Modelling the redshift distribution of *Euclid*'s lensed galaxies for field-level analyses

PhD position

Laboratory: CEA Paris-Saclay/IRFU/AIM/CosmoStat
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Application Deadline: 30/03/2026

As part of the ERC-funded **OCAPi** project, we invite applications for a **fully funded PhD position** on field-level inference of weak lensing. The student will work on forward modelling the redshift distribution of lensed galaxies using physical templates and machine-learning techniques.

Context

The *Euclid* mission will deliver weak lensing data with unprecedented precision, which has the potential to revolutionise our understanding of dark energy and the growth of cosmic structures. Extracting its full information content requires going beyond the standard analyses. To make optimal use of the data, the OCAPi project will analyse *Euclid's* lensing maps directly at the pixel level. This approach, known as field-level inference, captures all the information and provides up to 5 times better constraints on the cosmological parameters (Porqueres et al. 2022, 2023).

This increased precision, however, requires an accurate modelling of the data. One of the main calibration challenges in weak lensing surveys is the redshift distribution of the lensed galaxies. Current calibration methods were designed for the standard analyses and may not be sufficiently accurate for field-level techniques. Quantifying the accuracy requirements and developing methods capable of reaching it is essential to enable field-level analyses of *Euclid* data and unlock the full scientific potential of the survey.

PhD thesis

The goal of this PhD project is to develop a new redshift sampler for weak lensing, designed to meet the accuracy requirements of field-level inference. This sampler will combine physical models of galaxy populations with flexible machine-learning techniques. The thesis will contribute to maximising the potential of *Euclid's* weak lensing data and advance our understanding of the formation of cosmic structures.

Outline of the project and methodology

1. Quantify redshift accuracy requirements for field-level analyses: The student will determine the level of accuracy needed in the redshift distribution for field-level cosmology. This includes studying the impact of variations in survey depth across the sky.

2. Develop a redshift sampler for field-level inference: Combining physics templates and machine-learning techniques such as Mixture Density Networks (Alsing et al. 2023, Leistedt et al. 2022), the student will develop a redshift sampler that meets the accuracy requirements for field-level analyses.

3. Integrate the sampler into the field-level pipeline: The sampler will be incorporated in the existing field-level pipeline (Porqueres et al. 2023) to jointly infer the redshift distribution of the galaxies, the cosmological parameters and the initial conditions of the Universe. This will automatically propagate the redshift uncertainties to the cosmological constraints.

4. Validation and application to *Euclid* data: After validating the sampler with simulated data, the student will apply the field-level framework to *Euclid's* weak lensing data.

Scientific environment

The PhD will take place in the CosmoStat laboratory at the Département d'Astrophysique at CEA Saclay, under the supervision of Natalia Porqueres and Martin Kilbinger. The student will join the OCAPi team, working on advancing field-level analyses of weak lensing and contributing to the scientific exploitation of the *Euclid* mission.

CosmoStat hosts a multidisciplinary team whose research includes statistics, machine learning, artificial intelligence, and cosmology. The group is strongly involved in the weak lensing analysis of the *Euclid* space mission.

Application

The candidate should hold a Master 2 degree (or equivalent) in either physics/astrophysics or applied mathematics/signal processing/data science. Experience with Python/C++ and Git would be advantageous, but not required. Applicants should send:

- CV
- Grade transcripts from the Master's and Bachelor's
- Summary of past research (max. 2 pages)

to **nporqueresrosa@gmail.com** before the application deadline.
Additionally, applicants should provide the names and contact details of two referees who may be contacted for a reference. Early submissions are encouraged, and inquiries about the position are welcome.