Galaxy Clusters

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Ultra-diffuse galaxies (UDGs) are intriguing in the sense that they are much larger than dwarf galaxies but have much lower surface brightness than normal galaxies. To date, UDGs have been found only in the local universe. Taking advantage of deep and high-resolution HST images, we search for UDGs in massive galaxy clusters in the distant universe. In this work, we present our search results of UDGs in three massive clusters of the Hubble Frontier Fields: Abell 2744 (z=0.308), Abell S1063 (z=0.348), and Abell 370 (z=0.375). These clusters are the most distant and massive among the host systems of known UDGs. The color-magnitude diagrams of these clusters show that UDGs are mainly located in the faint end of the red sequence. This means that most UDGs in these clusters consist of old stars. Interestingly, we found a few blue UDGs, which implies that they had recent star formation. The radial number densities of UDGs clearly decrease in the central region of the clusters in contrast to those of bright galaxies which keep rising. This implies that a large fraction of UDGs in the central region were tidally disrupted. These features are consistent with those of UDGs in nearby galaxy clusters. We estimate the total number of UDGs (N(UDG)) in each cluster. The abundance of UDGs shows a tight relation with the virial masses (M_200) of thier host systems: M_200 \propto N(UDG)^(1.01+/-0.05). This slope is found to be very close to one, indicating that efficiency of UDGs does not significantly depend on the host environments. Furthermore, estimation of dynamical masses of UDGs indicates that most UDGs have dwarf-like masses (M_200 < 10^11 M_Sun), but a few UDGs have L*-like masses (M_200 > 10^11 M_Sun). In summary, UDGs in distant massive clusters are found to be similar to those in the local universe.

[구 GC-18] The first detection of intracluster light beyond a redshift of 1

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Not all stars in the Universe are gravitationally bounded to galaxies. Since first discovered in 1951, observations have revealed that a significant fraction of stars fills the space between galaxies in local (low-redshift) galaxy clusters, observed as diffuse intracluster light (ICL).

Theoretical models provide mechanisms for the production of intracluster stars as tidally stripped material or debris generated through numerous galaxy interactions during the hierarchical growth of the galaxy cluster. These mechanisms predict that most intracluster stars in local galaxy clusters are long-accumulated material since z~1.

However, there is no observational evidence to verify this prediction. Here we report observations of abundant ICL for a massive (above 10^{14} solar masses) galaxy cluster at a redshift of z=1.24, when the Universe was 5 billion years old.

We found that more than 10 per cent of the total light of the cluster is contributed by the diffuse ICL out to 110 kpc from the center of the cluster, comparable to 5–20 per cent in local, massive galaxy cluster. Furthermore, we found that the colour of the brightest cluster galaxy located in the core of the cluster is consistent with that of the ICL out to 200 kpc.

Our results demonstrate that the majority of the intracluster stars present in the local Universe, contrary to most previous theoretical and observational studies, were built up during a short period and early (z>1) in the history of the Virgo-like massive galaxy cluster formation, and might be concurrent with the formation of the brightest cluster galaxy.

[구 GC-19] Newly discovered galaxy overdensities and large scale structures at z~1

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Galaxy clusters are the largest gravitationally bound structures in the universe and located in the densest peak of the dark matter. They can constraint cosmologicals model from their dark matter halo distribution and they are good laboratories to study how galaxy evolution varies with their environment. Especially, studies of galaxy clusters at $z \gtrsim 1$ are important because (i) galaxy evolution at z >1 is still controversial (Elbaz et al. 2007; Faloon et al. 2013) and (ii) some studies show that mass of galaxy clusters at z>1 seems to be higher than expected value from the concordance LCDM cosmological model (Kang & Im 2009; Gonzales et al. 2012). In spite of their significance, there have not been many studies of galaxy clusters at $z \gtrsim 1$ because of the lack of

wide and deep multi-wavelength data. We newly found galaxy cluster candidates at 0.2 < z < 1.4 and a LSS spanning over 100Mpc at z~0.9 in the ELAIS-N1 field which is one of the IMS (Infrared Medium-deep Survey; Im et al. 2019, in preparation) fields. Thanks to K-GMT science program, we performed spectroscopic follow-up observation for a z~1 galaxy cluster candidates with GMOS of Gemini North and for z~0.9 supercluster candidates with Hectospec of MMT in 2018A and confirmed the large scale structures. We present the newly discovered galaxy overdensities from the observation and the analysis result.

[구 GC-20] Unveiling Quenching History of Cluster Galaxies Using Phase-space Analysis

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We utilize times since infall of cluster galaxies obtained from Yonsei Zoom-in Cluster Simulation (YZiCS), the cosmological hydrodynamic N-body simulations, and star formation rates from the SDSS data release 10 to study how quickly late-type galaxies are quenched in the cluster environments. In particular, we confirm that the distributions of both simulated and observed galaxies in phase-space diagrams are comparable and that each location of phase-space can provide the information of times since infall and star formation rates of cluster galaxies. Then, by limiting the location of phase-space of simulated and observed galaxies, we associate their star formation rates at z ~ 0.08 with times since infall using an abundance matching technique that employs the 10 quantiles of each probability distribution.

Using a flexible quenching model covering different quenching scenarios, we find the star formation history of satellite galaxies that best reproduces the obtained relationship between time since infall and star formation rate at z ~ 0.08. Based on the derived star formation history, we constrain the quenching timescale (2 - 7 Gyr) with a clear stellar mass trend and confirm that the refined model is consistent with the "delayed-then-rapid" quenching scenario: the constant delayed phase as ~ 2.3 Gyr and the quenching efficiencies (i.e., e-folding timescale) outside and inside clusters as ~ 2 - 4 Gyr ($\propto M_*^{-1}$) and 0.5 - 1.5 Gyr ($\propto M_*^{-2}$), Finally, we suggest: (i) ram-pressure is the main driver of quenching of satellite galaxies for the local Universe, (ii) the quenching trend on stellar mass at z > 0.5 indicates other quenching mechanisms as the main driver.

[구 GC-21] Cosmological QUOKKAS: A new method for measuring distances using an extended KVN to Australia

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Measuring distances at cosmological scales is one of the most important, yet most difficult to acquire astronomical quantities, allowing astronomers to determine the expansion rate of the universe. Typically, astronomers have sought to find ``standard candles'' that have a known intrinsic brightness in order to determine their distance. The most well known standard candles are Type 1a supernova and Cepheid variable stars making the so-called ``distance ladder''. Here we present a method for determining cosmological distances via light travel-time arguments, which can be extended from nearby sources to very high redshift sources.

[박 GC-22] On the Global and Local Environmental Dependence of Type Ia Supernova Luminosity from the Analysis of SALT2 and MLCS2k2 Light-Curve Fitters

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There is growing evidence for the dependence of Type Ia supernova (SN Ia) luminosities on the environments. The origin of this correlation, however, is under debate. In order to explore the physical origin of the trend in detail, we analyze SN Ia light-curves by combining a sample of 1231 SNe Ia over a wide redshift range (0.01 < z < 1.37) in various SN surveys and employing two independent light-curve fitters of SALT2 and MLCS2k2. Although SALT2 is the most widely used fitter in the SN community, MLCS2k2 has a novelty in the context of an investigation of the luminosity evolution of SNe Ia. For this reason we use both fitters and analyze them separately. We also determine a stellar mass and a star formation rate (SFR) for a sample of ~600 host galaxies. In addition, because recent low-redshift studies suggest that this dependence manifests itself most strongly when using the local SFR at the SN