ALMA MATER STUDIORUM
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Department of Physics and Astronomy - DIFA

GENESIS

Title of the Project: *GENESIS:* Characterizing the primordial structures in the heart of the Galaxy with JWST

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Scientific Case: The problem of galaxy bulge formation is still largely debated in the literature. Among the most credited models, the "merging picture" proposes that galaxy bulges form from the merging of primordial sub-structures, either galaxies embedded in a dark matter halo, or massive clumps generated by early disk fragmentation. Although the vast majority of these primordial structures should dissolve to form the bulge, it is possible that a few of them survived the total disruption and are still present in the inner regions of the host galaxy, roughly appearing as massive globular clusters (GCs). At odds with genuine GCs, however, these fossil relics should have been massive enough to retain the iron-enriched ejecta of supernova (SN) explosions, and possibly experienced multiple bursts of star formation. As a consequence, they are expected to host multi-iron and multi-age sub-populations. Two of these remnants, disguised as genuine GCs, have been recently discovered in the bulge of the Milky Way: Terzan5 (Ferraro et al., 2009, Nature,462, 483) and Liller1 (Ferraro et al., 2021, Nat. Astr., 5, 311). These systems (1) are indistinguishable from genuine GCs in their appearance, (2) have metallicity distributions and abundance patterns incompatible with those of GCs and well in agreement with those observed in the bulge field stars, (3) host a dominant old stellar population (testifying that they formed at an early epoch of the Galaxy assembly), (4) host at least one young stellar population, several Gyrs younger than the old one (demonstrating their capacity of triggering multiple events of star formation).

The available photometric and spectroscopic information and the shape of the preliminary star formation histories reconstructed so far suggest that multiple bursts did occur both in Terzan5 and in Liller1. However, the exact number of these events and the accurate cosmic epochs of their occurrence are still unknown, and our understanding of these fascinating stellar systems came to a standstill. Indeed, the results obtained so far, with the pre-JWST front-line instrumentation, leave a number of questions unanswered. For instance: How many multi-age components are present in these systems? How long did the first formation episode last? How old are the most metal-poor components?

Outline of the Project: In this framework, we are using the exceptional angular resolution and NIR capabilities of JWST, to finally obtain the answers to these questions through an unprecedented exploration of the main-sequence turn-off (MS-TO) region of these puzzling systems. Indeed, the presence of stellar populations with different ages is univocally witnessed by the detection of distinct MS-TOs, and the JWST precisely provides the instrumental characteristics required in such high-crowding and high-extinction conditions.
The PhD student will analyse and interpret the ultra-deep observations of Terzan5 that we have secured with the JWST, and analogous observations of Liller1 that will be soon available in the JWST Archive. The JWST data will allow us to finally pinpoint any stellar sub-population hidden in Terzan5 and Liller1, determining their total number and their formation ages. This will have a crucial impact on several Astrophysical areas, ranging from unveiling unknown interactions occurred into the Galactic bulge, to clarifying the formation processes of galaxy bulges, up to obtaining a definitive characterization of the photometric and spectroscopic calibrators of the theoretical SEDs needed to interpret the integrated spectra of massive galaxies through cosmic time.

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