High-z Clusters and ProtoClusters in the (pre)Euclid era

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High-redshift ($z \gtrsim 1.5$) clusters and proto-clusters offer a unique chance to observe how transformational processes, such as mergers and violent relaxation affect the evolution of the thermo- and chemo-dynamical properties of their intracluster medium (ICM), and of the galaxy population within these extreme environments. This $z \gtrsim 1.5$ epoch is a crucial one: it corresponds to when the progenitors of brightest cluster galaxies (BCGs) are expected to assemble through violent mergers between actively star-forming galaxies, while moving through a rapidly evolving potential within a pressurizing proto-ICM hot atmosphere. This is also the quasar era, during which accretion onto super-massive black holes in the forming BCGs reaches the peak of activity and the properties of the ICM are set.

While multiwavelength observations have enabled extensive investigation and characterization of the cluster population up to $z \sim 1.5$ (Allen et al. 2011; Kravtsov and Borgani 2012), the exploration of higher redshift systems remains limited and their results are much more ambiguous (e.g., Gobat et al. 2011a; Strazzullo et al. 2019; Andreon et al. 2008; Mantz et al. 2020; Brodwin et al. 2013; Miley et al. 2009). Indeed, for cluster environments at $z \gtrsim 1.5$ currently available data are unable to properly characterize their nature and how representative they are of the underlying general population. Different cluster search approaches have different − and in most cases very uncertain − selection functions, and the resulting population of known systems in this redshift range is a poorly constrained mix of already established, quasi-virialised clusters and forming protoclusters.

Nevertheless, characterizing this population is a key step towards extending our understanding of cluster physics and evolution into the epoch of early cluster formation, and across the crucial $1.5 \lesssim z \lesssim 2.5$ transition time bridging highly star-forming $z > 2$ protoclusters and largely quiescent $z < 1$ clusters (Alberts et al., 2016; Overzier, 2016; Miley and De Breuck, 2008).

The observational landscape of (proto-)cluster environments in this critical redshift range will drastically change in the next few years, with the advent of ongoing and upcoming multi-wavelength surveys. In particular, Euclid (Laureijs et al., 2011) will provide hundreds of clusters/protoclusters at this redshift and therefore it is crucial to be prepared for this massive flow of incoming data.
This project, will exploit state-of-the-art multiwavelength surveys from the deep NIR (GCAV - PI Nonino, VEILS, VIDEO), IR (WISE), optical (DES), and radio (EMU, SUMSS, NVSS, FIRST), to identify and characterize the high-redshift clusters and protoclusters.

The candidate is expected to produce the working photometric catalogues from the images in the different fields, which might also include WISE or Spitzer data.

From those catalogues, high redshift structures will be selected using photometric redshifts, spatial analysis, and other multiwavelength data. Physical quantities for the galaxies defining the high redshift structures candidates will be estimated in order to be
compared with simulations.
This analysis will provide a benchmark study for the upcoming Euclid survey.