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 - Chemistry

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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: The atmospheres of stars keep memory of the chemical composition of the interstellar medium (ISM) from which they formed. In turn, if more than one burst of star formation occurs, the chemical abundance of the ISM is expected to vary in time because of the ejecta of each stellar generation. Thus, stars formed at different epochs in environments with different star formation rates (SFRs) have different chemical compositions, and by analysing the chemistry of each stellar population one can univocally trace the enrichment process of the ISM. Different abundance patterns are expected depending on the stellar polluters, the enrichment timescale and the SFR, with a few of them being so distinctive that they can be used as DNA tests of the stellar population origin. For instance, the [α/Fe]−[Fe/H] pattern traces the SNII and SNIa enrichment, with a characteristic knee occurring at increasing values of [Fe/H] for increasing SFR: [Fe/H] ~ −1.5, −1.0, −0.5 is measured in dwarf galaxies, the MW halo/disk, and the MW bulge, respectively. Hence, homogeneous iron abundances and the typical O-Na anticorrelation would testify a genuine GC, while significant iron spread and [α/Fe]−[Fe/H] pattern like that of the bulge (or a dwarf galaxy) would suggest a remnant of the bulge formation process (or the nuclear star cluster of an accreted structure). Additional DNA tests based on iron-peak elements (as Vanadium and Zinc) can further be used to distinguish in-situ formed from externally accreted GCs (Minelli et al., 2021,ApJ,918,L32; Mucciarelli et al., 2021, Nature Astr.,5, 1247).

In this context, the PhD student will:
(1) perform accurate analysis of high-resolution spectra acquired (with CRIRES@VLT) for large samples of giant stars in the target bulge GCs;
(2) measure the chemical abundances of key elements from the analysis of atomic lines and molecular bands in the spectra of each observed star,
(3) perform a detailed comparison of the [α/Fe]–[Fe/H] pattern and other key indices (such as [V/Fe] and [Zn/Fe]) with those observed in different environments of the Local Universe (MW bulge, halo, disk, and dwarf galaxies) to univocally identify how the investigated stellar system formed.

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