

NASSP Masters Project 2026

1. Level of the project:

Masters

2. Name of primary supervisor:

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3. Institution of supervisor:

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4. Name of co-supervisor(s):

Prof. Kavilan Moodley

5. Institution of co-supervisor:

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7. Project title:

Calibration of Weak Lensing Survey Systematics Using HI intensity mapping surveys

8. Description of project:

Weak gravitational lensing is one of the promising cosmological probes, but its cosmological power is limited by optical systematics in galaxy shape catalogues, especially intrinsic galaxy alignments (IA) that mimic true shear. Neutral hydrogen (HI), mapped via 21-cm intensity mapping, traces the underlying matter field with very different observational systematics. This project will exploit that complementarity by using HI as an external tracer to help separate true gravitational shear from IA in LSST-like surveys.

As we have already developed a squeezed-limit bispectrum simulation pipeline that connects small-scale HI two-point spectra to large-scale shear, we will now extend this framework to include optical systematics explicitly. Since the estimator measures the response of HI to large-scale shear, we will study how this response is modified when the shear field is contaminated by IA and related systematics, and quantify the resulting change in the inferred response function.

Objective:

The objective of this project is to adopt a simulations-based approach to using neutral hydrogen (HI) as an external, spectroscopic tracer to calibrate key weak lensing survey systematics, with a particular focus on intrinsic galaxy alignments (IA) that contaminate cosmic shear measurements. By exploiting precise HI redshift information and higher-order statistics between HI and optical shear, the project will (i) quantify how IA and photometric-redshift induced lens-source overlap bias LSST-like shear observables, and (ii)

develop a response-based calibration scheme, built on a squeezed limit HI-shear bispectrum estimator, that can recover IA model parameters.

Methodology:

We will use the publicly available [CosmoGridV1](#) (Kacprzak & Fluri 2022) lightcone suite. It provides shear maps including both shear and IA contributions, based on standard IA prescriptions such as the Non-Linear Alignment model (Joachimi et al. 2011).

Building on a pre-developed squeezed limit integrated-bispectrum (IB) pipeline, we will correlate small-scale HI power spectra measured in sky patches with large-scale shear fields from these simulations. This defines a response of small-scale HI clustering to long-wavelength shear modes, which, when IA is present, is sensitive to both the true gravitational shear and the IA contamination in the optical maps. We will first calibrate “pure lensing” and “pure IA” response templates using the lensing-only and IA-only CosmoGridV1 shear maps, and then apply the same estimator to realistic lensing+IA maps to obtain a total HI-shear response. Interpreting the IB signal, we will construct a compact parametric model in which the measured response for DES-like (later LSST) source samples is decomposed into lensing and IA components controlled by a small set of IA parameters.

A crucial step will be validation against CosmoGridV1 benchmark runs, which vary box size, particle resolution, and shell spacing. By repeating the same IB-based calibration on these benchmarks, we will assess the sensitivity of our method to simulation systematics such as box replication, particle shot noise, and projection approximations, following the strategy already used for peak statistics and other non-Gaussian features (Zürcher et. al.)

Expected Outcome:

The project will deliver a response-based pipeline that uses CosmoGridV1 simulations and HI-shear cross-bispectra to calibrate intrinsic alignment contamination in LSST-like weak lensing surveys. We expect to show, in a controlled setting, that HI-assisted squeezed limit statistics can recover IA model parameters (amplitude and redshift evolution) with useful precision, and quantify the robustness of this calibration to CosmoGridV1 numerical choices.

Requirements: Students must have some background in cosmology at the Honours level, including familiarity with basic statistics. Proficiency in Python or C/CPP is essential as the project heavily relies on coding.
