

A new look at CLASH: Extended Star formation from sub-Solar metallicity gas in the central giant elliptical galaxy of MACSJ 0329.6-0211

The Cluster Lensing and Supernova survey with Hubble (CLASH) program imaged 25 massive clusters in 16 broadband filters spanning the near-UV to near-IR. This program provides an unprecedented opportunity to investigate how precisely we can infer stellar properties - ages and metallicities - by fitting theoretical spectra from stellar population syntheses to spatially-resolved spectral energy distributions (SEDs) spanning a very broad wavelength range. Here, we apply this method to study recent star formation in the central giant elliptical galaxies of CLASH clusters that exhibit spatially extended UV emission. Those that reside in dynamically relaxed clusters where the temperature of the intracluster X-ray gas decreases towards the cluster center preferential exhibit luminous optical line-emitting gas and star formation, implicating cooling of the intracluster gas for the recent star formation. If so, then the star formation in these galaxies should be extended not just over space but also over time, and have a metallicity resembling that of the intracluster gas.

To extract the SEDs of the young stellar population, we first fitted 2-dimensional models to the light distribution of the old stellar population. Continuum light from the old stellar population is most dominant at near-IR wavelengths; at the same time, however, light from the younger stellar population (which need not necessarily be detectable at near-UV wavelengths, and sometimes difficult to discern at optical wavelengths owing to brighter light from the old stellar population) and dust seen in silhouette is least discernible at these wavelengths. In this step, we therefore took great care to mask out the younger stellar population and silhouette dust as seen in colour images, as well as cluster members (or other galaxies) along the line of sight. To determine how well we subtracted the old stellar population, we carefully inspected the subtracted images to see how well they matched the features seen in the colour images, as well as how well the model parameters for the 2-dimensional light distribution of the old stellar population matched across different wavelengths. As a final check, we inspected the continuity of the SED of the younger stellar population in each spatially-resolved region. Note that by not relying on SEDs to model the old stellar population, we overcome the degeneracy of modeling the SEDs of both the younger and older stellar populations simultaneously as performed in previous studies.

We then examined the spatially-resolved SEDs using different tools: (i) color-color diagrams; (ii) color-magnitude diagrams; (iii) chi-square minimization fit; and (iv) Monte-Carlo Markov Chain (MCMC) inference. Here, we present the detailed results for the central giant elliptical galaxy in the CLASH cluster MACSJ 0329.6-0211. We find the younger stellar population in this galaxy to have ages spanning the range from <10 Myr to ~ 100 Myr, and a clearly sub-solar metallicity; these are features expected for stars forming from cooled intracluster gas. Our work provides a benchmark for what can be learnt about star formation in elliptical galaxies - comprising the relatively simple case of a younger stellar population projected against an old stellar population - from high quality broadband images spanning a wide wavelength range. Our work also highlights the need for stellar population synthesis models having finer metallicity steps, a deficiency that currently constrains our ability to more precisely determine the metallicity of the younger stellar population.