The environmental dependence of galaxy properties at $z>1.5$

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A spectroscopically confirmed X-ray galaxy cluster at $z=1.62$


This is a patch of the Subaru/XMM-Newton Deep Field. The contours show X-ray emission and the arrows indicate photo-z selected galaxies at $z=1.6$. There are two concentrations of galaxies in the field, both of which are detected in X-rays. We carried out near-IR spectroscopic follow-up observations with MOIRCS on Subaru and measured redshifts of the galaxies with the circles in the figure. Redshifts with '?' are possible redshifts. The triangles show low-mass blue galaxies observed by Papovich et al. 2010. XCLJ0218-0510 hosts more than 10 galaxies at $z=1.6$ and it is now the most distant X-ray cluster published so far. The other system, XCLJ0218-0512, still needs to be confirmed with more redshifts.

The left plot shows color-magnitude diagrams of galaxies at $z_{\text{phot}}=1.6$. The dotted lines show the model red sequence formed at $z=2, 3, 4, \text{and } 5$. In the right panel, we applied statistical field subtraction without photo-z. A clump of red massive galaxies can still be seen. The right plot is a spectrum of the most massive member galaxy, which has no emission lines. Massive galaxies in clusters are already dead at $z=1.6$. When did they die? When was the environmental dependence of galaxy properties shaped? To address these questions, we take a look at a cluster at $z=2.15$ in the right half of this poster.

The left plot compares the spatial distribution of galaxies in PKS1138 and GOODS at $z_{\text{phot}}=2.15$. The photo-z selected galaxies are color-coded in the plot. We observe a factor of $\sim15$ over-density in PKS1138 compared to GOODS. The PKS1138 galaxies form the brightest tip of the red sequence as shown in the right plot, while there are few massive red galaxies in GOODS. The two plots clearly shows that PKS1138 is an over-density region at $z=2.15$.

We now compare galaxy populations. We focus on massive galaxies ($>10^{11} \text{ M}_\odot$, Salpeter IMF), for which we are complete. The plots compare age, star formation time scale (we assume the tau-model), SFR, and dust extinction. If you carefully look at these plots, you find (1) similar ages, (2) shorter star formation time scale, (3) lower SFRs, and (4) smaller $A_v$ in PKS1138 compared to GOODS. The environmental dependence of galaxy properties is already there as early as $z=2.15$.

Assuming the tau-model, we can derive the epoch when the galaxies form 80% of stars that they would have at $z=0$. The left plot shows that PKS1138 galaxies assembled typically at $z>3$, while GOODS galaxies form at $z<3$. There is 1Gyr difference in the formation epoch. The right plot is the summary plot of the work, which shows the median star formation histories of galaxies in the high and low density regions at $z=2.15$. For further discussions, take a look at the paper!