (NASA) has made an exciting announcement regarding the redirection of the asteroid Dimorphos around its parent asteroid Didymos. In a historic achievement, the Double Asteroid Redirection Test (DART) spacecraft impacted Dimorphos at 1:14 am SAST on September 27, 2022, resulting in a successful alteration of its orbital period. Astronomers at the South African Astronomical Observatory (SAAO) closely monitored this event.

NASA confirmed that DART effectively modified the orbit of Dimorphos, reducing its orbital period around Didymos from 11 hours and 55 minutes to 11 hours and 23 minutes, representing a 32-minute change.

This groundbreaking experiment marked the world's first test of the kinetic impact technique, aimed at deflecting asteroids for planetary defense against potentially hazardous objects that may pose a threat to Earth. It is important to note that neither Dimorphos nor Didymos presented any danger to Earth before or after the controlled collision with DART.

Due to South Africa's favorable location and time zone, the Sutherland region in the Northern Cape became one of the few sites worldwide capable of observing the impact in real time. Two astronomers based in Cape Town, Dr. Nicolas Erasmus from SAAO and Dr. Amanda Sickafoose from the Planetary Science Institute, successfully observed the impact on Dimorphos using the Mookodi instrument mounted on SAAO's 1-meter Lesedi telescope.

Dr. Erasmus described the conditions during the observation as perfect, stating, "Initially, we anticipated only a slight increase in brightness of the 'spot' in our telescope images representing the Didymos-Dimorphos system. We were very excited when, after only a few seconds post-impact, we started witnessing the emergence of a beautiful ejecta plume in our images. Sutherland also offered ideal observing conditions that night, with near-perfect weather and a remarkably dark sky."

Additional observations were carried out by several other telescopes in Sutherland, including the Asteroid Terrestrial-impact Last Alert System (ATLAS-STH) and the Las Cumbres Observatory (LCO). The LCO telescope network, which includes the facilities in Sutherland, played a crucial role in determining the new orbital period post-impact.

The calculations required continuous monitoring over an extended period, and the LCO network, with its global coverage across multiple time zones, effectively fulfilled this requirement.

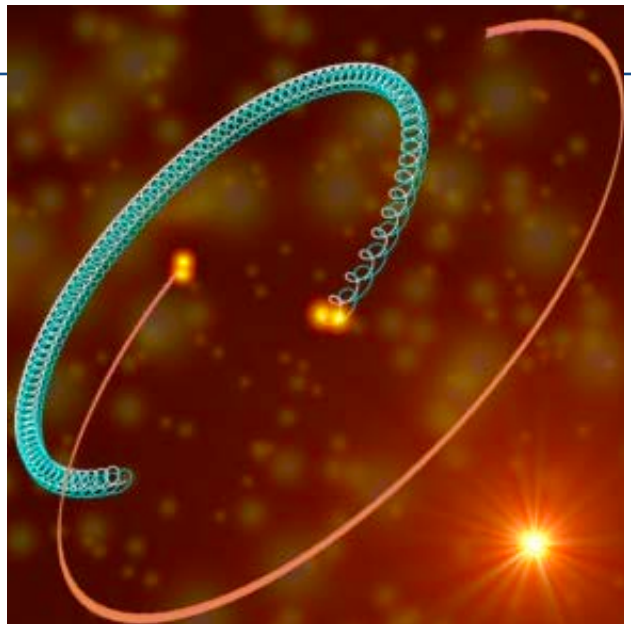
Dr. Tim Lister from LCO explained, "Access to the infamous Las Cumbres Observatory telescopes at SAAO greatly aided in determining the new period. With telescopes in South Africa approximately six hours ahead of Chile, where the primary observations took place, we were able to capture instances when Dimorphos passed behind or in front of Didymos, which were otherwise not visible from Chile. This significantly contributed to determining the new period and the extent of change caused by the DART impact."

WE WERE VERY EXCITED WHEN, AFTER ONLY A FEW SECONDS POST-IMPACT, WE STARTED WITNESSING THE EMERGENCE OF A BEAUTIFUL EJECTA PLUME IN OUR IMAGES.

Prior to the impact, Dr. Erasmus and Dr. Sickafoose conducted exposures in multiple photometric filters using the Mookodi instrument on the Lesedi telescope to determine the pre-impact color of the asteroid and its moon. During the impact, they switched to high-speed photometry, capturing data every second using a single filter—a specialised capability of the observatory and its instruments.

The animation provided in Figure 1 is a product of these observations, spanning approximately 40 minutes. Each frame represents a median stack of thirty 1-second exposures. Following the impact, they resumed multi-filter photometry to investigate the post-impact color of the system and the resulting ejecta from the collision.

SALT AND UNIVERSITY OF CANTERBURY'S MOUNT JOHN OBSERVATORY DISCOVER FOUR-STAR SYSTEM



The Southern African Large Telescope (SALT) and the University of Canterbury's Mount John Observatory in New Zealand have collaborated in the recent discovery of a system consisting of four stars orbiting each other. Initially identified in 2017 as part of the Gaia-European Southern Observatory (ESO) Survey, the use of high-resolution spectrographs and meticulous observations has enabled researchers to calculate the orbits of these four stars. The system comprises two short-period binary stars orbiting each other within a longer orbital period.

In the realm of stars, companionship is common, and unlike our Sun, most stars in the galaxy have one or more stellar companions. Binary stars, in particular, play a significant role in various astrophysical phenomena, as evidenced by the detection of gravitational wave emissions in 2017. Additionally, binary stars provide a means to derive fundamental stellar parameters such as masses, radii, and luminosities with greater accuracy compared to single stars. They serve as invaluable resources for numerous astrophysics studies.

While binary star systems have garnered considerable attention, higher-order stellar systems have received less focus until recently, despite their diverse range of interactions, especially within compact systems. Stellar quadruples, which constitute only a small fraction of multiple systems (a few percent), undergo complex evolution involving mass transfer and collisions. These interactions can lead to mergers and serve as potential progenitors of thermonuclear supernovae. Such supernovae act as standard candles for determining the distance scale of the Universe, although the evolutionary pathways leading to the progenitors of these explosions remain subjects of intense debate.

THESE OBSERVATIONS REVEALED THAT THE QUADRUPLE SYSTEM CONSISTS OF FOUR GRAVITATIONALLY BOUND STARS...

A spectroscopic quadruple system, known as HD 74438, was discovered in 2017 as part of the Gaia-ESO Survey. This publicly accessible survey aims to provide a comprehensive understanding of the stellar population in the Milky Way, characterising over 100,000 stars. Subsequent follow-up spectroscopic observations of HD 74438 were conducted using high-resolution spectrographs at the University of Canterbury's Mount John Observatory and the Southern African Large Telescope. These observations revealed that the quadruple system consists of four gravitationally bound stars, with a configuration of two short-period binaries orbiting each other within a longer orbital period (2+2 configuration). Notably, HD 74438's membership in the open cluster IC 2391 makes it the youngest spectroscopic quadruple system discovered to date, with an age of 43 million years. It also possesses one of the shortest outer orbital periods among known quadruple systems, lasting 6 years.

The spectroscopic analysis of HD 74438 demonstrates that this quadruple system undergoes dynamic effects on timescales longer than its orbital periods. Specifically, one of the inner binaries should have evolved into a circular orbit, but instead maintains an eccentric one due to the gravitational influence of the distant binary companion. State-of-the-art simulations of the system's future evolution suggest that these gravitational dynamics could result in one or multiple collision and merger events, producing white dwarfs with masses slightly below the Chandrasekhar limit.

A star, like our Sun, eventually evolves into a white dwarf as it reaches the end of its life. The mass of white dwarfs cannot exceed the Chandrasekhar limit. However, through mass transfer or merger events, white dwarfs can surpass this limit, causing them to collapse and trigger a thermonuclear supernova. Intriguingly, it is now suspected that 70 to 85% of all thermonuclear supernovae result from the explosion of white dwarfs with sub-Chandrasekhar masses. The evolution of stellar quadruples such as HD 74438 presents a new and promising pathway for the formation of such supernovae.

SUPPORTING DEPARTMENTS


Night Info
Last available Seeing
Weather forecast for the next 48 hours
Seeing Monitor all-sky image
LCOGT all-sky image
1.9m - 74inch

SUPPORTING DEPARTMENTS

LIBRARY/INFORMATION SERVICES

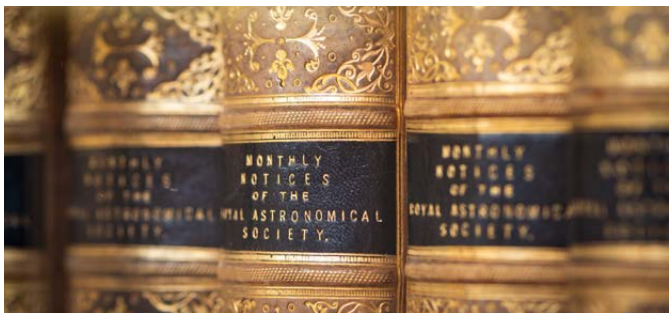
Significant developments have taken place within the SAAO library system, primarily driven by the migration to a Software-as-a-Service (SaaS) environment. This transition was necessitated by a crash that occurred at iThemba LABS, the previous hosting site for the library system. By moving to a SaaS environment, the library system now operates on a shared platform that facilitates resource sharing among various facilities within the NRF, including the SAAO, iThemba Labs, and SARAO.

Despite the migration efforts, there has been a backlog in updating the system due to the transition process. To expedite the updates, assistance was sought from students at UWC, who played a crucial role in accelerating the progress. Their involvement has been instrumental in addressing the backlog and ensuring that the library system remains up-to-date and efficient.

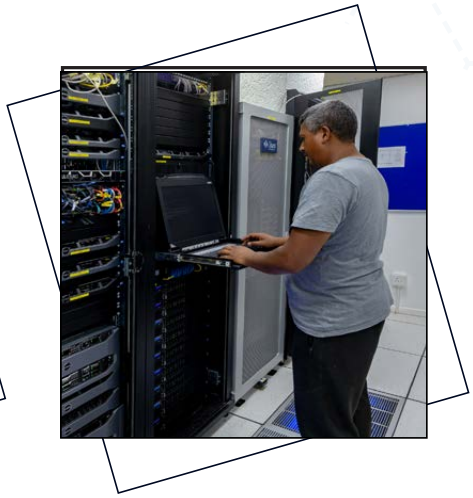
The SAAO library actively celebrated South African Library Week this year. The primary aim of this initiative was to raise awareness and promote the library services among SAAO staff, particularly new members. During this event, staff members were informed about the wide range of services offered by the SAAO library and the vital role that librarians play within the organisation. It was also an opportunity to address misconceptions among non-astronomers who believed that the library primarily caters to astronomers. Librarians took the opportunity to emphasise that the services provided by the library are available to all staff members, irrespective of their specific fields. Additionally, the SAAO library has established Memoranda of Understanding with other higher education institutions, allowing SAAO staff members to access resources from these institutions, even if they are not registered there.

Looking ahead, the SAAO library has a lineup of activities planned for the remainder of the year. These initiatives aim to further enhance the library's services and ensure its continued relevance and effectiveness.

- Zuthobeke Mvakade



INFORMATION TECHNOLOGY (IT) SERVICES



NETWORK

Significant advancements have been achieved in improving the network infrastructure and operations. The upgrade of the Cape Town-Sutherland link, entrusted to Telkom, is progressing smoothly. While the speed upgrade from 1 Gig to 10 Gig has yet to be implemented, the introduction of two separate fibres for redundancy has proven highly effective. Notably, there have been no instances of network outages or telescope downtime due to cable breaks or vandalism.

SECURITY

During the first quarter, a comprehensive security assessment was conducted on all network hosts, resulting in ongoing upgrades and vulnerability patching. This assessment has significantly enhanced our security posture, and we are actively addressing the findings to establish a more secure environment.

STORAGE SERVERS

The IT storage tender process has reached its finalisation stage, with all parties at SAAO having signed off on the tender document. It has now been forwarded to Pretoria for the ultimate signoff. This step is crucial for meeting the growing demand for storage capacity observed over the past year. Furthermore, we are promptly addressing issues with certain hard drives and working on their timely replacement. The recent discretionary funding allocation of R2.4 million will greatly support the completion of the IT storage capacity project.

SOFTWARE

IT has successfully deployed an alternative mail gateway that incorporates spam, antivirus, and malware filtering. This new system replaces the outdated mail gateway running D-spam, which is no longer supported. The mail scanner is continuously trained using user input, and the new interface provides a comprehensive spam management system.

PROJECTS

Several projects are currently underway to enhance our ICT infrastructure and streamline our processes. We have commenced collaboration with SCM (Supply Chain Management) to develop a web-based form that will replace the existing RFQ (Request for Quotation) form, thereby streamlining the procurement process. Additionally, a web form has been set up on the intranet for New Staff to request IT resources such as laptops, phones, access to file-shares, and group membership.

Furthermore, preliminary connectivity has been established for the POLSA telescope team via WiFi, with the required fiber connection to be provided upon completion of the fiber installation. Moreover, the SAEON building at the Cape Town site has been connected to the SANREN network.

Despite the challenges posed by load shedding, measures have been taken to mitigate its impact. UPS batteries have been replaced, and the generator has undergone repair and servicing to ensure operational continuity during load-shedding events.

SHARED SERVICES

We actively participated in the NRF ICT shared service discussion, exploring opportunities where we can provide assistance to other facilities and benefit from the skills and resources available.

The global chip shortage has had a tangible impact on our ability to procure hardware and has resulted in revised timelines and budgets for various projects.

- Iriwaan Simon

SCIENCE ENGAGEMENT AND OUTREACH

CAPE TOWN **VISITORS' CENTRE**

Over the past year, significant strides have been made in advancing the project aimed at showcasing the heritage and astronomy research in Africa through the development of the South African Astronomical Observatory Visitors' Centre in Cape Town.

One of the key highlights of the Visitors' Centre is the creation of captivating exhibits that effectively showcase the science and technology associated with the South African Astronomical Observatory (SAAO). Over the past year, significant efforts have been dedicated to the development of these exhibits, ensuring they offer an engaging and immersive experience for visitors. The exhibits will encompass interactive presentations of astronomical data throughout different ages, shedding light on the evolution of astronomy. Additionally, a technical exhibit focusing on the remarkable instruments utilised at the SAAO, including the Southern African Large Telescope (SALT), has been conceptualised.

To enrich the visitor experience and celebrate the cultural heritage intertwined with astronomy, the Visitors' Centre incorporates raw sketches artworks and animations based on traditional Khoi and San starlore. These elements add depth and authenticity to the exhibits, providing visitors with a unique perspective on the astronomical legacy of these indigenous communities. The inclusion

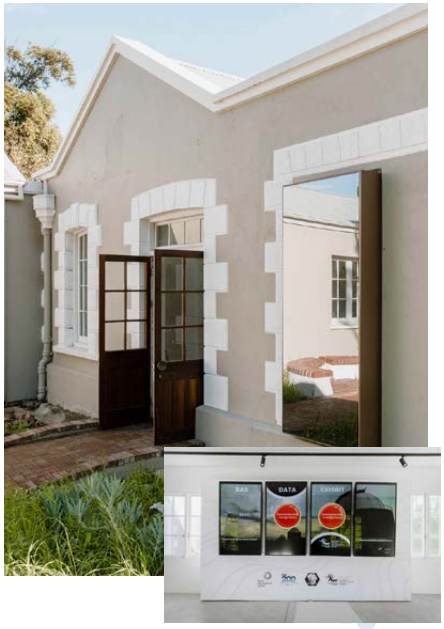
of such cultural aspects emphasises the commitment to honoring and preserving African heritage in the context of astronomy research.

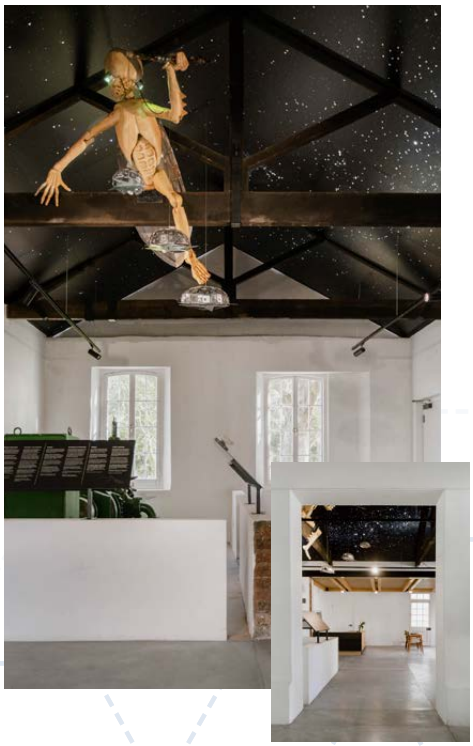
In pursuit of inclusivity and much needed accessibility, a multilingual approach has been adopted to ensure effective communication with diverse audiences. To that end, conceptual write-ups accompanying the exhibits have been initially provided in four languages: Khoekhoegowab, isiXhosa, Afrikaans, and English. This approach enables visitors from various linguistic backgrounds to engage fully with the content and fosters a greater sense of inclusiveness within the Visitors' Centre. The project team aims to expand the language offerings in the future to embrace additional national minority languages.

The project has not been without its share of challenges. Adapting an old building for the Visitors' Centre has presented specific difficulties, including addressing leaks and other structural concerns. However, diligent efforts have been undertaken to overcome these challenges, resulting in successful modifications and improvements to ensure the structural integrity and functionality of the building. Furthermore, the resourceful incorporation of a heliostat within the Centre, despite initial difficulties in securing required infrastructure, demonstrates the project's ability to adapt and innovate to provide unique and engaging experiences for visitors.

Looking ahead, the project will focus on completing the construction of the exhibits, with a target date set for mid-2023. The diligent efforts of the project team, supported by the commitment to delivering a comprehensive and awe-inspiring Visitors' Centre, provide a promising outlook for meeting this milestone. Once the exhibits are finalised, the Visitors' Centre will be ready to open its doors to the public, offering a captivating journey into the world of African astronomy and the rich cultural tapestry that intertwines with it.

The past year's progress highlights the project's determination to create a world-class facility that showcases South Africa's astronomical heritage and ignites excitement among visitors regarding the exceptional astronomy research conducted on the African continent. By successfully addressing challenges, adhering to timelines, and incorporating cultural and multilingual elements, the project team remains steadfast in their commitment to delivering a transformative experience that celebrates the legacy of African astronomy while inspiring future generations of scientific exploration.





CAPE TOWN **OPEN NIGHTS**

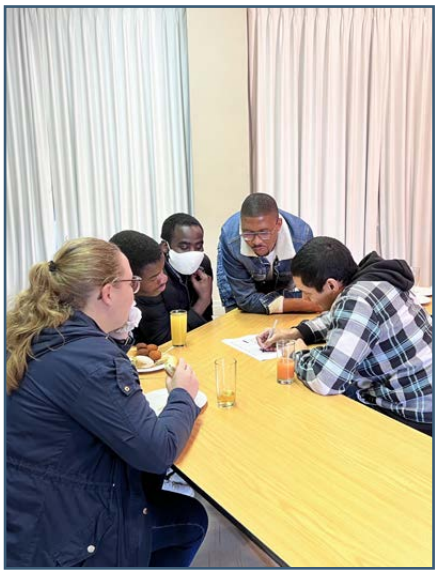
The SAAO organises a series of Cape Town Open Nights, taking place twice a month. These highly anticipated events are free and open to the public, providing an invaluable opportunity for individuals to delve into the captivating realms of astronomy and stargazing.

Each Open Night commenced with an enlightening presentation delivered by esteemed experts in the field of astronomy or physics.

The talks of featured captivating topics, leaving attendees enthralled and inspired.

Following the presentations, visitors are treated to a guided tour of the illustrious McClean telescope, the observatory museum, and the library. Weather permitting, participants are also afforded the extraordinary opportunity to engage in stargazing activities facilitated by telescopes specially set up for the occasion.

The SAAO Cape Town Open Nights serve as a remarkable platform for individuals of all ages to acquire knowledge about astronomy and stargazing. Furthermore, these events provide an avenue for the public to personally witness the profound beauty of the stars, guided by the expertise of the astronomers in attendance.



SALT COLLATERAL BENEFITS PROGRAMME

The Salt Collateral Benefits Programme (SCBP) was established during the construction of SALT and is aligned with the South Africa Agency for Science and Technology Advancement (SAASTA), the International Astronomical Union's Office of Astronomy for Development, and the Department of Science and Technology's decadal strategy for astronomy development in South Africa.

Its mandate is to utilise the knowledge, technology and other available resources within the SAAO and similar institutions in order to facilitate education enhancement, science communication, socioeconomic development and public engagement, and thereby contribute to the improvement of the quality of life of all people within reach.

Over the period 2022/2023, the SAAO education and outreach teams continued persistently to communicate the beauty, relevance and power of astronomy despite the ever-changing environment.

10 297 Learners, 217 educators & 10 758 members of the public were reached over this period, and they engaged through a number of programmes including girl-focussed programmes, school outreach, the astronomy debate, astronomy quiz, astronomy competitions for teachers, projects aimed at Sutherland learners and youth, teacher-based workshops, Sutherland site tours, indigenous astronomy programmes and a Job Shadow program.

SOME EXAMPLES OF THE SCBP ACTIVITIES ARE SHOWN BELOW:

SCHOOL OUTREACH

SIYABULELA PRIMARY SCHOOL, 18TH MAY 2022

Buzani Khumalo visited Siyabulela Primary where she held workshops demonstrating acids and bases, as well as chromatography experiments to 167 grade 7 learners.

SCHOOL OUTREACH

STAR COLLEGE, 8TH & 9TH NOVEMBER 2022

Cedric Jacobs hosted learners from Star College on the SAAO site in Cape Town, A presentation was conducted by Dr. Daniel Cunnama. Cedric Jacobs Also conducted a telescope workshop, presentation and site tour.

NAMAKWALAND HIGH MATHS & SCIENCE PIONEERS - 11 MARCH 2023

Jeremy Stuurman hosted 17 learners, grades 9 to 12, from the Namakwaland High, Maths & Science Pioneers group. The group visited the SAAO site in Sutherland and Jeremy treated them to a SALT Day Tour and a stargazing session.

THE VINE SCHOOL – 22 APRIL 2023

Cedric Jacobs hosted 20 grade R learners from The Vine School on our site in Cape Town. He entertained the learners with an astronomy presentation, a site tour and a binocular workshop.

SUMMERDALE HIGH SCHOOL - 24 APRIL 2023

SCBP staff, Education Officer – Buzani Khumalo and Education Assistant – Cedric Jacobs, arranged a visit and an opportunity for 39 grade 9 learners from Summerdale High to meet with American Scientists. Buzani and Cedric accompanied the American Scientists, Dr. Sanlyn Buxner, Dr Amanda Sickafoose and Dr Mark Lewis, on their visit to the school, where they gave an astronomy presentation with Q&A sessions to the learners.

EDUCATOR WORKSHOPS

EDUCATORS VISIT SUTHERLAND WITH BUZANI KHUMALO - 24TH & 25TH MAY 2022

Buzani Khumalo took 5 educators up to Sutherland for a day tour and some stargazing.

TEACHER WORKSHOP AT E.A. JANARI PRIMARY SCHOOL - 28 FEBRUARY 2023

Buzani Khumalo held a Pale Blue Dot Teacher Workshop for 8 educators at E.A. Janari Primary School.

FREE STATE TEACHER WORKSHOPS, 26TH TO 29TH SEPTEMBER 2022

Buzani Khumalo and Claudine Vernooi travelled all the way to the Free State to present the Earth & Beyond Workshops. Tshya Education Centre - 36 Teachers, Witsieshock Primary School - 22 teachers, Bethlehem Education District Office - 40 teachers & Tumisang Primary School - 27 teachers

OTHER VISITS / WORKSHOPS / LECTURES

ASTRONOMY TALK AT THE SEVENTH DAY ADVENTIST CHURCH IN LANGA – 26 FEBRUARY 2023

Buzani Khumalo delivered an Astronomy Career Talk to 35 people at the Seventh Day Adventist Church in Langa.

KRAAIFONTEIN VOORTREKKERS, 18TH JUNE 2022

Jeremy Stuurman took 21 members of the Kraaifontein Voortrekkers on a tour of SALT.

ROGGE CLOOF GUEST FARM STAFF VISIT SAAO SITE IN SUTHERLAND – 7TH JUNE 2022

Jeremy Stuurman hosted 5 staff members of the Rogge Cloof Guest Farm at the SAAO site in Sutherland. The enthusiastic visitors were taken on a tour of the site and the telescopes, including a technical tour of SALT.

EXHIBITIONS

KIRKWOOD FESTIVAL, 24TH TO 26TH JUNE 2022

Cedric Jacobs represented the SAAO at the Kirkwood Festival, where thousands were in attendance. He held workshops for 410 learners and exhibited to 2200 members of the public.

CAREERS EXHIBITION AT THEMBELIHLE HIGH IN KHAYELITSHA – 13 APRIL 2023

Cedric Jacobs represented the SAAO at the Careers Exhibition held at Thembelihle High School where 369 learners, grades 10 to 12, were in attendance.

CHIETA CAREER EXHIBITION FOCUS DAY – 18 MARCH 2023

Buzani Khumalo and Cedric Jacobs attended the CHIETA Career Exhibition which was held at Westridge High School. Grade 11 and 12 learners from various schools attended 680 in total.

PROJECTS & EVENTS

DARTMOUTH VISIT TO ALOE JUNIOR – 30TH JANUARY 2023

A large outreach event took place at Aloe Junior on Monday, 30th January 2023, which saw a team of Dartmouth University students entertaining 384 grade 9 learners with activities on scaling the solar system. This was in collaboration with the SAAO and Cedric Jacobs hosted them both on site and at the school.

SUTHERLAND CULTURAL EVENT – 31 MARCH 2023

SCBP staff in Sutherland organized a cultural event which was held in the hall at Roggeveld Primary School on the evening of Friday 31 March 2023. The event was brilliantly put together by Jeremy Stuurman and the local drama group with assistance from many others. It was entertaining to watch all of the performers on stage, all of which 120 participants. The highlight of the event was the REEL dancing by both young and not-so-young people.

SANBI'S BIODIVERSITY EDUCATION & PUBLIC ENGAGEMENT EVENT – 1ST MARCH 2023

Jeremy Stuurman attended SANBI's Biodiversity Education & Public Engagement Event which was held at the Karoo Desert National Botanical Garden. He held Telescope Workshops for 57 grade ten learners.

JOB SHADOW PROGRAMME

JOB SHADOW – 4TH & 5TH OCTOBER 2022

The SAAO's job shadowing initiative underwent a hiatus in 2020 and 2021, amidst widespread disruptions. Learners in grade 11, and occasionally grade 10, partake in career-focused job shadowing as part of their cross-curricular week, a pivotal component of their academic curriculum.

On October 4th and 5th, a pivotal event occurred as SAAO resumed an 'in-person' Job Shadow Programme. Nine learners participated, one travelling extensively to attend. The team, including Christian Hettlage, Daniél Groenewald, Munira Hoosain, Nazir Makda, Daniel Egbo, Egan Loubser, Malcolm Hendricks, and the workshop team, along with Willie Koorts, Rudi Kuhn, Jimmy Makoloane, and Sivuyile Manxoyi, presented a comprehensive view of their careers and the observatory's offerings.

The learners left enriched yet fatigued, a sentiment reflected in their feedback forms. The team's efforts were instrumental in delivering a valuable experience to the learners, impacting their perspectives and aspirations.

The Job Shadow Programme at SAAO signifies a resilient commitment to education and exploration. Its impact underscores the enduring pursuit of knowledge and learning.

NOTABLE MEETINGS

XXXI IAU GA IN BUSAN, SOUTH KOREA, AUGUST 2022

The XXXI International Astronomical Union (IAU) General Assembly (GA), which took place in the beautiful city of Busan, South Korea was attended by a large delegation from South Africa and Africa alike, with teams from the OAD, SAAO, AfAS, BRICS Astronomy, NRF, DSI, Tourvest (Professional Conference Organisers) and many other African delegates.

The GA2024 booth shared by SALT, AfAS and SAAO was beautifully designed and kept all the delegates engaged about Astronomy in Africa, the expertise that our beautiful continent has contributed to the advancements of astronomy and many other things that Africa still has to offer to the global audience. The delegates also had an opportunity to learn about Cape Town and what they can expect when they come for the General Assembly in 2024.

SCIENTIFIC TALKS

Three members of SAAO contributed to the astronomy and research advancements by presenting some insightful talks, namely;

- Ramotholo Sefako - SAAO Site Protection against Light and Dust Pollution
- Zara Randriamanakoto - The SUNBIRD Survey: insights into smallscale star formation mechanisms through the NIR study of young massive clusters in a sample of starburst and luminous infrared galaxies
- Petri Väisänen participated in a panel discussion on the future of current telescopes as part of the IAU Working Group meeting on Global Coordination of Ground and Space Astrophysics.

IAU OFFICE OF ASTRONOMY FOR DEVELOPMENT (OAD)

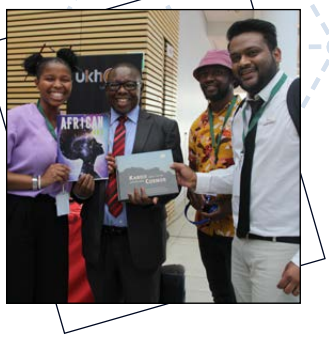
The OAD organised five sessions creating a platform for presentations and engagements from various members of the astronomy community. Given the scale of activity and the significant global OAD network, these meetings allowed IAU members and delegates to engage with the work of the OAD and contribute to shaping its future.

CLOSING CEREMONY

The handover of the flag was truly significant, as members of the team accepted the IAU flag, the African delegates waved South African flags with pride and the whole room had no choice but to look and draw inspiration from such a beautiful occasion. When Takalani Nemaungani, Chief Director of Astronomy at the Department of Science and Innovation, and Vanessa McBride, the co-chair of IAU GA2024, gave their speeches, the room was filled with so much emotion and had all team members beaming with pride.

The Team showed up and showed the world the true African spirit, seen through the togetherness, diversity and love shared among each other and those who crossed their paths.

WORLD SCIENCE FORUM IN CAPE TOWN, DECEMBER 2022



SAAO AND SALT FEATURE PROMINENTLY AT THE WORLD SCIENCE FORUM

For the first time on African soil, South Africa had the opportunity to host the World Science Forum in Cape Town from 6-9 December 2022. South Africa hoped to achieve three main goals by hosting the forum in Africa, namely;

1. to promote global debate that inspires action;
2. to provide support for African leadership in global science policy discussions;
3. and to promote South Africa as a strategic partner for global science collaboration in response to societal challenges.

This high-profile event featured prominent speakers alongside South Africa's Minister for Science and Innovation, Dr. Blade Nzimande and the event was officially opened by the President of South Africa, His Excellency Cyril Ramaphosa.

With South Africa playing host to the SKA project, astronomy featured prominently at the event with SAAO and SALT among other astronomy bodies taking centre stage throughout the forum. Speakers such as Prof. Catherine Cesarsky, Chair of the SKAO council were also part of panel discussions at the forum.

The highlight of the event for many was the Astronomy Corner being visited by President Ramaphosa and chatting with many astronomers including Kevin Govender, IAU OAD Director and Petri Vaisanen, SAAO Managing Director who briefly chatted to the president about the cutting-edge science that SAAO is doing and also South Africa's part in hosting the GA 2024 Assembly, here in Cape Town.

SAAO and SALT were visited by many notable scientific leaders from around the world and this provided an excellent stage to showcase what SAAO and SALT have to offer as leading scientific institutions globally. The forum also provided a solid platform to network and engage with various interested individuals.

3RD ANNUAL AFAS CONFERENCE IN JOHANNESBURG, MARCH 2023

Over 360 astronomers and African countries' representatives registered for the third annual conference of the African Astronomical Society (AfAS). The conference took place from 13 to 17 March 2023 as a hybrid event hosted by the University of the Witwatersrand (Wits) Centre for Astrophysics. About 100 local and international delegates attended the meeting in person at the Wits Origins Centre in Johannesburg, South Africa. Other participants joined online through the Zoom and Sched platforms.

Days 1 to 4 of the conference focused on science, outreach, communication, and education activities emanating from Astronomy in Africa and enhancing collaboration among countries in Africa and the rest of the world. A total of 87 abstracts were accepted for talks, 60 for Science and 27 for Education, Development, and Outreach. An additional 25 abstracts were accepted for posters.

This year's meeting had a total of seven special sessions organised by AfAS sub-committees and partner projects dedicated to:

- IAU General Assembly 2024 in Cape Town: Gearing up for the GA in 2024
- Breakthrough Listen: Opportunities for commensal SETI with radio telescope arrays.
- African Dark Sky and Astro-Tourism (ADSAT) strategy
- AfAS membership updates – Admission of members, Membership fees, benefits, and Conference fees.
- African Strategy on Fundamental and Applied Physics (ASFAP) Astrophysics and Cosmology Working Group: current status and the way towards the White Papers
- Education, Development, and Outreach (EDO)
- Astronomers 4 Planet Earth
- African Women in Astronomy: updates from AfNWA
- African Planetarium Association (APA) Workshop

The conference's final day (18 March 2022) was dedicated to the Business Meeting, held every three years.

SAAO STAFF

SAAO EXECUTIVE

IN THE REPORTING PERIOD OF APRIL 2022 TO MARCH 2023, THE SAAO EXECUTIVE COMPRISED THE FOLLOWING:

PROF. PETRI VÄISÄNEN
Managing Director: SAAO

MR KEVINDRAN GOVENDER
Director: IAU OAD

MR EUGENE LAKEY
Manager: Finance and Operations

PROF. STEPHEN POTTER
Head: Astronomy

DR RAMOTHOLO SEFAKO
Head: Telescope Operations

DR ENCARNI ROMERO COLMENERO
Head: SALT Astronomy Operations

MR PAUL RABE
Head: SALT Technical Operations

MR HITESH GAJJAR
Head: Instrumentation

MR SIVUYILE MANXOYI
Manager: SALT Collateral Benefits Programme

MRS LINDA TOBIN
Manager: Human Resources

MR IRIWAAN SIMON
Manager: Information Technology

ASSOC/PROF.VANESSA MCBRIDE
Head: Research

STAFF LIST

THIS LIST INCLUDES CASUAL STAFF, HONORARY FELLOWS AND STUDENTS WORKING AT SAAO BETWEEN APRIL 2022 AND MARCH 2023. STAFF ARE LISTED IN ALPHABETICAL ORDER, ACCORDING TO SURNAME.

NAME	TITLE	GENDER	JOB TITLE	MUNICIPALITY
Abrahams Florine	Ms	Female	Casual	Cape Town
Adams, Shamiel	Mr	Male	Software Engineer	Cape Town
Appolis, Wade	Mr	Male	CNC Machinist	Cape Town
April, Koos	Mr	Male	Driver Maintenance	Sutherland
Baadjies, Dawid	Mr	Male	Driver Maintenance	Sutherland
Baadjies, Elizabeth	Mrs	Female	Receptionist	Sutherland
Banda, Richard	Mr	Male	Mechatronics Engineer	Sutherland
Banda, Thabo	Mr	Male	Maths and Science Educator	Sutherland
Bernardo, Jean	Mr	Male	IT Support Technician	Sutherland
Bershady, Matthew	Dr	Male	SARChi Chair	Cape Town
Bichanga, Brian	Mr	Male	MSc Student	Cape Town
Bonokwane, Kelebogile	Ms	Female	PhD Student	Cape Town
Booysen, Paul	Mr	Male	IT Systems Administrator	Sutherland
Botha, Lucian	Mr	Male	Senior Systems Engineer	Cape Town
Breytenbach, Hannes	Mr	Male	PhD Student	Cape Town
Brink, Jaco	Mr	Male	MSc Student	Cape Town
Brink, Janus	Mr	Male	Software Engineer	Cape Town
Buckley, David	Dr	Male	Astronomer	Cape Town
Chandra, Sunil	Dr	Male	Post-Doctoral Fellow	Cape Town
Chattopadhyay, Sabyasachi	Dr	Male	Post-Doctoral Fellow	Cape Town
Chingozha, Tawanda	Mr	Male	OAD Intern	Cape Town
Chipembe, Bryne	Mr	Male	SALT Software Engineer	Sutherland
Christian, Brendt	Mr	Male	Mechanical Technician	Sutherland
Christians, Alrin	Mr	Male	Mechanical Design Draughtsman	Sutherland
Claassen, Siphosethu	Mrs	Female	Human Resources Officer	Cape Town
Cloete, Valencia	Mrs	Female	Office and Grant Manager	Cape Town
Crause, Lisa	Dr	Female	Scientist	Cape Town
Crook-Mansour, Justine	Ms	Female	Science Engagement Intern	Cape Town
Cunnama, Daniel	Dr	Male	Science Engagement Astronomer	Cape Town
De Bruin Juan	Mr	Male	Casual	Sutherland
De Bruyn Jeremeen	Ms	Female	Casual	Cape Town
De Villiers, Mikhail	Mr	Male	MSc Student	Cape Town
De Water, Katriena	Ms	Female	Housekeeper and Mirror Cleaner	Sutherland
De Wet, Simon	Mr	Male	PhD Student	Cape Town
De Young, Theresa	Ms	Female	Librarian	Cape Town
DeBeer, Gideon	Mr	Male	MSc Student	Cape Town
Egbo, Daniel	Mr	Male	PhD Student	Cape Town
Erasmus, Nicolas	Dr	Male	Instrumentation Scientist	Cape Town
Firth, Andrew	Mr	Male	MSc Student	Cape Town
Fischer, Dalene	Mrs	Female	Financial Controller	Cape Town
Fransman, Timothy	Mr	Male	Mechanical Technician	Sutherland
Gajjar, Hitesh	Mr	Male	Head of Instrumentation	Cape Town
Geduld Franklin	Mr	Male	Casual	Cape Town
Geen, Ulrich	Mr	Male	MSc Student	Cape Town

NAME	TITLE	GENDER	JOB TITLE	MUNICIPALITY
Genade, Anja	Ms	Female	PhD Student	Cape Town
Gibbons, Denville	Mr	Male	Mechanical Assistant	Sutherland
Gobeni Lusanda	Ms	Female	Intern	Cape Town
Govender, Kevindran	Mr	Male	Director: IAU OAD	Cape Town
Govender, Pranesthan	Mr	Male	Public Outreach Officer	Cape Town
Groenewald, Danièl	Dr	Female	SALT Astronomer	Cape Town
Hatamkhani, Narges	Dr	Female	Research Fellow	Cape Town
Haupt, Jamie-Lee	Ms	Female	Procurement Assistant	Cape Town
Hendricks, Johan	Mr	Male	Driver Maintenance	Sutherland
Hendricks, Malcolm	Mr	Male	CNC Operator	Cape Town
Hercules, Nazli	Mrs	Female	Personal Assistant	Cape Town
Hettlage, Christian	Dr	Male	SALT Software Engineer	Cape Town
Higgo, Liam	Mr	Male	MSc Student	Cape Town
Hlakola Moloko	Mr	Male	Software Developer	Cape Town
Hoosain, Munira	Ms	Female	PhD Student	Cape Town
Jacobs, Amelde	Ms	Female	Casual Worker	Cape Town
Jacobs, Cedric	Mr	Male	Education Officer Assistant	Cape Town
Jacobs, Nicolaas	Mr	Male	Mechanical Trainee Assistant	Sutherland
Januarie Karel	Mr	Male	Casual	Sutherland
Jones, Natalie	Mrs	Female	Communication and Resource Officer	Cape Town
Jonker Anita	Ms	Female	SALT Software Developer	Cape Town
Kabini, Sunnyboy	Mr	Male	SALT Software Engineer	Cape Town
Kamfer, Hilton	Mr	Male	Mechanical Technician	Sutherland
Kayyunnaparayil Thomas, Jessymol	Ms	Female	Post-Doctoral Researcher	Cape Town
Kgengwe, Mpho	Mr	Male	Purchasing Officer	Cape Town
Khangale, Zwido	Dr	Male	PhD Student	Cape Town
Khumalo, Buzani	Miss	Female	Education Officer	Cape Town
Klaasen, Dillon	Mr	Male	SALT Software Engineer	Cape Town
Klaaste, Petrus	Mr	Male	Driver/ Maintenance	Sutherland
Klein , Annalize	Ms	Female	Casual	Cape Town
Klein Meagan	Ms	Female	Casual	Cape Town
Klein, Francois	Mr	Male	Tour Guide	Sutherland
Klein, Sina	Mrs	Female	Hostel Assistant	Sutherland
Knaizev, Alexei	Dr	Male	Astronomer	Cape Town
Koen, Thea	Miss	Female	Telescope Operator	Sutherland
Koeslag, Anthony	Mr	Male	Software Engineer	Cape Town
Koorts, Willem	Mr	Male	Electronics Technician	Cape Town
Kortje, Sofia	Mrs	Female	Housekeeper	Sutherland
Kotze, Enrico	Dr	Male	Astronomer	Cape Town
Kubheka, Duduzile	Ms	Female	Project Coordinator	Cape Town
Kuhn, Rudolf	Dr	Male	SALT Astronomer	Cape Town
Lakey, Eugene	Mr	Male	Manager: Finance and Operations	Cape Town
Lancaster, Tamara	Ms	Female	MSc Student	Cape Town
Lande, Cornelius	Mr	Male	Casual Worker	Cape Town
Ledwada, Gontse	Ms	Female	Honours Student	Cape Town
Lethetsa, Katleho	Mr	Male	Intern	Cape Town
Lewis, Sanchia	Ms	Female	Safety and Site Officer	Cape Town
Loubser, Egan	Mr	Male	Mechanical Technician	Cape Town
Louw, Rianelda	Ms	Female	Machine Operator	Cape Town
Love, Jonathan	Mr	Male	Mechanical Technician	Sutherland
Maartens, Deneys	Mr	Male	Software Engineer	Cape Town
Macebele, Nhlavutelo	Mr	Male	SALT Software Developer	Cape Town

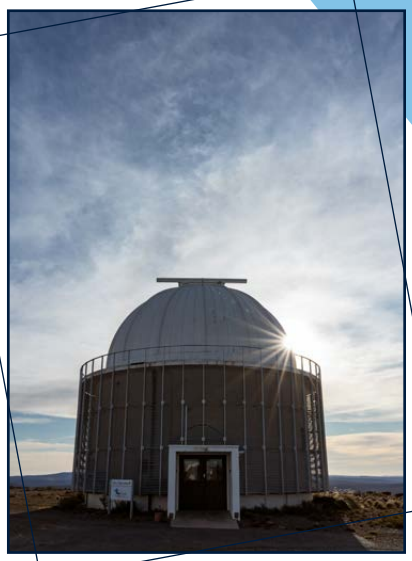
SAAO STAFF LIST

NAME	TITLE	GENDER	JOB TITLE	MUNICIPALITY
Macfarlane, Sally Ann	Dr	Female	Post-Doctoral Research Fellow	Cape Town
Madhanpall, Nikhita	Ms	Female	OAD Big Data Fellow	Cape Town
Maerman, Nkululeko	Mr	Male	Machine Operator	Cape Town
Mahoro, Antoine	Mr	Male	PhD Student	Cape Town
Makananise, Thabelo	Mr	Male	Instrumentation Technician	Sutherland
Makda, Nazir	Mr	Male	PhD Student	Cape Town
Makoloane, Lehlohonolo	Mr	Male	IT Systems administrator	Cape Town
Makolomakwe, Kgomotso	Ms	Female	Electronics Engineer	Cape Town
Makwetja, Moloko	Mr	Male	Science Engagement Intern	Cape Town
Mamo, Alemiye	Mr	Male	PhD Student	Cape Town
Mantungwa, Thembela	Ms	Female	Communications Officer	Cape Town
Manxoyi, Sivuyile	Mr	Male	Head of Salt Collateral	Cape Town
Maqam, Malibongwe	Mr	Male	Systems Administrator	Cape Town
Mashile, Tokelo	Mr	Male	Honours Student	Cape Town
Matlala, Kgothatso	Mr	Male	Electronics Engineer	Cape Town
Matthys, Jan	Mr	Male	Casual Worker	Cape Town
Mbengashe Sibabalo	Ms	Female	Procurement Officer	Cape Town
Mcbride, Vanessa	Dr	Female	Astronomer	Cape Town
Meswatu, Jandre	Mr	Male	Casual	Cape Town
Meswatu, Julie	Mr	Male	Manager: Sutherland Site	Sutherland
Mgwatyu, Ayanda	Mr	Male	Site Supervisor	Cape Town
Mgwatyu, Sithembele	Mr	Male	Groundsman	Cape Town
Mkhize, Dumazile	Ms	Female	Intern	Cape Town
Mnisi, Mandle	Mr	Male	Honours Student	Cape Town
Mofokeng, Chaka	Mr	Male	SALT Astronomy Software Developer	Cape Town
Mogotsi, Moses	Dr	Male	Astronomer	Cape Town
Moosa, Surayda	Mrs	Female	Accounts Clerk	Cape Town
Msezeni, Sandiswa	Ms	Female	Intern	Cape Town
Mulaudzi, Avhapfani	Mr	Male	Electronics Technician	Sutherland
Mutobvu, Todani	Ms	Female	SCM Manager	Cape Town
Mvakade, Zuthobeke	Miss	Female	Librarian Assistant	Cape Town
Naicker, Tasheen	Mr	Male	Senior Mechanical Engineering	Cape Town
Naluminsa, Elizabeth	Dr	Female	Post-Doctoral Fellow	Cape Town
Ndaba, Bongekile	Mrs	Female	Mechanical Technician	Sutherland
Ndaliso, Xola	Mr	Male	SALT Operator	Cape Town
Nel, Sherelene	Ms	Female	Housekeeper	Sutherland
Ntame, Masixole	Mr	Male	Electronics Assistant	Sutherland
Paul, Bynish	Dr	Male	PhD Student	Cape Town
Pieterse, Jonathan	Mr	Male	SALT Supply Chain& Administration Officer	Sutherland
Potter, Stephen	Dr	Male	Head of Astronomy	Cape Town
Pretorius, Magaretha	Dr	Female	Instrumentation Scientist	Cape Town
Prins, Adneciah	Ms	Female	Casual	Cape Town
Prins, Willem	Mr	Male	Lead Maintenance Assistant	Sutherland
Rabe, Paul	Mr	Male	SALT Technical Operations Manager	Sutherland
Ramalatswa, Katlego	Mr	Male	MSc Student	Cape Town

NAME	TITLE	GENDER	JOB TITLE	MUNICIPALITY
Randriamampandry, Solohery	Dr	Male	SALT Astronomer	Cape Town
Randriamanakoto, Zara	Dr	Female	Astronomer	Cape Town
Romero Colmenero, Encarnacion	Dr	Female	Head of SALT Astronomy Operations	Cape Town
Roode, Susan	Ms	Female	Hostel Assistant	Sutherland
Rosie, Kathryn	Ms	Female	Mechanical Engineer	Cape Town
Saayman, Melanie	Miss	Female	Optical Engineer	Cape Town
Sanker, Sriram	Mr	Male	MSc Student	Cape Town
Sass, Craig	Mr	Male	Head of Mechanical Workshop	Cape Town
Scarrott, Malcolm	Mr	Male	SALT Software Developer	Cape Town
Scheepers, Garthvine	Mr	Male	Casual Worker	Cape Town
Seconna, Lisa	Ms	Female	MSc Student	Cape Town
Sefako, Ramotholo	Dr	Male	Head of Small Telescope Operations	Cape Town
September, Juliana	Miss	Female	Receptionist	Sutherland
Simon, Etienne	Mr	Male	Electronics Technician	Sutherland
Simon, Iriwaan	Mr	Male	Head of IT	Cape Town
Skelton, Rosalind	Dr	Female	SALT Astronomer	Cape Town
Skermand, Russel	Mr	Male	Lead Maintenance Assistant	Sutherland
Snowball, Glenda	Mrs	Female	Financial Officer	Cape Town
Solomon, Nuhaah	Mrs	Female	Office Manager : IAU OAD	Cape Town
Solomons, Kyle	Mr	Male	MSc Student	Cape Town
Stuurman, Jeremy	Mr	Male	Tour Guide	Sutherland
Swanevelder, Pieter	Mr	Male	Electronics Engineer	Cape Town
Taaibos, Sinethemba	Mr	Male	All Sky Monitor Operator	Sutherland
Titus, Keegan	Mr	Male	Electronics Technician	Cape Town
Tobin, Linda	Mrs	Female	Manager: Human Resources	Cape Town
Townsend, Lee	Dr	Male	SALT Astronomer	Cape Town
Väisänen, Petri	Dr	Male	Director: SAAO	Cape Town
Van de Merwe, Christian	Mr	Male	PhD Student	Cape Town
Van Der Merwe, Nicolaas	Mr	Male	SALT Mechanical Engineer	Cape Town
Van Der Westhuizen, Willem	Mr	Male	SALT Electronics Engineer	Sutherland
Van Dyk, Anke	Ms	Female	PhD Student	Cape Town
Van Gend, Carel	Dr	Male	Software Developer	Cape Town
Van Rensburg, Petro Janse	Ms	Female	PhD Student	Cape Town
Van Wyk, Magdalena	Mrs	Female	Hostel Supervisor	Sutherland
Van Wyk, Patrick	Mr	Male	Tour Guide	Sutherland
Van Wyk, Veronica	Miss	Female	Telescope Operator	Sutherland
Venugopal, Ram	Mr	Male	OAD Project Manager	Cape Town
Vernooi, Claudine	Ms	Female	Tour Guide	Sutherland
Vertue, Dominic	Mr	Male	OAD Intern	Cape Town
Viljoen, Johanna	Ms	Female	MSc Student	Cape Town
Visser, Martin	Mr	Male	CNC Operator	Cape Town
Whitelock, Patricia	Prof	Female	Astronomer	Cape Town
Wiid, Eben	Mr	Male	Mechanical Technician	Sutherland
Worters, Hannah	Dr	Female	Astronomer	Cape Town
Xipu, Athule	Ms	Female	Intern	Cape Town
Zibaya, Nomandla	Ms	Female	Procurement Officer	Cape Town

SAAO STUDENTS

The SAAO takes pride in the rich diversity and culture of our students who come from all over the world and, in particular, from other African countries. During the reporting period, 25 students were supervised by SAAO staff. 11 staff members acted as their SAAO supervisors, with others as UCT supervisors or mentors. 1 PhD, 1 MSc, and 1 Honours student graduated at the start of 2022. The MSc student has now proceeded to their PhD, and is again being supervised by SAAO staff. 12 students are currently busy with their PhD (7 are male and 5 are female). 8 students are doing their MSc (7 are male and 1 is female). 3 students enrolled with us for their Honours, all of which are male.



STUDENT SUPPORT

SAAO is committed to providing enhanced support to our students and supervisors, with the primary goal of ensuring a higher rate of successful completion of their studies within the specified timeframes.

To streamline the process and ensure timely stipend disbursement, SAAO has taken on the administration of NRF bursaries for our students to the extent possible. This allows students to receive their stipends on a monthly basis, without delays. Additionally, we allocate top-up funding from our research and publication incentives grant to ensure that all SAAO-supervised students receive a respectable level of financial support. In return, students are required to contribute 40 hours per year to service work at the observatory.

This service work encompasses activities such as service observing, assisting with open nights, and participating in a school tutoring program. These responsibilities not only support SAAO's activities but also help develop essential skills in the students.

Each PhD student is assigned a Postgraduate Advisory Committee (PAC), which conducts an annual meeting with the student and supervisor to evaluate progress. In the first year, the PAC reviews the research proposal, while in subsequent years, it identifies any potential issues and offers suggestions for additional support if needed. Currently, PACs are optional for MSc students, but we are considering making their involvement mandatory for evaluating the progress of all students.

SAAO ensures that adequate and well-equipped office space is dedicated to all students based at our main building. Students also have access to the on-site health clinic and therapist provided by the NRF for staff members. We organise regular skills sessions for students, facilitated by SAAO astronomers, to enhance their knowledge and capabilities. Furthermore, a weekly shuttle service is provided to transport students to UCT, enabling them to participate in the Astronomy Department's writing circle, journal club, and astro lunch.

Lastly, we have allocated a modest budget for social functions, giving students the flexibility to organise their own opportunities for social interaction in accordance with NRF finance regulations.

GRADUATED STUDENTS

PHD STUDENTS

ZWIDOFHELANGANI NDAMULELO KHANGAL

Research Title: Accretion Processes in magnetic cataclysmic variables: a detailed study of UZ Fornacis

Supervisors: Prof. Patrick Woudt (UCT/UNIVEN) and Prof. Stephen Potter (SAAO/UJ)

This thesis explores the emissions from magnetic cataclysmic variable (mCV) stars, focusing on the eclipsing AM Her system called UZ Fornacis (UZ For). The goal is to investigate the underlying emission mechanisms and accretion dynamics in UZ For to enhance our understanding of this class of objects. The strong magnetic field in UZ For makes it particularly interesting in terms of its influence on accretion dynamics and emission processes.

The thesis begins with 33 new mid-eclipse times observed over eight years in UZ For. These new timings test the two-planet model proposed to explain the periodic variations in eclipse times. While the proposed model generally aligns with the new timings, significant deviations exist. To accommodate the new data, the model requires highly eccentric orbits for one or both planets, which are considered unstable. This study explores the possibility of additional cyclic terms or alternative mechanisms contributing to the eclipse time variations.

The thesis also includes phase-resolved spectroscopy of UZ For, enabling a detailed Doppler tomography study. The blue spectrum shows dominant emissions from HeII 4686 Å and the Balmer lines, while the red spectrum displays emissions from CaII lines. Doppler tomography reveals three emission regions: the irradiated face of the secondary star, the ballistic stream and threading region, and the magnetically confined accretion stream.

Additionally, the thesis presents the first simultaneous optical and MeerKAT radio observations of UZ For. The optical data show broad emission features and negative circular polarisation in the blue region, with cyclotron emission features corresponding to different harmonic numbers. The radio observations detect a faint source at the L-band.

This study highlights the importance of multi-wavelength observations in understanding emission processes in mCVs. UZ For proves to be an intriguing AM Her system, with results supporting the presence of two planets and offering insights into its circular spectropolarimetry and radio emissions.

GRADUATED STUDENTS

PHD STUDENTS

ANTIONE MAHORO

Research Title: Outflows from active galactic nuclei (AGN) and star-forming galaxies

Supervisors: Prof. Petri Väisänen(SAAO), Prof. Mirjana Pović (ESSTI) Dr. Kurt van der Heyden (NRF), Assoc. Prof. Phineas Nkundabakura(UR)

This thesis performs a comprehensive investigation of active and non-active galaxies within the "green valley," a region postulated to signify a parameter space where galaxies undergoing morphological changes can be observed. Our study centres on Far-Infrared (FIR) active and non-active galaxies within the redshift range $0.2 \leq z \leq 1.2$, utilising both publicly available data from the Cosmological Evolution Survey (COSMOS) and proprietary data collected from the 11m-Southern African Large Telescope (SALT).
Our research encompasses an extensive examination of morphological attributes, stellar populations, and the [OIII]λ5007 Å emission line profile, offering insights into gas flows within these galaxies. Key findings emerge from this study:

Peculiar galaxies indicating interactions and mergers are more prevalent among FIR AGN (38%) compared to non-AGN (19%) galaxies within the green valley. Non-AGN galaxies primarily exhibit a spiral morphology (46%).

A substantial portion of green valley galaxies align with the main sequence of star formation, irrespective of morphology—a contrast to earlier optical and X-ray analyses.
FIR AGN and non-AGN green valley galaxies both exhibit intermediate stellar populations (67% and 53%, respectively), with median stellar ages of <log t> = 8.5 and 8.4 years. Most sources (62% AGN, 66% non-AGN) potentially underwent bursts and sustained star formation, possibly occurring more than 0.1 Gyr ago in a larger fraction of FIR AGNs (38%) than FIR non-AGNs (27%).

Similar quenching time scales of approximately 70 Myr are evident in both FIR AGN and non-AGN green valley galaxies.
The [OIII]λ 5007 Å line profile analysis, using SALT observations, highlights distinctive features of AGN and non-AGN galaxies, such as higher FWHM velocities and blue wings in AGN cores.

Intriguingly, some outflow candidates exhibit centrally driven gas outflows spanning the entire galaxy, primarily aligned with the main sequence of star formation—an indication of potential AGN-induced positive feedback on host galaxy star formation.

Collectively, our study suggests that FIR AGN green valley galaxies manifest heightened star formation rates compared to their non-AGN counterparts, implying a potential positive feedback mechanism driven by AGN, contrary to previous X-ray and optical studies suggesting negative feedback. This investigation contributes to a more comprehensive understanding of the intricate interplay between galaxy evolution and active galactic nuclei.

GRADUATED STUDENTS

PHD STUDENTS

MICHAEL SIPHO HLABATHE

Research Title: Reverberation Mapping of Active Galactic Nuclei

Supervisors: Prof. Patricia Whitelock(SAAO/UCT), Dr Encarni Romero-Colmenero(SAAO/SALT), Dr Steve Crawford(NASA)

This study delves into recent advancements in observational campaigns focused on expanding the dataset of active galactic nuclei (AGNs) by employing the reverberation mapping (RM) technique to estimate super-massive black hole (SMBH) masses. RM utilizes the temporal variations of broad emission lines from the nearby broad-line region (BLR) to determine their response time or delay (τ) in relation to the incident ionizing continuum from the accretion disc. By leveraging light-travel time effects, this delay facilitates the measurement of BLR size (RBLR = cτ, where c is the speed of light). By combining the Doppler broadened emission line's velocity width (ΔV) with RBLR, the SMBH mass (M) can be estimated, assuming gas cloud motions in the BLR are virialized.

Additionally, RM can assess accretion-disc size through the study of X-ray variability sources, influencing UV/optical variations in the accretion disc. Wavelength-dependent delays are explored, scaling as τ ∝ λ^4/3. This investigation involves photometric and spectroscopic observations of AGNs, including 3C 120, PG 2304+043, and SDSS J132447.65+032432.6, utilising the Southern African Large Telescope (SALT) and Las Cumbres Observatory (LCO) robotic telescopes. Employing methods such as the Interpolated Cross-Correlation Function (ICCF) and Continuum REverberation AGN Markov Chain Monte Carlo (CREAM), the study measures broad emission-line and inter-band continuum delays.

Results for 3C 120 exhibit multi-line lag measurements relative to the V-band continuum, and the Hβ delay, combined with its velocity width, yields the determined SMBH mass as M = 6.3 × 10^7 (f/5.5) M. Investigations into continuum inter-band delays align with predictions from a geometrically-thin, optically-thick accretion disc, albeit with a larger observed disc size. The velocity-resolved measurements illustrate a kinematic structure in the BLR consistent with Keplerian motion. Furthermore, outcomes for PG 2304+043 present a CREAM model with distinct parameters, while for SDSS J132447.65+032432.6, the Hβ delay and velocity width determination lead to a central SMBH mass of M = 5.18 × 10^7 (f/3.85) M.

While subject to ongoing investigation, these findings hold significance for the broader understanding of AGN reverberation mapping.

GRADUATED STUDENTS

MSC STUDENTS

TAMARA JANE LANCASTER

Research Title: The Broad Spectral Energy Distributions of Accreting White Dwarfs

Supervisors: Dr Retha Pretorius(SAAO) and Prof. Patrick Woudt (UCT/UNIVEN)

The text discusses the study of Cataclysmic Variable stars (CVs) as multi-wavelength objects, detected across various frequencies, from radio to γ-ray. The focus of the study is on the broad spectral energy distributions (SEDs) of these CVs, which have not been extensively studied despite the existence of large sets of multi-wavelength data. The thesis presents the largest collection of broad CV SEDs assembled to date.

The methodology involves selecting a sample of well-studied, nearby cataclysmic variables from different CV classes and gathering existing multi-wavelength data covering a wide frequency range. The thesis identifies the various contributions to the spectra and compares them between different classes of CVs.

To estimate the mass accretion rates, the thesis models the accretion disc as a series of concentric annuli, each emitting as a black body with an effective temperature corresponding to its radius. The resulting best-fit accretion rates are compared with published values for the systems.

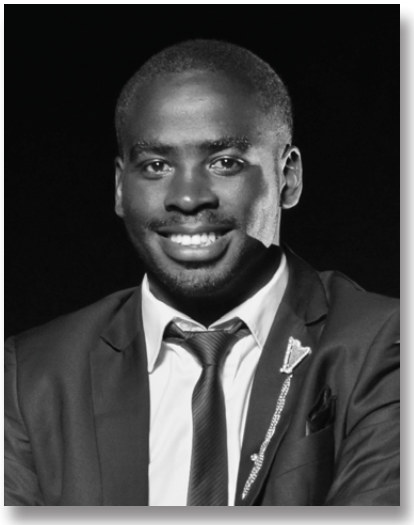
The method of modelling the emission as a sum of blackbodies proves reliable to within a factor of 5 for systems with steady-state discs. However, it underfits the data in all cases, indicating that other contributions to the spectrum need to be considered.

The study also explores the ratios of flux densities in different wavebands. The data reveals two previously reported correlations: shorter-period CVs have higher X-ray to optical flux ratios, and magnetic CVs exhibit higher X-ray brightness compared to non-magnetic CVs. Additionally, the study finds that polars are radio-bright compared to IPs.

While this method is a valuable tool for modelling spectra and estimating accretion rates, it requires a large dataset and accounting for other spectrum contributions. Attempts to obtain accretion rate estimates for a larger, volume-limited sample of non-magnetic CVs were not successful.

GRADUATED STUDENTS

MSC STUDENTS



BRIAN ONGERI MOMANYI BICHANG'A

Research Title: Three-dimensional structure of edge-on disk galaxies in the COSMOS field to z=0.5

Supervisors: Prof. Matthew Bershady (SAAO/UCT/UW Madison)

In this study, we have examined edge on-spiral disks at = 0.5, utilising deep HI imaging in the COSMOS field. Our analysis focuses on the three-dimensional stellar light distribution to gain insights into the formation and dynamical evolution of stellar disks. The sample includes 146 galaxies, limited to 814 < 21, spanning a range of masses around that of the Milky Way.

Using one-dimensional models, we have analyzed the radial and vertical light profiles of these galaxies. Our results reveal the presence of both a thick disk component and a more extended component, consistent with our nearby calibrator sample (NGC 4565, NGC 4013, and NGC 522). The measurements for the dust scale-height at low attenuation levels are similar to those expected for thin-disk stellar components.

We have observed that both scale-heights and scale-lengths increase with stellar mass, but they do so roughly in tandem, with no significant trend in the flattening of thick and extended components concerning redshift or total stellar mass.

Additionally, we have confirmed previous findings that the fraction of galaxies with visible dust lanes strongly depends on stellar mass, increasing sharply above a stellar mass of 9.75-10 dex and being negligible below 9.25 dex (solar units).

Characteristic values for the flattening (h/h) of disk components show variations: 0.066 ± 0.025 for the dust (thin) component, 0.16 ± 0.06 for the thick component, and 0.38 ± 0.20 for the extended component.

The Milky Way-luminosity sample displays a mean disk scale length h of 5.2 ± 1.8 kpc and mean disk scale heights of h = 0.39 ± 0.19 kpc, 0.75 ± 0.24 kpc, and 2.2 ± 0.5 kpc for the dust (thin), thick, and extended components, respectively. Although scale-heights are comparable to corresponding Milky Way components, typical scale-lengths are notably larger.

Furthermore, we have observed that scale-lengths and truncation radii tend to increase with height, which could be interpreted as disk flaring in the context of a one-component model or simply as a superposition of disk components with increasing thickness and radius. These findings provide valuable insights into the complex interplay between mass assembly and dynamical evolution in the formation of stellar disks in spiral galaxies

GRADUATED STUDENTS

MSC STUDENTS

KATLEGO RAMALATSWA

Research Title: Multi-dimensional simulations of bow shocks of massive, high-velocity runaway stars

Supervisors: Prof Shazrene Mohammed(UoM)

This thesis focuses on stellar bow shocks resulting from the supersonic collision between stellar winds ejected by runaway stars and the interstellar medium (ISM). Understanding these bow shocks provides valuable insights into various factors, such as mass-loss rates, stellar wind velocities, and ISM properties. The research specifically examines high-velocity runaway (HVR) stars found at the tail end of the runaway velocity distribution.

To conduct the simulations, we employed the PLUTO magneto-hydrodynamics grid code. We performed hydrodynamic simulations in both 2D and 3D, incorporating thermal conduction and detailed radiative cooling/heating. Extensive 3D freely expanding stellar wind models were used to validate the numerical aspects of PLUTO, while additional 2D models were employed to analyze runaways with velocities around 40 km/s, comparing the results with analytic models and existing literature.

The primary focus was on HVRs with space velocities of 200 km/s and 400 km/s, considering stars in their main-sequence (MS) and red-supergiant (RSG) phases, interacting with various ISM phases: the hot ionized medium (HIM), H II regions (HII), warm neutral medium (WNM), and cold neutral medium (CNM). We observed that the star's evolutionary phase, ISM phase, relative space velocity, thermal conduction and radiative cooling/heating significantly impact the morphology and evolution of the bow shocks.

The thesis delved into the properties of the reverse shock and the contact discontinuity of all HVR bow shock models. Additionally, it explored the development of instabilities, identifying the carbuncle phenomenon and non-linear thin-shell, Kelvin-Helmholtz, and Rayleigh-Taylor instabilities as contributing factors. Furthermore, the effect of dimensionality (2D vs. 3D) on the growth of these instabilities and the carbuncle phenomenon was thoroughly examined.

The thesis outlines future directions for work, including investigating the observability of these HVR bow shocks through multi-wavelength estimates and synthetic imaging. This includes plans to integrate hydrodynamic models with established stellar evolutionary codes and incorporate the influence of magnetic fields and stellar rotation.

In summary, this thesis sheds light on the formation and evolution of stellar bow shocks, with a particular focus on HVR stars and their interactions with the ISM. The findings provide a basis for further research exploring observational aspects and more comprehensive modelling that considers additional physical effects.

CURRENT STUDENTS

PHD **STUDENTS**

ANJA GENADE (SAAO/UCT)

Research Title: Observational studies of centaur characteristics

Supervisors: Prof. Paul Groot (UCT/ SAAO/Radboud University (NL), Dr. Amanda Bosh (MIT/Lowell Observatory)

ANKE VAN DYKE (SAAO/UCT)

Research Title: Transient follow-up and characterisation in the LSST era

Supervisors: Emeritus Prof David Buckley (SAAO), Vanesssa McBride (SAAO/UCT)

CHRISTIAN VAN DER MERWE (SAAO/UCT)

Title: Explosive transients from stellar collisions

Supervisors: Prof. Shazrene Mohamed (SAAO/UCT/ University of miami (UM)

OKWUDILI DANIE EGBO (SAAO/UCT)

Research Title: Multi-wavelength study of MeerKAT Galactic Plane Point Sources

Supervisors: David Buckley (SAAO/ UCT)

HANNES BREYTENBACH (SAAO/UCT)

Research Title: A Study of Quasi-Periodic Oscillations in magnetic Cataclysmic Variable Stars

Supervisors: Dr David Buckley (SAAO), Prof Patrick Woudt (UCT)

KELEBOGILE GASEALAHWE

Research Title: The study of Stellar Mass Black Hole and Neutron Star X-ray Binaries

Supervisors: Dr Itumeleng Monageng (UCT & SAAO), Prof. Rob Fender (University of Oxford & UCT), Prof. Patrick Woudt (UCT)

CURRENT PHD STUDENTS

PETRO JANSE VAN RENSBURG (SAAO/UCT)

Title: Studying gas flows in the SUNBIRD starburst galaxies and LIRGs

Supervisors: Dr Moses Mogotsi (SAAO/SALT), Prof. Petri Väisänen (SAAO/SALT) & Prof. Matthew Bershady (SAAO/UCT/UW-Madison)

NAZIR MAKDA (SAAO/UCT)

Title: Ultra-Diffuse Galaxies: A Multiwavelength Study

Supervisors: Dr Rosalind Skelton (SAAO), Assoc Prof Sarah Blyth (UCT)

SIMON DE WET (UCT)

Title: Gamma-Ray Bursts with MeerLICHT

Supervisors: Prof. Paul Groot (UCT/SAAO/Radboud University)

MUNIRA HOOSAIN (UCT/SAAO)

Title: Measuring the cosmic neutral hydrogen density in LADUMA

Supervisors: Assoc Prof Sarah Blyth (UCT) & Dr Ros Skelton (SAAO)

CURRENT STUDENTS

MSC STUDENTS

ANDREW FIRTH (UCT/SAAO)

Research Title: Resolving Atomic Hydrogen in Galaxies in Next- Generation Radio Surveys Using High-Resolution Optical-Near- infrared Imaging

Supervisors: Prof Matthew A. Bershady (SAAO / UCT / UW Madison)

GIDEON DEBEER (UCT/SAAO)

Research Title: Extended radio sources in the Small Magellanic Cloud

Supervisors: Prof Vanessa McBride(SAAO/UCT)

JACO BRINK (UCT/SAAO)

Research Title: Spectroscopic Analysis of Transient Sources

Supervisors: Prof David Buckley (SAAO/ UCT/UFS), Prof. Paul Groot (SAAO/ UCT/ Radboud)

JC VILJOEN (NWU/SAAO)

Research Title: Determining the properties of galaxies in MeerChoirs groups

Supervisors: Dr Moses Mogotsi (SAAO), Prof Ilani Loubser (NWU)

KYLE SOLOMONS (UCT/SAAO)

Research Title: A spectral and timing study of the low-mass X-ray binary MAXI J1820+070 during its outburst
Supervisors: Dr. Sunil Chandra(SAAO), Dr. Itumaleng Monageng(UCT)

LIAM HIGGO (SAAO/UCT)

Research Title: Conceptual design of a distributed spectroscopic telescope array

Supervisors: Prof Paul Groot (UCT/ SAAO), Dr Retha Pretorius (SAAO)

CURRENT MSC STUDENTS

LISA SECONNA (UCT/SAAO)

Research Title: Investigating the blue stellar clumps of the Penguin galaxy

Supervisors: Dr Zara Randriamanakoto (SAAO), Dr Jacinta Delhaize(UCT)

ULRICH GEEN (UCT/SAAO)

Research Title: A new spectrograph: Characterisation and early transient science

Supervisors: Dr Retha Pretorius (SAAO), Dr Nicolas Erasmus (SAAO), Prof. Paul Groot (UCT/SAAO)

MIKHAIL DE VILLIERS (UCT/SAAO)

Title: Ultra-Diffuse Galaxies: A Multiwavelength Study

Supervisors: Dr Rosalind Skelton (SAAO), Assoc Prof Sarah Blyth (UCT)

SRIRAM SANKAR (UCT/SAAO)

Research Title: Linking the evolution of galaxies, groups, and the baryon cycle using MeerKAT and SALT

Supervisors: Moses Mogotsi (SAAO, SALT), Matthew A. Bershady (SAAO, UCT, UW-Madison)

HONOURS STUDENTS

GONTSE LEDWABA

SAAO PUBLICATIONS 2022

REFEREED PUBLICATIONS

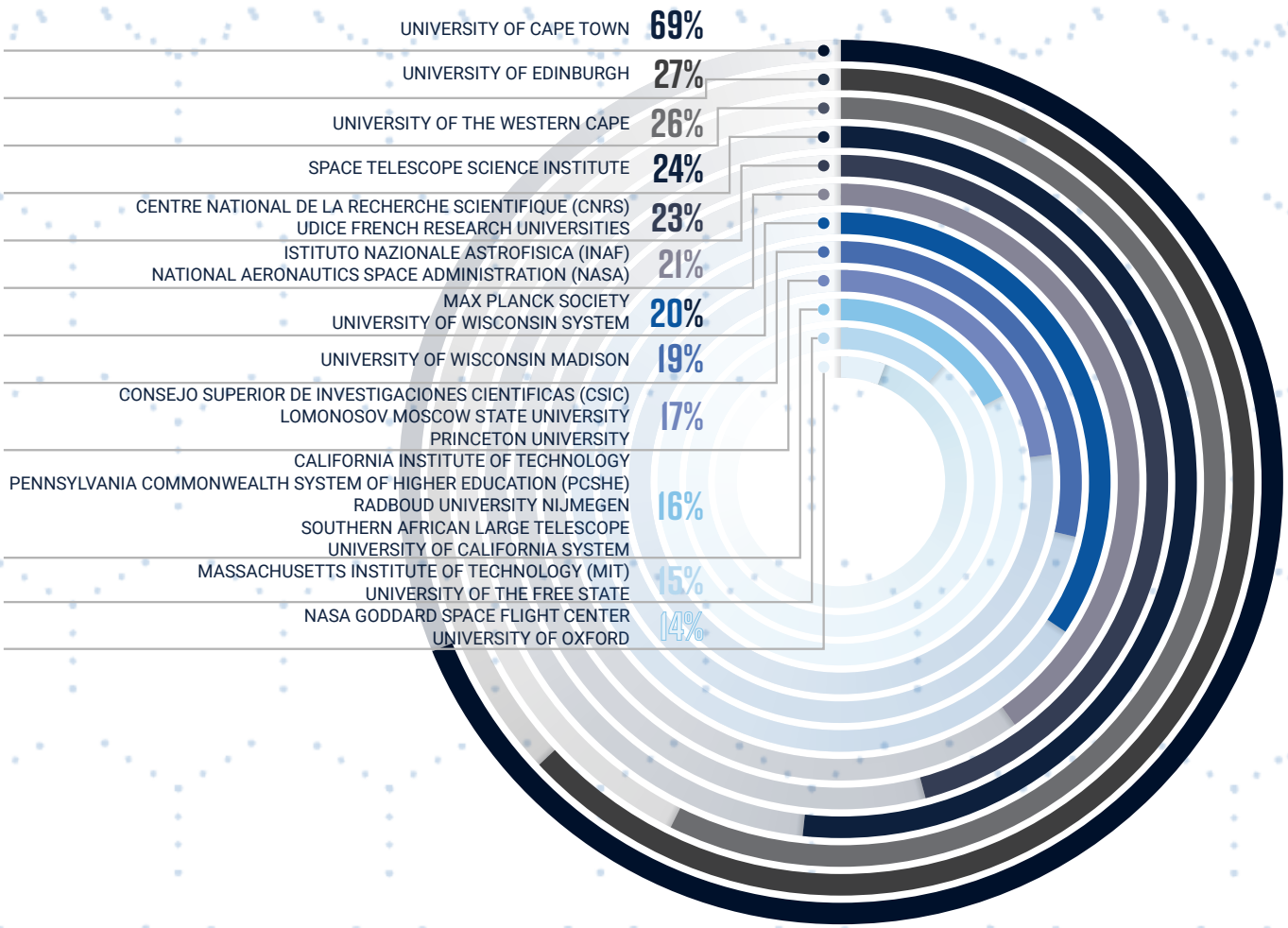
BREAKDOWN OF REFEREED PUBLICATIONS USING SAAO & HOSTED FACILITIES

Refereed publications by SAAO staff: 138
Refereed publications by non-SAAO staff based on SAAO & hosted facilities: 136
Total refereed publications:274

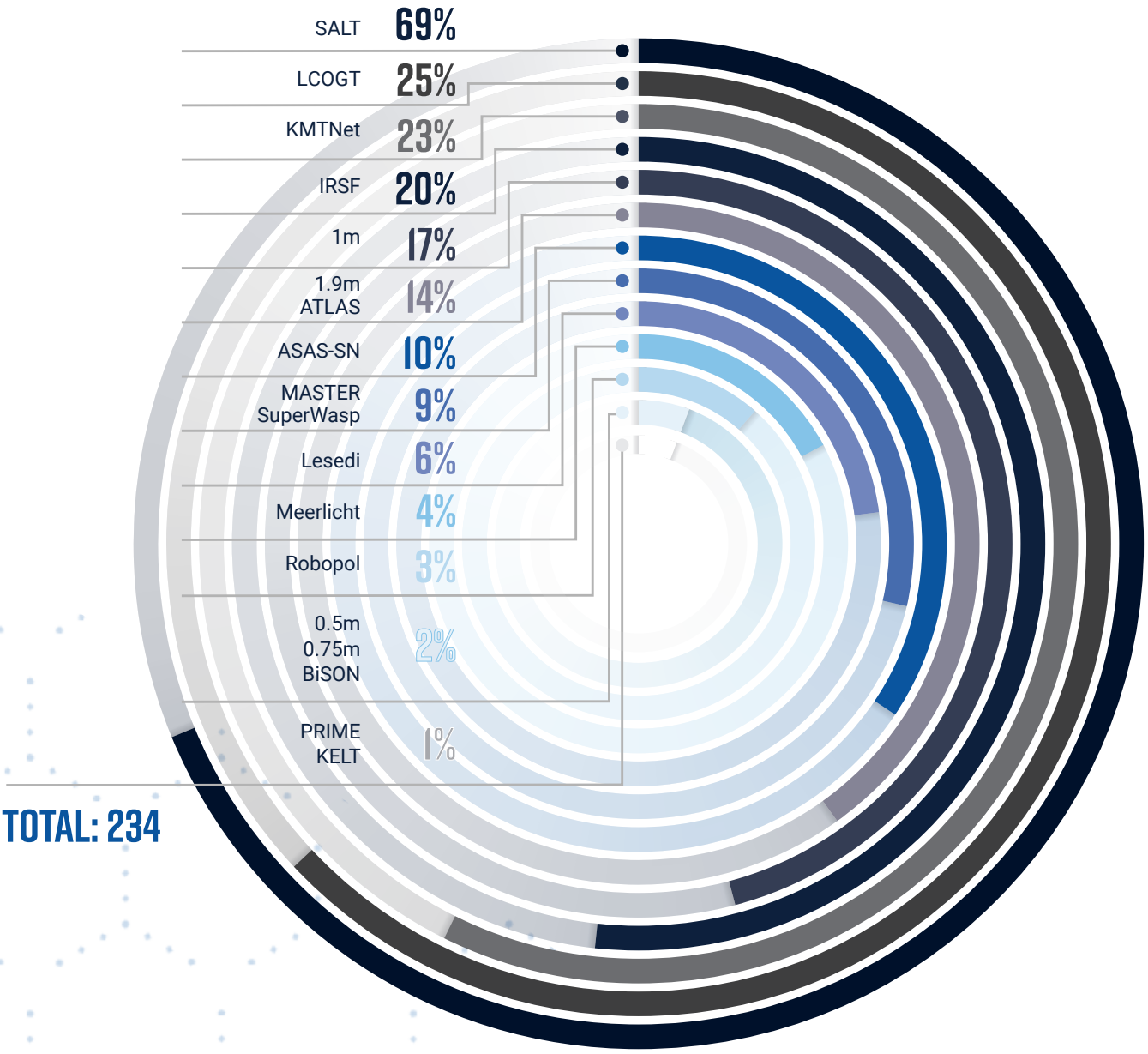
COLLABORATIONS

The SAAO has a number of publications each year, many of which are collaborations of SAAO researchers with scientists from some of the most prestigious institutions across the globe. The impact of these publications stems not only from their contributions to the field of astronomy, but also from the number of citations and headlines that these sparked across the globe.

ORGANISATIONS THE SAAO HAS MOST FREQUENTLY COLLABORATED WITH, BASED ON THE REFEREED SAAO STAFF PAPERS:



PAPERS PUBLISHED PER TELESCOPE



TOTAL: 234

PUBLICATION LISTS

PUBLICATIONS **WITH SAAO AFFILIATION**

Abdurro'uf, A.; Accetta, K.; Aerts, C.; et al.: "The Seventeenth Data Release of the Sloan Digital Sky Surveys: Complete Release of MaNGA, MaStar, and APOGEE-2 Data", 2022,The Astrophysical Journal Supplement Series, vol. 259, id.35.

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IMPRESSUM

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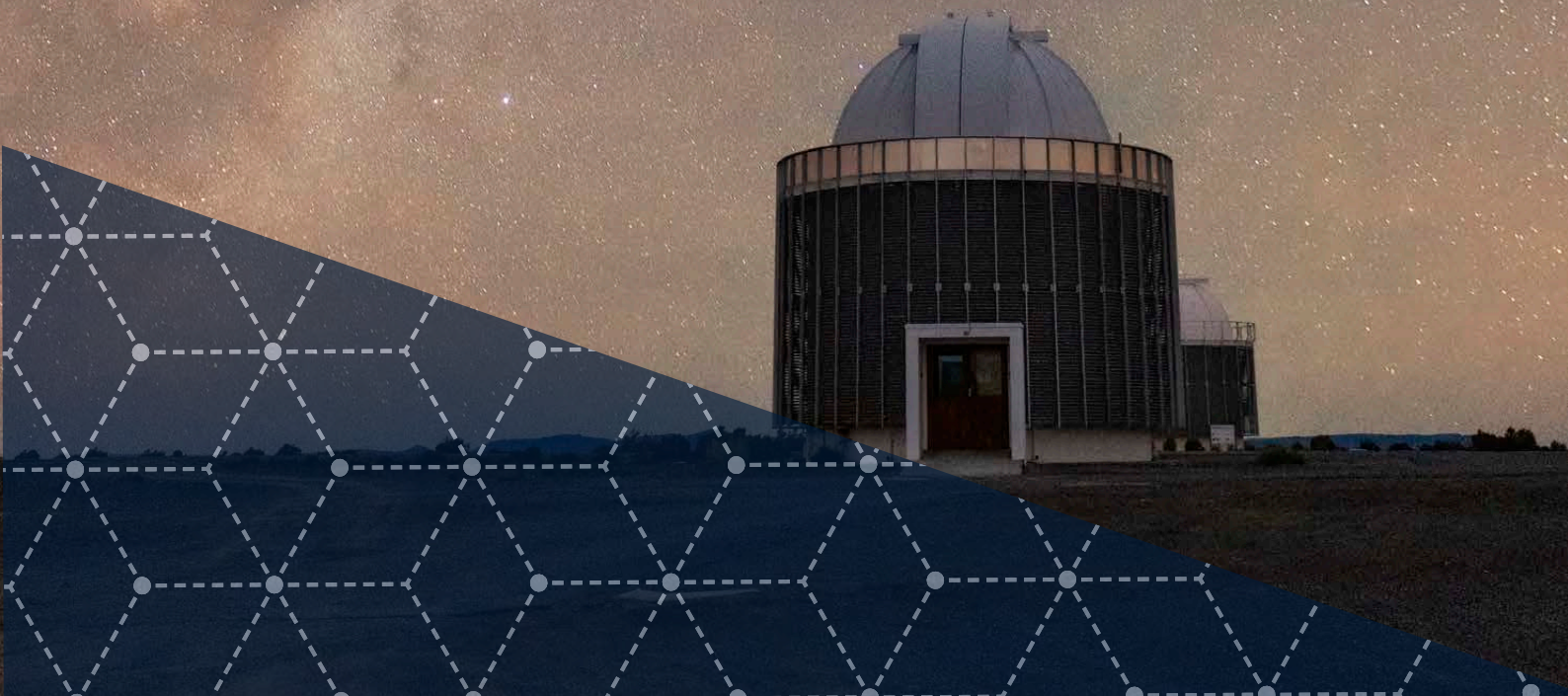

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