Modeling Globular Clusters in the era of large Space Telescope surveys

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Globular Clusters (GCs) are common and old stellar systems whose nature and origin remains unknown. Thanks to the rapid advancements of space programs, including the Euclid mission and the JWST telescope, an unprecedented amount of GCs observations is progressively becoming available. However, the state-of-the-art modeling techniques rely on GPU-expensive N-body simulations [1], making a detailed comparison between the large number of observations and models overall unfeasible.

To extract GCs properties and unveil their formation mechanism, a leap forward from the modeling side is required. This thesis aims to capitalize on recent progress in deep-learning techniques to develop an algorithm applicable to a variety of new datasets, based on the-proof-of-concept algorithm *π-DOC* [2]. The key aspects of the project include: (i) implementing a forward modeling approach to translate the existing N-body simulations into mock observations, automatically accounting for observational biases; (ii) developing and training the algorithm on these simulations to allow the extraction of GC properties (e.g., age, distance, dynamical mass, stellar mass function); (iii) applying the algorithm to the new data sets.

This project will deliver important milestones for the understanding of GCs in the universe, while significantly contributing to the establishment of innovative methodological advancements for theoretical modeling.

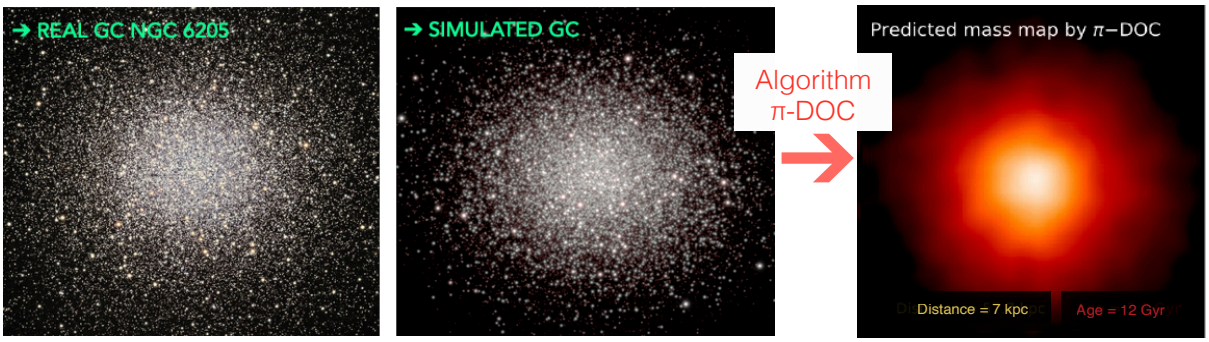

Figure 1: Real GC (NGC 6205, credit: NASA) vs. a simulated GC with 250,000 stars evolved for 13 Gyr using the supercomputer Jean Zay (GENCI), for a total of ~8,000 GPU hours. Thousands of artificial images can be extracted from one such simulation. Right plot: example of properties predicted by the algorithm π-DOC

[1] Wang et al. 2016, *"The DRAGON simulations: globular cluster evolution with a million stars"*
Monthly Notices of the Royal Astronomical Society, 458, 1450-1465

[2] Chardin & Bianchini, 2021, *"Predicting Images for the Dynamics Of stellar Clusters (π-DOC): a deep learning framework to predict mass, distance and age of globular clusters"*
Monthly Notices of the Royal Astronomical Society, 504, 5656