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Investigating the properties of a galaxy group at z = 0.6

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Abstract. Galaxy groups offer an important perspective on how the large-scale structure of the Universe has formed and evolved, being great laboratories to study the impact of the environment on the evolution of galaxies. We aim to investigate the properties of a galaxy group that is gravitationally lensing HELMS18, a submillimeter galaxy at $z = 2.39$. We obtained multi-object spectroscopy data using Gemini-GMOS to investigate the stellar kinematics of the central galaxies, determine its members and obtain the mass, radius and the numerical density profile of this group. Our final goal is to build a complete description of this galaxy group. In this work we present an analysis of its two central galaxies: one is an active galaxy with $z = 0.59852 \pm 0.00007$, while the other is a passive galaxy with $z = 0.6027 \pm 0.0002$. Furthermore, the difference between the redshifts obtained using emission and absorption lines indicates an outflow of gas with velocity $v = (278.0 \pm 34.3)$km/s relative to the galaxy.

Keywords. galaxies: groups, galaxies: high-redshift, galaxies: general

1. Introduction

Characterizing the mass distribution of structures across the full mass range, from single galaxies to galaxy clusters, can be used to test and constrain the model of structure formation and evolution (Bartelmann *et al.* 2013). Galaxy groups bridge the gap between individual galaxies and galaxy clusters, so they offer a new window of investigation in the mass spectrum. So far, few studies have been done to measure the mass distribution of groups, despite being the most common structures in the Universe, hosting at least half of all galaxies in the local Universe. Furthermore, galaxy groups are great laboratories to study the influence of the environment in the galaxy evolution. The main goal of this project is to investigate the properties of a galaxy group that is gravitationally lensing HELMS18, a submillimeter galaxy at $z = 2.39$ from Herschel's HerMES Large Mode Survey (HELMS; Nayyeri *et al.* 2016). We aim to have a complete description of this galaxy group, including its members, mass, redshift, radius and the numerical density profile. Hence we hope to shed some light on how the mass distribution varies across the mass spectrum, from individual galaxies to galaxy clusters.

2. Data and Methods

Multi-object spectroscopy data were obtained for this galaxy group with Gemini-GMOS (Gemini Multi-Object Spectrographs) to investigate its properties. We used the R400-G5325 diffraction grating, whose resolution is R∼1000. The grating covers the rest-frame spectral interval from ∼3500−6000Å, allowing the observation of absorption features and emission lines. The size of the slit used was 1″. Two masks were made in

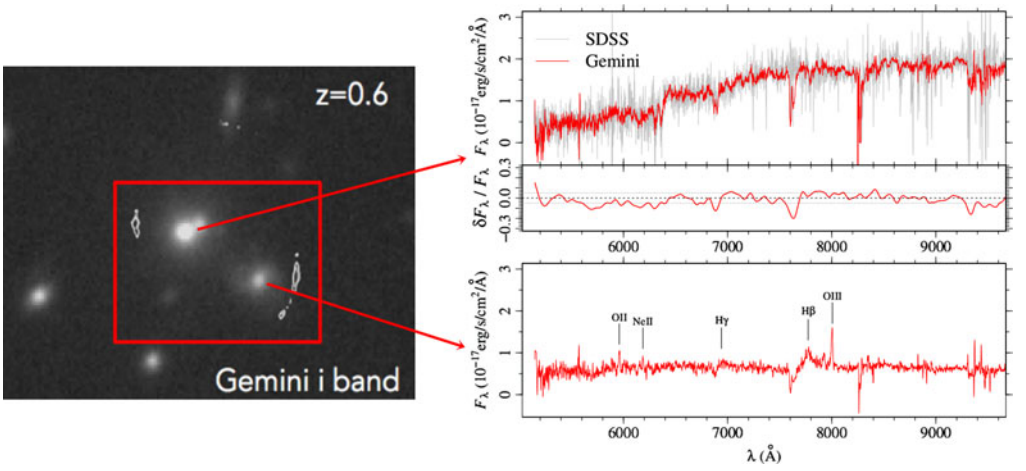

Figure 1. *Left:* Gemini *i*-band image, showing the innermost region of the group and its two central galaxies. The overlapping white contours correspond to the images of the HELMS18 submillimeter lensed galaxy, obtained with ALMA. *Right:* spectra of the two central galaxies. The upper panel shows the comparison between the SDSS and Gemini spectra of the passive galaxy. The bottom panel shows the spectrum of the active galaxy and the emission lines detected.

order to maximize the number of objects observed. Thus, we observed 55 galaxies. The total exposure time for the two masks was 8 hours.

The data reduction was done in IRAF (Image Reduction and Analysis Facility) following the standard Gemini data reduction pipeline, using the GMOS tasks. We present the results of the two central galaxies (a quasar and a passive galaxy), while data reduction is ongoing for the remaining galaxies. The redshifts were determined using the Radial Velocity Package developed at the Smithsonian Astrophysical Observatory (`RVSAO`), which is a package to measure radial velocities from spectra using the emission lines (EM) or the cross-correlation (XC) technique. The redshift of the quasar was determined using `EMSAO` and `XCSAO` tasks, while we used only `XCSAO` task for the passive galaxy. We used the spectra of 10 galaxy as templates for the cross-correlation procedure.

3. Results

We obtained the spectra of the two central galaxies, being one of them a quasar, as can be seen in the spectrum in the bottom right panel of Figure 1. We determined that the redshift of the quasar is $z = 0.59852 \pm 0.00007$. The redshift of the elliptical galaxy is $z = 0.60246 \pm 0.00004$, which is in accordance with the value of the Sloan Digital Sky Survey (SDSS), which is $z = 0.6027 \pm 0.0002$. The difference between the redshifts obtained using the emission lines ($z = 0.59852 \pm 0.00007$) and absorption lines ($z = 0.59945 \pm 0.00009$) indicates an outflow of gas with velocity 278.0 ± 34.3 km/s relative to the galaxy.

We intend to finalize the data reduction and measure the redshifts of remaining galaxies to identify the members of the group. Then, we plan to obtain a complete description of the properties of this galaxy group.

References

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