

# **Spatial Heterodyne Spectrometer to Search for Missing Baryons: Design, development and commissioning of a Spatial Heterodyne Spectrometer for SAAO's Sutherland telescopes to detect diffuse nebular emission around galaxies**

Type: PhD project (Instrumentation/Observational analysis)

Supervisor: Prof. M. Bershadsky

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Requirement: Masters degree in astronomy or a closely aligned field.

Key words: astronomical instrumentation; interferometric techniques in spectroscopy; nebular spectroscopy

*Description:* We seek applicants to undertake a three-year Ph.D. program with Prof. M. Bershadsky co-leading the design, construction and commissioning of a spatial-heterodyne spectrometer (SHS) for telescopes at Sutherland, including the Southern African Large Telescope (SALT). The instrument will be used to detect and characterize diffuse nebular emission around nearby galaxies, thereby contributing to our understanding of where the missing cosmic baryons are located. The instrumentation development will be carried out in parallel with an observational program using existing instruments (e.g., SpUpNic on the 1.9m or RSS on SALT) that motivates and informs the SHS development.

The SHS is a grating-dispersed Michelson interferometer with no moving parts; it generates a spectral interferogram yielding high spectral resolution for a much larger entrance aperture than a conventional spectrograph. SHS instruments are competitive for observations of diffuse nebular emission over narrow spectral band-pass but wide field-of-view. The SHS to be designed will be shoe-box in size, yet capable of achieving resolutions comparable to SALT's high-resolution spectrograph with an entrance aperture of 40 arcsec<sup>2</sup> (on SALT). The instrument will be optimized to detect specific nebular spectral diagnostics to determine the chemical content and the physical conditions of the ionized gas. This instrument will enable new discoveries with SALT and it will be a path-finder for future instruments that include high multiplex, wide-field coverage as well as compact payloads for future space missions in the ultraviolet and infrared.

*Project scope:* The Ph.D. program will include (1) high-level design of the SHS instrument based on specific science requirements established by the student and supervisor; (2) procurement, fabrication and alignment of optics, opto-mechanical assemblies, mounts and fixtures based on this instrument design; (3) development of the data-analysis tools to transform the spectral interferogram into a spectrum; (4) laboratory calibration of the instrument; (5) packaging the instrument for use on SALT and/or other telescopes at SAAO; and (6) commissioning the instrument on-sky to complete a pilot program demonstrating science performance. In parallel

with the above the student also undertake an observational program using SAAO facilities in Sutherland. The completed dissertation will describe the instrument and its performance, the results of the observational program, and the results of pilot observations. The thesis will be suitable for publication in two or more peer-reviewed articles.

The student will work closely with Prof M. Bershadsky (SAAO SARCHI), his research team of observers and instrumentalists (including a team building a fibre-optic test facility and a fibre integral-field unit for SALT), members of the SAAO Machine Shop, as well as other members of the SAAO technical and science staff.

*Detailed requirements:* Applicants should have some background in astronomical instrumentation. Knowledge of astronomy and geometric optics at the undergraduate or graduate levels is required. Completion of a Masters in astronomy a closely aligned field (such as physics or atmospheric science) is required. An interest to learn laboratory skills and undertake instrument development with optics and imaging detectors is required.