



RESEARCH VISION 2030

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Our research vision for SAAO is a vibrant, well connected and internationally renowned community that

- leads astrophysical research on the international stage
- supports and develops cutting edge technology
- through a transformed and inclusive workforce

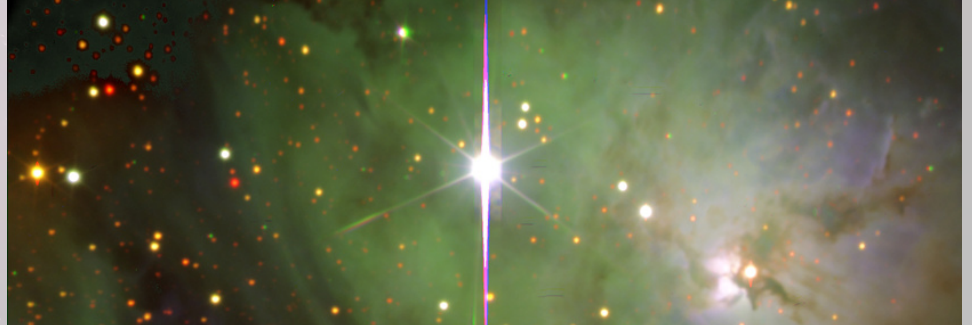
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Guiding principles

The guiding principles of this research vision are:

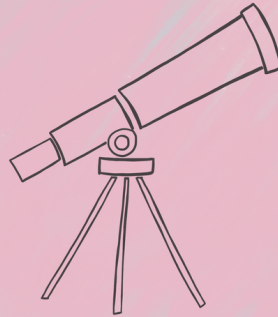
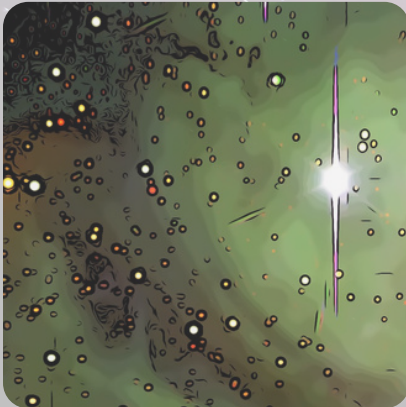
1. all researchers should have the **freedom** to pursue a research agenda driven by curiosity
2. astrophysics is a discovery-based science, and any vision should have the **flexibility** to adapt to the changes that come through new discoveries
3. the **impacts** of the research are felt broadly across science and society
4. the SAAO is an observatory, and as such, research is part of the **mandate**



Why these research focus areas?

Astrophysically exciting

Our research has the potential for new discoveries and knowledge that can lead to a deeper understanding of the history of the universe and our place in it.

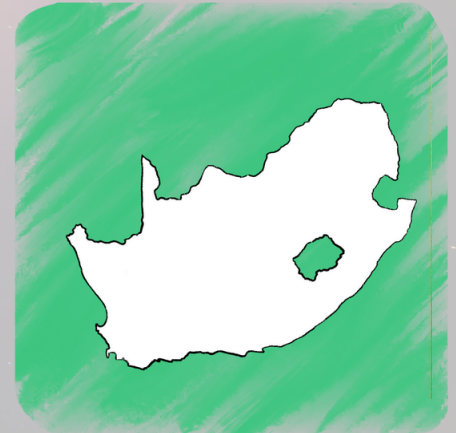


Develop new or build on existing instrumentation

Our research endeavour is aligned with existing local instrumentation or the research focus areas are used to drive development of novel instruments or observing and analysis techniques.

Local interest

There is strategic South African interest in developing these research areas, or such focus areas are already of interest to members of the South African astronomy community.



Geographical advantage

The SAAO in Sutherland, Northern Cape is a superb dark site in the southern hemisphere and is protected by the Astronomy Geographic Advantage Act (2007). Our research focus areas make use of these intrinsic characteristics and strategic advantages.



People

These research areas have one or more champions at SAAO to drive development and growth of the area. Strategic hiring, with a focus on new growth areas can be used to build expertise.




International collaboration

These research areas have the potential to strengthen existing or leverage new international partnerships or research collaboration networks.

Focus areas for 2030

1: Characterisation of astrophysical transients



In the last decade, new discoveries in transient astrophysics have become possible through increases in survey speed brought about by wide-field telescopes. The biggest of these surveys, the Legacy Survey of Space and Time (LSST) is expected to generate approximately 10 million transient alerts per night! This number is impressive, but step changes in our knowledge only come upon a more detailed analysis: for example, discovering a whole new type of behaviour in a particular class of object, or discovery of something completely unknown.

The SAAO is poised to exploit exactly this process of **rapid and specialised follow-up** of transient and variable sources for characterisation.

This is a research focus area for SAAO over the next decade because it fulfils all five of the criteria:

The **astrophysical excitement** is clear from the scale of international investment in transient astrophysics, e.g. projects such as Master, MeerLICHT, ZTF, LSST.

Our **local** South African astrophysical community has expertise and interest in a wide range of astrophysical objects that exhibit transient behaviour including blazars, cataclysmic variables, X-ray and gamma-ray binaries and near-earth objects. There is also the potential for synergy with our sister facility, SARAo, through the ThunderKAT and TRAPUM large projects on transients that are already active on the MeerKAT radio telescope.




Instrumentation - SALT, being a queue-scheduled spectroscopic telescope, is ideal for transient follow-up, especially faint transients. The Intelligent Observatory project at SAAO is gearing up the entire suite of telescopes on the SAAO plateau to work in a similar, queue-scheduled observing mode. Remote observations are now possible on all small telescopes, which is the first step to a robotic mode.

People - the SAAO is already home to researchers who are internationally recognised in this area. Time domain astrophysics has been a niche area of the observatory for a long time. Areas of expertise include cataclysmic variables, X-ray binaries, gravitational wave counterparts

Geographic advantage - South Africa is located at a longitude where there are no other telescopes in the Southern Hemisphere, making it key for time critical follow up observations. This is seen by the hosting of observing stations for the Las Cumbres Observatory, NASA's ATLAS project and the Russian MASTER project at Sutherland.

Focus areas for 2030

2: The assembly and evolution of galaxies



An enduring question in astronomy and cosmology is how galaxies form and evolve over cosmic time. Effort has been directed to massive, multiplexed surveys of galaxies to compile sufficient statistics of galaxies at different redshifts for various types of evolutionary censuses.

However, there is also a need to look galaxies that are near enough to be spatially resolved and bright enough to be spectrally resolved to understand:

- how age, metallicity and stellar velocities vary with scale height in galaxies like the Milky Way
- how the interstellar medium changed within and across galaxies
- the nature and distribution of dwarf galaxies, including ultra-diffuse and low surface brightness galaxies
- how star formation is fed by cold gas, and how it is quenched

For more distant galaxies, research directions undertaken at SAAO include:

- the content of the circumgalactic medium, how it interacts with galaxies and what happens the edges of galaxies
- nature and evolution of active galactic nuclei and the co-evolution of supermassive black holes and galaxies
- how mergers and the larger scale environment in galaxy groups, filaments and clusters influence the evolution of galaxies.

Assembly and evolution of galaxies is a research focus area for SAAO because it satisfies the following criteria:

The **astrophysical excitement** of this focus area can be seen through the questions above and the sheer number of large international observational projects aimed at understanding galaxy evolution.

Our **local** South African community works on galaxies at all scales. There is multi-wavelength complementarity, with a number of MeerKAT large survey projects exploring aspects of galaxy evolution e.g. MIGHTEE and LADUMA, which are led by South Africans, while there is strong local involvement in spatially resolved radio and optical surveys of nearby galaxies, e.g. MHONGHOOSE, MeerKAT Fornax Survey, SINGG, Sunbird, and various MeerKAT open time projects.



The galaxy cluster Abell 1689, from the Hubble Space Telescope

The latest SALT **instruments** are strongly focussed around Integral Field Units which will be able to resolve details like metallicity, dust content and abundances both spatially and spectroscopically.

People - the SAAO is already home to researchers who are internationally recognised in this area.

Geographic advantage - the dark skies of Sutherland are perfectly suited to spectroscopic observations of low surface brightness galaxies, meaning that SAAO is well placed to push to lower magnitude limits in these studies than other observatories. Being in the Southern Hemisphere enables our telescopes to be able to follow up or contribute to studies performed on cutting edge telescopes such as ALMA, MeerKAT, MWA, ASKAP etc. It also provides us with the opportunity to follow up or enhance the science performed by wide field IFU extragalactic surveys in the South such as the 4MOST Extragalactic surveys, Taipan, SKA-precursor surveys, SAMI and others.

Focus areas for 2030

3: Searching for Earth-like planets



Artists's impression of rocky exoplanet. Image from NASA/TESS.

The quest of detecting Earth-like planets around stars, along with the potential of bio-signatures in the atmospheres of these planets, is driving major advancement in ground-based spectroscopic and photometric techniques.

This is a nascent field at SAAO, but recent feasibility studies with SALT have show that a custom-built laser frequency comb will open the door to precision radial velocity measurements required to detect planets around nearby stars.

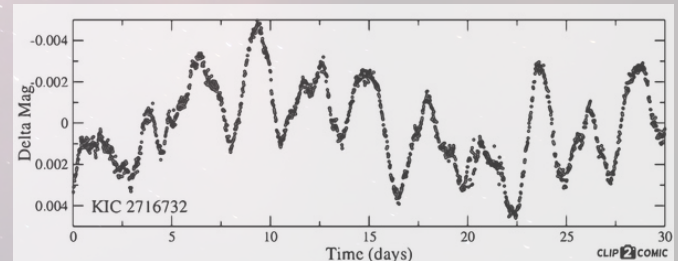
This is a research focus area for the future, that will grow and flourish with strategic investment in both instrumentation and human capital.

4: High speed astrophysics

This has been a niche area for the South African community for many decades, and is built around our expertise in instrumentation. Rapid, time-resolved observations have extended our understanding of the accretion process in close binaries, and the physical characteristics of blazars.

SAAO is able to do rapid time resolved photometry on telescopes from the 40-inch to SALT, and we have expanded these capabilities to high speed spectroscopy and spectro-polarimetry on SALT.

Future capabilities in time-resolved polarimetry through WALOP are on the horizon, further extending the capability of SAAO in this area.



Lightcurve of a variable star.





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*A feature of science is that as the frontiers of our knowledge
are extended, new mysteries, just beyond the frontiers, come
into sharper focus.*

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Martin J. Rees, On the Future: Prospects for Humanity



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