Development & on-sky Commissioning of the Integral-field Spectro-Polarimetry Mode for the SAAO Cassegrain Spectrograph

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Overview: We are offering a Masters project at the SAAO to work on the development of an upcoming new polarimetric mode at the SAAO.

Supervisors

1. Dr. Siddharth Maharana (SAAO, Cape Town)
2. Dr. Sabyasachi Chattopadhyay (SAAO, Cape Town)
3. Prof. Matt Bershady (SAAO, Cape Town)

Contact: siddharth@saao.ac.za

Context & Motivation

Polarimetry, as the name suggests, refers to measurement of the state of polarisation of light coming from a source. It entails ascertaining the amount and direction/sense of any preferred polarisation state in the light beam. Polarimetry is a powerful tool which has been used by astronomers to understand the physics of myriad kinds of astrophysical objects, such as active galactic nuclei, supernovae, proto-planetary systems and dust clouds in the interstellar medium (ISM). In particular, it is useful in study of objects that have an inherent asymmetry in their light emission or propagation mechanism. In fact, often, polarimetry is the only method to find the geometry of an astrophysical object/system and it cannot be obtained by other methods such as imaging and spectroscopy.

Modern polarimeters in astronomy come in two broad kinds: imaging polarimeters and spectropolarimeters. As the name suggests, imaging polarimeters create the polarisation image of a sky field in different broadband filters, while spectropolarimeters enable polarisation measurement as a function of wavelength across a large wavelength range. In general, spectropolarimeters are a more powerful way to probe the physics of astronomical sources, just as the spectra of a source has more encoded information than only the intensity information obtained through images. However, all present day spectropolarimeters operate as long slit or point-source instruments, i.e, usually only point sources can be observed with them and as such, these are not efficient for spectro-polarimetric measurements of 2D/extended objects.

2D spectro-polarimetry is one of the next challenges in astronomical polarimetry, along with its promise of rich scientific dividends. Today, 2D spectroscopy, also referred to as Integral Field Spectroscopy (IFS), is an advanced and mature technology used in many of the major telescopes and instruments around the world. 2D spectro-polarimetry, to be referred to as Integral Field SpectroPolarimetry (IFSP) from here on, will open up a new parameter space of information mining from astrophysical objects and can potentially transform the study of many classes of objects by providing hitherto unavailable data. The primary science targets with IFSP are the study of dust properties in the ISM of nearby galaxies, galactic nebulas, molecular clouds and star forming regions, supernova remnants, asteroids and comets.

Project Details

At SAAO, we are developing an IFSP front end (called SPIFS for now) for the existing, upgraded cassegrain spectrograph on the SAAO 1.9 m telescope (SpUpNIC). SPIFS will be mounted on the Guiding and Acquisition Module (GAM) of SpUpNIC on the 1.9m telescope. SpUpNIC is the workhorse instrument on the 1.9m SAAO telescope at the Sutherland Observatory that has been working successfully over many years. It is a conventional long-slit spectrograph that can obtain medium to low resolution spectra over the entire optical wavelength range of 350 to 1000 nm using various gratings.

Masters Project Description:

Currently, the instrument is in an advanced design phase. The instrument optical design has already been completed and the opto-mechanical design is underway. The work on the fibre-IFU development, assembly and characterisation of the instrument and commissioning is scheduled for early next year. The key challenges for the instrument development in future are as follows:

a. Accurate assembly and alignment of the optical system, including the fibre IFUs.

b. Measurement of the various polarimetric and spectroscopic systematics of the coupled fibre IFUs and polarimetric system such as its dependance on the length of fibre, temperature etc.

c. Develop the calibration strategy to measure the instrument induced polarisation (instrumental polarisation) and a methodology to correct for it, both in the lab and the sky.

d. Performance characterisation of SPIFS in the lab.

e. Development of the data reduction pipeline for the instrument.

f. Commission on sky and early science and publications.

The Masters project will consist of working in some or all of the above sub-projects, depending on the interest of the student. Please contact us to know more details of the work. The final choice of topics will depend on the student's interests, supervisor and co-supervisor availabilities and the requirements of the programme. We request the potential students to contact the supervisors to discuss the options before submitting their applications.

Research Impact:

SPIFS will be the first of its kind of instrument in astronomy and is expected to break new grounds in both technical aspects of polarimetric instrument development as well as the new and unique science capabilities it will provide to astronomers. Further, successful commissioning of SPIFS will be act as a technology demonstrator for IFSP modes on bigger telescopes such as the SALT.

Required Skillsets:

While there is no strict prerequisite skillset needed for the project, during the course of the work, the student will need to spend a substantial amount of their time in the lab, in particular with optical systems. Although no prior programming knowledge is needed, it is expected that the students will need to learn it during the course of the project depending on the requirements.

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