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ABSTRACT
Lyman-alpha emitters (LAEs) are low-mass, high specific star formation rate galaxies that are thought to be predominantly responsible for the reionisation of the Universe. In spite of their importance, it is extremely difficult to characterise in detail all but the brightest, most massive of these galaxies; this is unsatisfactory, since the faint LAE population is expected to contribute significantly to the reionisation. Here we present a study of a new sample of 20 strongly lensed Ly-α emitting galaxies at $z \sim 2.3$, where we take advantage of the lensing magnification (typically a factor of about 20) to characterise some of the physical properties of low star-formation rate LAEs for the first time.

Key words: gravitational lensing – galaxies: structure

1 INTRODUCTION

Lyman-alpha emitting galaxies (LAEs) represent a population of star-forming systems with very large Lyα equivalent widths and some of the highest specific star-formation rates (sSFR) in the Universe, and these low-mass galaxies are thought to be predominantly responsible for the reionisation of the Universe. However, it is extremely difficult to characterise these galaxies in detail because they are intrinsically very faint. Typical LAE galaxies have strong star-formation, high-ionisations, and are typically low metallicity; these properties, combined with a (mostly) low dust content, allow for the escape of a large fraction of Lyα photons. At redshift $2 < z < 3$, well-studied LAEs are typically at the bright end of this parameter space, being L∗ galaxies with M∗ ∼ 109 M$_\odot$ and typical SFRs of about 30 to 100 M$_\odot$/yr (e.g. Erb et al. 2016), and investigations of lower-SFR objects have generally been limited to quantifying the properties of strong optical lines (e.g. Trainor et al. 2015). For example, Hagen et al. (2016) have recently shown that low-SFR LAEs (M∗ as low as 107 M$_\odot$ and SFR ∼ 1 to 100 M$_\odot$/yr, consistent with local-Universe *green pea* LAEs, e.g., Henry et al. 2015) have optical strong line (H$_\alpha$ and [O iii]) properties consistent with optically-selected star-forming galaxies of the same masses at z ∼ 2, but they are unable to directly determine the properties of these galaxies that may affect the UV escape fraction, including the gas metallicity, density, and kinematics, without additional very large investments in telescope time. Strong gravitational lensing can be used to overcome this limitation, but the difficulty is that most strongly lensed galaxies at z ∼ 2 are not LAEs, and at present the properties of only three lensed LAEs have been investigated in detail (Christensen et al. 2012; Vanzella et al. 2016). Fortunately, new HST V -band observations of LAE galaxies selected from the BOSS survey have revealed a sample of strongly lensed systems at $\langle z \rangle \sim 2.5$. Our subsequent lens modelling shows that the typical lensing magnification of these objects is $\mu \sim 20$ and, after accounting for this magnification, these objects are compact galaxies with SFRs of ∼ 12 M$_\odot$/yr (i.e., a factor of 3 to 8 lower than previous detailed studies).

2 DATA

The dataset analised was released as part of the third Sloan Digital Sky Survey (SDSS-III) and consists of publicly available data. A sample of 21 lensed Lyman-alpha emitting galaxies were discovered between November 2015 and December 2016 during the BOSS survey. Their redshifts span from 2 to 3 while the lensing objects are massive galaxies, mostly elliptical galaxies, at redshift around 0.55. Optical data as the considered sample, can allow us to detect substructures with mass in the range $10^7 - 10^8 M_\odot$ given their resolution; lower mass substructures can be detected using interferometric data that can take advantage of a higher resolution. The nature of the lensed galaxies is carefully selected to increase our sensitivity to the presence of substructures. Lyman-alpha emitters (LAEs) consist of inhomogeneous distribution of star forming knots and are often composed by distinct (components) units merging into one object. Given their structure, they present an extremely lumpy and dis-

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continuous brightness profile which we can exploit to enhance the capability of identifying a substructure, as follows. Provided that the latter is located in the lens galaxy main halo and in correspondence of the Einstein ring, its presence would lead to a distortion in the brightness distribution of the lensed images. This local brightness perturbation will be more evident the more lumpy is the original unperturbed brightness profile in the same way changes in the positions of bricks in a wall are more easily identified if neighbouring bricks are differently coloured.

3 LENS MODELLING

The lens modelling of each system was performed using the Bayesian pixelated technique developed by Vegetti & Koopmans (2009) (see also Vegetti et al. 2014). The mass density distribution of the lens is parametrised with an elliptical power-law profile (plus external shear) with a total of eight free parameters. The surface brightness distribution of the lens is parametrised using elliptical Sersic profiles and it is simultaneously modelled with the lens mass distribution. The surface brightness distribution on the unlensed background source is instead reconstructed using an adaptive Delaunay tessellation.

4 RESULTS

5 DISCUSSION

REFERENCES

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Vegetti S., Koopmans L. V. E., Auger M. W., Treu T., Bolton A. S., 2014, MNRAS, 442, 2017

Table 1. Add caption here.

Name (SDSS)	z_{lens}	z_{src}	R_{ein}

Table 2. Add caption here. This table should contain the best parameters for the sersic models

Name (SDSS)	n_{Ser}