Star Clusters as Chronometers for Galaxy Evolution.

MSE White Paper

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According to most textbooks, star clusters fall into one of two categories: open clusters, which are sparse and short-lived; and globular clusters, which are dense and very old. For the longest time there was no apparent bridge across this gap in observations. We now know this to be due to the obscuring dust in the Milky Way, a selection bias that only allows lines of sight toward nearby open clusters, and halo globulars.

One HST took the first high-resolution step outside the Milky Way, Holtzmann et al (1992, AJ, 103, 691) found dense, blue clusters in abundance. The studies that followed had by the end of the last century established a continuous distributions of age and mass for extragalactic star clusters. This finding holds for all types of star-forming environments, including all regions of spiral and irregular galaxies, tidal tails, and remnant HI debris in galaxy exteriors; and it is now materialising in the Milky Way as well.

The ubiquity of star clusters makes them a very handy astrophysical tool: since their age can be measured to a few Myr, and a non-zero fraction of all clusters that are born survive to old age, they can be used as tokens of star formation at any given time in the past. Given an understanding of the processes that disrupt clusters (on which there is too long a literature to quote here, led by the research groups and disciples of Lamers et al. and Fall et al.), they can establish the star formation history of any nearby galaxy, well beyond the few Mpc threshold where individual stars can be used to that extent.

The main limitation of photometric studies is a slew of persistent colour degeneracies. In the optical, dust extinction is degenerate with metallicity; in the near-infrared the stochastic (and mass-dependent) appearance of molecular bands prohibits the simple estimation of ages; and in all regimes the fullness of the sampling of the initial mass function of stars that make up these clusters is dependent on the cluster mass (Silva-Villa & Larsen 2010, A&A, 516, 10; Popescu & Hanson 2010, ApJ, 724, 296; Fouesneau & Lançon 2010, A&A, 521, 22). This allows low-mass clusters to masquerade as having higher masses, throwing measurements and interpretive models based on those cluster masses.

Optical spectroscopy is mostly exempt from such issues. As demonstrated through various techniques (e.g., Konstantopoulos et al., 2008, ApJ, 674, 846; Trancho et al. 2007, ApJ, 658, 993), fitting the upper Balmer series (accounting for in-filling) can deliver reliable ages for star clusters, while a variety of lines can be used to establish metal content. Spectra far outperform photometry on that front, but spectroscopic studies have so far been limited to either a handful of nearby galaxies (M82; Konstantopoulos et al, 2009, ApJ, 701, 1015) or the brightest clusters observable (log M/Msun > 6; e.g., Trancho et al., 2012, 748, 102).

MSE promises to reach a few magnitudes fainter than existing facilities (e.g., Gemini-GMOS) and therefore unlock the stellar populations of all galaxies in a large volume around us (at least 20 Mpc, depending on final specification). This would provide a tremendous boost to near-field cosmology, which is currently limited to a very small number of galaxies, most of them dwarfs.