Observing Simulated Galaxies as if They Were Real for Simulation-Based Inference

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Team   SIGMA team (*Signal, Modèles et Applications*)

Duration   Flexible depending on student availability, with a minimum of about three months

Keywords   cosmological simulations, synthetic observations, galaxy formation, data analysis

Scientific Context   Astrophysicists cannot experiment directly with the Universe, but they can simulate it on a computer. In particular, *digital twins* of the local Universe reproduce known cosmic structures (like the Virgo cluster of galaxies) and allow us to test physical models of galaxy formation.

To compare these simulations with real telescope data, simulations need to be "observe" as if they were real. This means producing realistic images and spectra that include observational effects such as dust or limited resolution.

Internship Topic   The student will use the radiative transfer code SKIRT (Baes & Camps, 2015) to transform simulated galaxies (from the CLONES project (Sorce et al., 2021)) into realistic images and spectra. Different versions of the simulations use different physics for galaxy formation, and the student will study how these differences show up in the synthetic observations.

If time allows, the student may also test the GalaxyGenius package (Zhou et al., 2025), which creates synthetic observations adapted to specific telescopes and complements SKIRT by adding instrumental effects.

This project is part of the UNIVERSITWINS project, funded by the University of Lille Initiative of Excellence. UNIVERSITWINS aims at bias-controlled interpretations of astronomical observations by building digital twins and leveraging AI to investigate mismatches between theory and data.

Objectives
- Learn to run SKIRT on CLONES simulations.
- Generate realistic images and spectra of simulated galaxies.
- Compare these results with real telescope observations of nearby galaxies.

Missions
- Discover how to use a radiative transfer code (SKIRT) and create synthetic galaxy images including realistic effects (dust, telescope resolution, etc.).
- Compare the synthetic data obtained with different physics with actual observations.
- Study how galaxy properties (luminosity, color, mass, etc.) appear in simulated vs. real data.
- Test GalaxyGenius as a complementary tool.

Required Skills
- Basic programming skills (Python preferred).
- Interest in astrophysics (galaxies, simulations, or observational astronomy).

References

Baes, M. & Camps, P. 2015, Astronomy and Computing, 12, 33
Sorce, J. G., Dubois, Y., Blaizot, J., et al. 2021, MNRAS, 504, 2998
Zhou, X., Yang, H., Li, N., et al. 2025, A&A, 700, A120