Star clusters:
a looking glass into galaxy evolution

SUMMARY.

Prepare to unlock the secrets of galaxies! In this exciting METEOR, we will embark on a thrilling path that will lead us to young and fiery star clusters as well as their ancient predecessors that formed just a few hundreds million years after the Big Bang. Along this journey we will delve deep into the heart of stars clusters, from stellar populations to gas and dust. But we will not stop there! Armed with some of the most advanced spectro-photometric models and harnessing the exquisite power of Bayesian statistics, we will explore these fascinating celestial objects and move closer to understanding what they really tell us about the formation and evolution of galaxies across the universe.

OBJECTIVES

Over this METEOR, our grand objective is to learn what extragalactic star clusters teach us about the formation and evolution of galaxies. Combining lectures and practical work, by the end of the course we will be able to assemble photometric spectral energy distributions for clusters observed with HST and JWST, apply modern modeling (and optionally Machine Learning) techniques to derive ages, masses and dust extinctions, and critically assess the robustness of these measurements. A particular emphasis is placed on understanding and quantifying modeling uncertainties so that cluster demographics can be compared across different galactic environments within nearby galaxies.

PREREQUISITES

None! Come as you are!

THEORY

by Janice Lee

Cluster-focused lectures: formation and early evolution of star clusters in galactic contexts; cluster initial mass function; environmental dependence of cluster formation efficiency; disruption processes and survivability; observational identification and classification of extragalactic clusters.

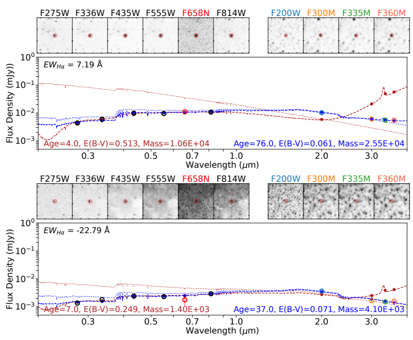
by Médéric Boquien

Modeling lectures: model ingredients (stellar population synthesis, nebular emission, extinction laws); fitting methods (χ^2, Bayesian inference); model degeneracies and how to mitigate them; interpreting posterior distributions and reporting uncertainties.

APPLICATIONS

by Médéric Boquien & Janice Lee

During this course, we will construct comprehensive panchromatic models and apply them to cutting-edge star clusters observations taken from the largest census to-date by the outstanding PHANGS HST and JWST Treasury surveys. Through the lens of Bayesian statistics, we will quantify the star clusters' physical properties. Subsequently, we will rigorously compare our findings with those of published studies, conducting a meticulous analysis to discern insights into the physical processes governing star cluster evolution and their consequence on galaxy formation and evolution.



Here we see a panchromatic star cluster model in action. It includes stars, ionized gas, and dust and is fitted to the multi-wavelength emission observed with both HST and JWST. Such models that we will build over the course of this METEOR will allow us to measure some of the fundamental physical properties of star clusters, such as their age and their stellar mass, which are essential for constraining galaxy evolution models. Figure adapted from Henny et al. (2025).

MAIN PROGRESSION STEPS

The first two weeks of the course will be dedicated to providing a comprehensive theoretical overview of panchromatic galaxy modeling, coupled with an introduction to the range of projects available, which will be selected by the end of the second week. The following weeks will be focused on the project implementation and presentations of complementary topics around galaxy cluster modeling. The course will culminate on the preparation of the oral presentations during the final week.

EVALUATION

The first component of the evaluation will comprise five short oral presentations that will complement theoretical lectures, revolving around the main physical components of galaxies and Bayesian techniques (30%). The second part of the evaluation will be based on the written document that will dig into one of the topics seen during the class (30%). Final oral presentation (40%).

BIBLIOGRAPHY & RESOURCES

- Boquien et al. (2019)
- Lee et al. (2022)
- Lee et al. (2023)
- Henny et al. (2025)

CONTACT

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