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 ≳ 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 ≳ 1 because of the lack of