Physical properties distribution of galaxy population in Abell 2142 cluster

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Abstract. In this work, we investigate the physical properties of galaxies in Abell 2142 using photometric and spectroscopic data from the Sloan Digital Sky Survey (SDSS). The sample was selected by two criteria: redshift of $0.0781 \leq z \leq 0.1038$ and the location within a radius of 100 arcminutes from the cluster centre. We found that the sample distributes into 2 groups, a foreground filament galaxies with $z \leq 0.085$ and the cluster members with $z > 0.085$. The relation between apparent magnitude in $g$ filter band and $u-z$ colour suggests that we can use the $u-z$ equals 3.2 as a criterion to separate galaxies into blue ($u-z < 3.2$) and red ($u-z > 3.2$) sequence galaxies. Moreover, blue sequence galaxies have higher value of equivalent width of hydrogen alpha corresponding to higher star forming activity than red sequence galaxies. The nearby filament contains higher fraction of star forming galaxies (65\%) than the cluster Abell 2142 galaxy members (46\%). This could be due to difference of the environmental effect.

1. Introduction

In the work of structure evolution and formation in the Universe, galaxy clusters are the largest and massive objects in the universe. Galaxy clusters consist of many galaxies bound together by gravity. A Study on galaxy properties can provide some clues of the evolution of the Universe. The nature of galaxies is described by physical properties of galaxies. Star formation is an interesting property because it is correlated with the evolution of galaxy. The equivalent width of hydrogen alpha (hereafter EW(H\textalpha{})) was used as a probe to study star formation region [1]. Moreover, the other optical properties of galaxies that widely used to investigate the nature of galaxies are magnitude and colour. Colour - magnitude relation was discovered by Baum [2], revealing that the average colour of elliptical galaxies are redder than globular galaxies.

In this work, we aim to investigate the properties of galaxies within Abell 2142 cluster. Abell 2142 (RA = 15h 58m 20.00s, Dec = +27d 14m 0.30s [3]) is a nearby rich cluster, locates near the Corona Borealis supercluster. Recently Baiesi Pillastrini [4] presented a filamentary structure connecting between both superclusters. The interesting point is that galaxy members of the Abell 2142 evolved in a relatively dense environment with respect to galaxies in the filament region. If Abell 2142 has subclusters connecting to the filamentary structure, the physical properties such as magnitude, colour index and star formation activity of the subclusters members might be different from the members in the cluster central region.
This paper organized as follows: Section 2 presents the methodology. Section 3 describes results and discussion. Section 4 presents the conclusions. Throughout this research, a standard $\Lambda CDM$ cosmology is assumed with $H_0 = 67.8$ km s$^{-1}$ Mpc$^{-1}$, $\Omega_m = 0.308$, $\Omega_\Lambda = 0.692$ [5].

2. Methodology

Data for Abell 2142 were collected from the Sloan Digital Sky Survey (SDSS). Abell 2142 has the radial velocity dispersion, $\sigma$, 1280 km s$^{-1}$ and the heliocentric redshift is 0.0909 [6]. Our galaxy sample was selected within $3\sigma$, redshift $0.0781 \leq z \leq 0.1038$, to avoid effect of background and foreground galaxies and location within 100 arcminutes from the cluster centre.

Magnitudes of galaxies were measured in the SDSS $ugriz$ filter bands. The SDSS catalogue provide magnitude of galaxies which all magnitude were corrected for the effect of galactic extinction. We perform the K-correction on magnitude from database using “K-correction calculator” code [7, 8] to correct the effect of a cosmological redshift in different filter bands.

To obtain the value of EW(H$\alpha$), we adopt EW(H$\alpha$) value from the MPA - JHU catalogue. The MPA - JHU catalogue was produced by researchers at the Max Planck Institute for Astrophysics (MPA) and John Hopkins University (JHU) providing a spectrum measurement from SDSS data release 7. The catalogue is available at https://wwwmpa.mpa-garching.mpg.de/SDSS/DR7/.

This work, we investigate the redshift distribution of the sample, the relation between $ugriz$ magnitude, colour and the effect of star formation activity for our sample.

3. Results and discussion

![Figure 1](image.png)

Figure 1. The redshift distribution of galaxy sample in Abell 2142, within the range $0.0781 \leq z \leq 0.1038$.

In this work, we investigate the physical properties of 878 galaxies within $0.0781 \leq z \leq 0.1038$ and the location within a radius of 100 arcminutes from Abell 2142 cluster centre. The distribution of redshift is shown in figure 1. Histogram reveals that our sample are separated into 2 groups by the value of $z = 0.085$. The number of galaxies with $z \leq 0.085$ and $z > 0.085$ are 219 and 659 galaxies, respectively. Because of the sample has redshift distribution dividing into 2 groups, the nature of galaxies in each group might have different physical properties. Therefore, we divided our sample into 2 groups, which group I was defined as $0.0781 \leq z \leq 0.085$ for a subcluster connecting to the filament region and group II defined as $0.085 < z \leq 0.1038$ for the other members locate closer to the cluster centre. Moreover, we investigate a relation between magnitude in the SDSS filter band $g$ and colour. The relation between magnitude in the SDSS filter band $g$ and $u-z$ colour, as shown in figure 2 for galaxies with $0.0781 \leq z \leq 0.085$, and figure 3 for galaxies with $0.085 < z \leq 0.1038$, display a reasonable view to separate galaxies into red and blue subsamples. The figures illustrated that for galaxies with $u-z < 3.2$ has scatter trend than galaxies with $u-z > 3.2$. Therefore, we separate galaxies into blue ($u-z \leq 3.2$) and red ($u-z > 3.2$) sequence galaxies.
We also investigate position of blue and red galaxies into 2 groups separating with redshift equal 0.085 as shown in figure 4 for position of galaxies with $z \leq 0.085$ and figure 5 for $z > 0.085$. We found that there are 37 galaxies located within 5 arcminutes from the cluster centre: 6 galaxies in group I and 31 galaxies in group II. Consider the sample in the central region for group I, 4 of 6 galaxies (66.67%) are red sequence galaxies. While for group II, 29 of 31 galaxies (93.54%) are red galaxies. Consider the overall sample for galaxies with $z \leq 0.085$, the number of blue and red galaxies are roughly similar, with 43.84% for blue and 56.16% for red sequence galaxies. While galaxies with $z > 0.085$, the number of blue sequence galaxies is half the red sequence galaxies. The red sequence galaxies with $z > 0.085$ are grouped at the centre of cluster.

Moreover, we also investigate a relation between EW(Hα) and $u - z$ as shown in figures 6 and 7. This work uses EW(Hα) as a probe to present star formation rate of galaxies, we define galaxy with EW(Hα) greater than 5 angstroms is an active galaxy. Our results show that for galaxies with $z \leq 0.085$, 78.125% of blue sequence galaxies are active while only 8.94% of red sequence galaxies are active. For galaxies with $z > 0.085$, 82.56% of blue sequence galaxies are active while 6.12% of red sequence galaxies are active. It is clear that blue sequence galaxies have higher evidence of EW(Hα) than red sequence galaxies for both groups. Figures 6 and 7 also reveal galaxies members around the cluster centre ($z > 0.085$) are more passive galaxies than outskirt members ($z \leq 0.085$) in the subcluster connecting to the filament region.

**Figure 2.** The magnitude in filter $g$ plotted against $u - z$ for galaxies with $z \leq 0.085$.

**Figure 3.** The magnitude in filter $g$ plotted against $u - z$ for galaxies with $z > 0.085$.

**Figure 4.** Position of galaxies with $z \leq 0.085$, the blue point displays galaxies with $u - z \leq 3.2$, the black cross displays galaxies with $u - z > 3.2$. The red plus shows the cluster centre.

**Figure 5.** Position of galaxies with $z > 0.085$, the blue point displays galaxies with $u - z \leq 3.2$, the black cross displays galaxies with $u - z > 3.2$. The red plus shows the cluster centre.
4. Conclusions
In this work, we have studied the physical properties such as $\text{EW}(\text{H}$,$\lambda)$, magnitude and colour of galaxies within 100 arcminutes from centre and $0.0781 \leq z \leq 0.1038$. The distribution of redshift shows that our sample separates into 2 groups, i.e., outskirt members with $z \leq 0.085$, belong to a subcluster connecting to the filament region and the clusters main members with $z > 0.085$. From the distribution in colour-magnitude diagram, $u - z$ is a good criterion for separating galaxies into blue sequence with $u - z \leq 3.2$ and red sequence with $u - z > 3.2$. The value of $u - z$ also relates with star forming activity. Our results show that the galaxies with $u - z \leq 3.2$ have $\text{EW}(\text{H}$,$\lambda)$ higher than galaxies with $u - z > 3.2$ for both groups. It implies that blue sequence galaxies in our sample have more star forming activity than red sequence galaxies. Moreover, $\text{EW}(\text{H}$,$\lambda)$ of galaxies in group 1 ($z \leq 0.085$) are higher than the other group, meaning that galaxies in the subcluster connecting to the filament region are more active than galaxy members around the cluster centre ($z > 0.085$). However, our sample with $z \leq 0.085$ is only about one-third of the other group. In further work, more galaxy sample extended to redshift less than the value that used in this work ($z < 0.0781$) are required to cover more sample in filament region and confirm the results of this work with strong significance. Moreover, other physical parameters such as morphology, metallicity will provide interesting information about the nature of cluster.

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