Master 2 Intership Proposal:
Visualizing Star and Galaxy uncertainty in 3D environments

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Figure 1. Examples of Euclid images shown on the WILDER screen, during working sessions in 2023 and 2024.

Euclid is a European cosmology space mission in operation delivering lots of high quality data [1]. As the Euclid dataset is large and processed mainly automatically, astronomers need to verify, explore and validate data in particular regions of interest. In our research team we have been developing an interactive system that allows astronomers to visually explore astrophysical data (from Euclid but also from other databases) in order to foster possible new discoveries. Preliminary collaboration work done in 2023 and 2024 between the LISN and IAS (Institut d'Astrophysique Spatiale) teams show the great potential of this project and focuses mainly on visualizing 2D images captured by Euclid (see Figure 1). Our system works both on individual desktops but also on a large wall display (WILDER wall [2]) that is well-suited for collaboration [3, 6].

Part of our work so far has been to visualize 2D images captured or generated by the Euclid mission. In our recent work with astronomers, we have started exploring the visualization of objects in the sky in 3D. The position of stars or galaxies of the observable universe is fairly accurate if we consider their position wrt to the earth's sky and often astronomers reason with distance in terms of visual angles or arcs. But their exact distance from earth and from each other is sometimes only approximately calculated, especially when it comes to celestial objects that are outside our own galaxy. Astronomical catalogues already have information about the uncertainty around the distance from earth, but how to visually communicate this uncertainty is an open problem [4]. Some prior work has considered the question in terms of star distances using a desktop system [5], but has not looked at how these designs scale in terms of galaxy distances (that are larger and more uncertain), nor how astronomers can use these in virtual reality settings. The goal of this internship is to represent this uncertainty visually in 3D, in a virtual reality headset, in order to help astronomers get a more accurate understanding about their data and confidence in their measurements and models.

- Review literature on visualizing uncertainty in 3D (including 3D environments and virtual reality);
- Design and implement prototypes for visualizing uncertainty in the context of star and galaxies;
- Run a user experience session with astronomers to evaluate these designs.

The intern will use Unity3D [7] or another 3D environment to develop their designs. Note that, depending on the intern's preference, the internship could either focus on the design part (*e.g.*, proposing several different visualization designs) or on the technical part (building software that can scale to showing many objects in 3D). Either focus will need to consider prior research on visualizing uncertainty. We note that we have at our disposal already a tool for visualizing objects (stars / galaxies) in 3D, so the main work of the student would be to prototype designs for the uncertainty aspects.

Requirements for Applicants: knowledge of Virtual reality (e.g., courses on Fundamentals of Virtual & Augmented Reality, Advanced Immersive Interactions) and experience with Unity3D or other 3D rendering software. Experience in Human-Computer Interaction methodology (e.g., have followed courses on the Design or the Evaluation of Interactive Systems) and Information Visualization is a plus.

Duration and period: 6 months starting in March.
Location: Université Paris-Saclay, Bâtiment 660.
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