Ministero dell'Università e della Ricerca

FIS

ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

GENESIS: Searching for the primordial structures of the Universe in the heart of the Galaxy - Kinematics

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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 Thesis project is aimed at determining the global and internal kinematics of the investigated stellar systems.
Internal kinematics: Internal kinematic peculiarities (as differences in the velocity dispersion, rotation, anisotropy profiles among different sub-populations) may help constraining the origin and evolutionary history of each system. Determining the internal kinematics of likely remnants of the bulge formation process is particularly relevant because preliminary results in Terzan5 suggest the possible presence of a parsec-scale dark matter halo.
Global kinematics: The reconstruction of the orbit is key to assess the in-situ or accreted origin of stellar systems. The distribution of star clusters in diagrams involving integrals of motion (as the total orbital energy versus angular momentum) can be used to associate each system to its own galaxy progenitor and even estimate the accretion epoch.
In this framework the PhD student will be involved in:
(1) measuring the radial velocity of individual resolved stars from the analysis of Integral Field Units data-cubes, and using them to construct the velocity dispersion and rotation profiles of the system (see, e.g., Leanza et al., 2023, ApJ, 944, 162);
(2) constructing the projected density profile (from resolved star counts in proper motion-selected and differential reddening-corrected color-magnitude diagrams) to determine the structural parameters of each system (e.g., Ferraro et al, 2021, Nat. Astr., 5, 311);
(4) reconstructing the orbit and determining the integrals of motion of each target, to assess the kinematic association to the Bulge (e.g., Massari et al. 2019, A&A, 630, L4);
(5) combining absolute proper motions and radial velocities to obtain the 3D kinematics of each sub-population, thus revealing possible signatures of rotation, anisotropies, or other anomalies ascribable to different formation processes.

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