GENESIS: Searching for the primordial structures of the Universe in the heart of the Galaxy – Models

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Scientific Case: High-redshift observations suggest that galaxy bulges may form through multiple mergers of massive clumps of gas and stars, and subsequently experience accretion events. Thus, a variety of relics tracing different phenomena are expected to populate galaxy bulges: the remnants of the primordial massive clumps that contributed to the bulge formation, in-situ formed and externally accreted globular clusters (GCs), and also nuclear star clusters of cannibalized galaxies. The signatures of different origins are imprinted in the photometric, chemical, and kinematic properties of these stellar systems. Being the only spheroid where individual stars can be observed, the Galactic bulge provides a unique opportunity for the exploration of the debris of those primordial and accreted structures, but no direct evidence has been found for decades because of the prohibitive observing conditions in this region of the Galaxy. Recent results, however, indicate that we likely reached a turning point: the discovery that two bulge stellar systems classified as GCs (Terzan5 and Liller1) host, instead, multi-age and multi-iron sub-populations strongly suggests that they could be the first exemplars of a variegated population of relics disguised under the false appearance of genuine GCs (Ferraro et al., 2009, Nature, 462, 483; Ferraro et al, 2021, Nat. Astr., 5, 311). Thanks to an exceptional series of on-going observing programs with the top-level astronomical instrumentation, combined with tailored chemo-dynamical models and simulations, GENESIS proposes to perform a full "genetic screening" of the massive GCs in the MW bulge to unveil their true nature and origin, thus finally revealing unknown chapters of the Milky Way story.

Outline of the Project: This PhD thesis is aimed at constructing realistic physical models able to reproduce the observational results, and therefore unveil crucial pieces of the past history of the most intriguing systems and their possible role in the formation and evolution of the Milky Way bulge.

In particular, two options are possible according to the candidate attitude and skills:

CHEMICAL EVOLUTIONARY MODELS. The student will use state-of-the-art chemical evolutionary models (see Romano et. al., 2023, ApJ, 951, 85) to reproduce the abundance patterns observed in Liller1, with the goal to constrain its progenitor minimum mass, mass stripping history, and the specific enrichment process through type-II and type-Ia supernovae (SNe). From the resulting number of black holes and neutron stars, this will also open the possibility to estimate of the contribution of the Milky Way bulge to gravitational wave emission.

HYDRODYNAMICAL SIMULATIONS. 3D hydrodynamical simulations (with RAMSES; Teyssier+02, A&A, 385, 337) including realistic treatments of star formation, pre-SN and SN feedback, and cooling will be run to reproduce the complex star formation history observed in Terzan5 and Liller1, thus characterizing the epoch and the intensity of each star formation burst. In turn, this could unveil and date past interaction events between these systems and some bulge sub-structure (e.g., the bar), which would bring new clues on the Milky Way evolutionary history.

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