

PhD Report – Year 1

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Supervisor: prof. Enzo Franco Branchini

Research

In the first year of my PhD, I focused on the study of the large-scale structure (LSS) of the Universe. The main objective was the development of methods for the cosmological reconstruction of the matter density field from the observed galaxy field, with the aim of correcting distortions and systematics in spectroscopic survey data and improving the precision of cosmological parameter inference.

Hybrid Density Field Reconstruction

I implemented and validated hybrid reconstruction methods combining perturbation theory with Convolutional Neural Networks (CNNs). As an initial step toward a full pipeline optimized for current and future large-scale galaxy surveys, I addressed Redshift Space Distortions (RSD), which arise from peculiar velocities of tracers along the line of sight and affect isotropy and Baryon Acoustic Oscillation (BAO) feature modeling.

In collaboration with P. Veena (UniGe), G. Degni (CPPM Marseille), and E. Branchini, I developed a hybrid pipeline for RSD removal. The approach involves pre-processing a catalogue of tracers using standard reconstruction methods based on linear perturbation theory, and then feeding the partially reconstructed density fields into a CNN. The network learns the residual, non-linear mapping between the distorted and true density fields by leveraging large sets of cosmological N-body simulations.

Main results:

- The hybrid approach outperforms both perturbation theory-based methods and CNN-only approaches;
- The reconstructed field exhibits isotropic two-point statistics consistent with real-space expectations over a wide range of scales;
- The method improves both autocorrelation and cross-correlation analyses of different tracers.
- This work has resulted in a first-author article, currently available on arXiv and under review at *Astronomy & Astrophysics* (A&A). Results were presented at the conference Optimizing the Extraction of Cosmological Information from the Latest Spectroscopic Redshift Surveys (Sexten Centre for Astrophysics, July 2025).

Contributions to the *Euclid* Collaboration

I also contributed to the activity of the ESA - Euclid mission, as an active member of the Euclid Consortium Science Working Group. In particular, I actively took part in the following research activities:

Analysis of Observational Systematics

I contributed to the Observational Systematics group in the study of catastrophic redshift errors and their impact on BAO reconstruction. I demonstrated that standard BAO reconstruction and cosmological inference methods remain robust with up to 20% contamination. These results were included in a Euclid Collaboration paper, submitted to A&A and currently under review.

Validation of the Reconstruction Pipeline on Simulations

Within the BAO key project, I applied the standard reconstruction procedure to 4000 realistic simulations of Euclid DR1 data. The resulting catalogs are now available to the collaboration and are used to validate analysis pipelines, test inference procedures, compute empirical covariance matrices, and validate analytical covariances.

Publications

- I. **E. Maragliano**, P. G. Veena, G. Degni, E. F. Branchini
From Redshift to Real Space: Combining Linear Theory With Neural Networks
[arXiv:2507.11462](#) [astro-ph.CO], submitted to A&A, under review
- II. Euclid Collaboration: I. Risso, A. Veropalumbo, E. Branchini, **E. Maragliano** et al.
Euclid preparation. The impact of redshift interlopers on the two-point correlation function analysis
[arXiv:2505.04688](#) [astro-ph.CO], submitted to A&A, under review

Workshops and Conferences

- Sexten Centre for Astrophysics, Sesto (BZ), 14–18 July 2025 - *Optimizing the Extraction of Cosmological Information from the Latest Spectroscopic Redshift Surveys*
Talk: From Redshift to Real Space: combining linear theory with convolutional neural networks
- ICTP–IFPU, Trieste, 14–18 April 2025 - *Reconstruction Strikes Back: Unveiling the Dynamics of the Universe in Next-Generation Spectroscopic Survey*
Talk: Combining Standard Reconstruction with Convolutional Neural Networks
- Max Planck Institute for Extraterrestrial Physics, Garching (DE), 20–24 January 2025 - *Euclid Science Working Group - Galaxy Clustering Meeting*
Flash talk: *Cosmological Reconstruction with Convolutional Neural Networks*
Contributed talk: *Status of the reconstruction pipeline within the Euclid Collaboration*
- Sestri Levante (GE), 16–17 September 2024 - *Understanding the Galaxy/Matter Connection in the Era of Large Surveys*
Contributed talk: Characterizing selection effects and data systematics in Stage IV spectroscopic surveys

PhD Courses

- Statistics of Parametric Models – Theory (Prof. M. Raveri) – completed
- Statistics of Parametric Models – Applications (Prof. M. Raveri) – completed
- Experimental Methods in Astrophysics (Prof. F. M. Zerbi) – completed
- The Double Trouble of the Missing Baryons and Dark Energy (Prof. E. Branchini) – to be completed

Outreach, Teaching, and Events

- Outreach event with middle school students (Antonio Cantore School, Genoa).
- Poster presentation at the MSc in Physics Open Day.
- Supervision of a 10-day astrophysics and cosmology project with a high school student, including analysis of Supernovae Ia datasets and cosmological parameter estimation.
- Organization of the Cosmology Journal Club, including two special sessions on DESI and ACT data releases (with G. Campailla). Since March 2025, I am responsible for its coordination.