Spectroscopic follow-up of lensing groups in the CFHTLS Strong Lensing Legacy Survey

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Abstract We present preliminary results from the spectroscopic follow-up campaign of 7 strong-lensing galaxy groups identified in the CHFTLS Strong Lensing Legacy Survey (SL2S). Our goals are to study the dynamics of the groups and to link these results with reliable gravitational lens models to probe the inner slope of the density mass profiles of those groups. A statistical approach will give us new insights in the transition between galaxies and clusters of galaxies.

INTRODUCTION

Groups of galaxies are the most common structures in the Universe, containing at least 50% of all galaxies at the present day (Eke et al. 2004) and covering the mass range of 10^{13} - 10^{14} M_O. In spite of the fact that galaxy groups are abundant, they are observationally challenging to detect at z>0.5 because they have very few bright members. In order to understand and test galaxy formation and evolution models it is useful to relate galaxies to observable groups as a proxy for their parent dark matter halos. Gravitational lensing offers a different approach to study, for example, how the mass is distributed in galaxy groups and the role of the baryons in the dark matter profile. The first study joining strong lensing and weak lensing measurements for a sample of strong lensing systems in groups was published this year (Limousin et al. 2009).

GROUP SAMPLE

The Strong Lensing Legacy Survey (SL2S; Cabanac et al. 2007) is a survey designed to discover strong lenses of various mass regimes in the Canada France Hawaii Telescope Legacy Survey (CFHTLS). The long term goal of our project is to study a statistically significant sample of lens galaxy groups in order to characterize their mass distribution, dynamics as well as luminosity and color evolution of their galaxies. We present preliminary results of the spectroscopy follow-up of 7 lensing groups which were observed with VLT/FORS2 GRIS_600RI.

GROUP MEMBERSHIP

We follow the formalism of Wilman et al. (2005) to determine the cluster membership, using Ω_m=0.3, Ω_Λ=0.7, H_0=70 km s^{-1} Mpc^{-1}. The group is initially assumed to be located at the position of the lens galaxy, z_{lens}, with an initial observed-frame velocity dispersion, $\sigma(v)_{obs}$=500 (1+z_{lens}) km s^{-1}. We set an initial redshift shell δz_{max} = 2$\sigma(v)_{obs}$/c and specify a maximum angular radius based on this redshift shell of

$$\delta\theta_{max} = 206,265\ \{cz/[b(1+z_{lens})H(z)D\,(z)]\}$$

with b=3.5. Upon identifying potential members as those galaxies inside the redshift shell δz_{max} and the maximum radius $\delta\theta_{max}$, we compute the velocity dispersion $\sigma(v)_{obs}$ of these potential members by using the biweight estimator (Beers et al. 1990). The updated value for $\sigma(v)_{obs}$ is then used to determine a new δz_{max} and $\delta\theta_{max}$, and finally to identify the spectroscopically confirmed groups members (Fig. 1). We finally compute the rest-frame velocity dispersion by using the biweight estimator and applying the cosmological correction, and the intrinsic velocity dispersion by applying the standard correction for velocity erros (Danese et al. 1980). For those systems showing two close peaks in the redshift distribution, we used an initial observed-frame velocity dispersion of $\sigma(v)_{obs}$=350 (1+z_{lens}) km s^{-1}.

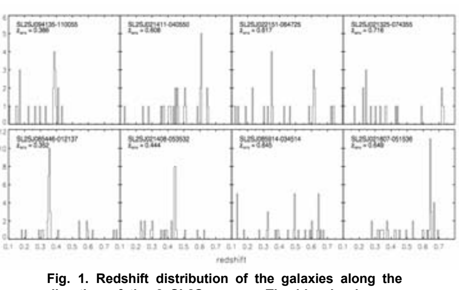

Fig. 1. Redshift distribution of the galaxies along the direction of the 8 SL2S groups. The bin size is Δz = 0.006. The spectroscopic data reveals that SL2SJ085446-012137 and SL2SJ021807-051536 show two separate groups each one.

Group name	z_{spec}	N	σ_V	
SL2SJ021411-040550	0.608	7	800.2 ± 281.1	
SL2SJ021408-0532	0.444	14	680.9 ± 174.8	
SL2SJ094135-110055	0.386	5	606.2 ± 185.0	
SL2SJ085446-012137	0.357	10	591.4 ± 135.4	
	0.352	7	344.8 ± 71.4	Lens
SL2SJ022151-064725	0.617	4	405.8 ± 64.3	
SL2SJ021807-051536	0.647	8	571.6 ± 174.6	Lens
	0.644	5	657.6 ± 171.6	
SL2SJ085914-034514	0.644	5	294.8 ± 101.4	
SL2SJ021325-074355	0.716	NA	NA	

The Table shows the velocity dispersion and number of members for each cluster. As seen in Fig. 2, the orientation of the luminosity contours for SL2SJ021408-053532 group is in good agreement with the spatial distribution of its confirmed members (red circles). For SL2SJ085446-012137, the outermost contours closely follow the distribution of the most massive spectroscopically confirmed group (red circles) and the innermost contours confirm the presence of a less massive group (blue circles).

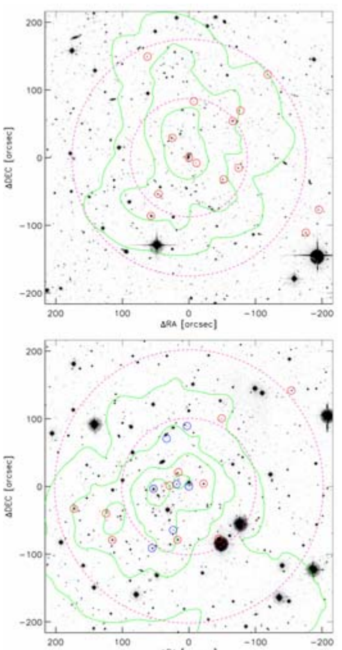

Fig. 2. Spatial distribution of galaxies along the directions of the SL2SJ021408-053532 (top) and SL2SJ085446-012137 (bottom) groups. Red circles show the position of the spectroscopically confirmed members associated to the most massive structure in the group region, and blue circles show the position of the ones associated to the less massive structure. The contours in green show the luminosity contours equal to 10^5, 3×10^5, 10^6, 3×10^6, 10^7 L_o kpc^{-2} as computed from weak-lensing by Limousin et al. (2009). The innermost and outermost big magenta circles mark a group-centric circular aperture of radius 0.5 and 1.0 Mpc, respectively.

SL2SJ02140-0532 LENS MODEL

SL2SJ02140-0532 at z=0.44, consist of three lens galaxies and three arcs (see Fig. 1). The arcs systems A1-A2 (z_{phot}=1.7) and B1 (z_{spec}=1.02) are produced by two different sources as confirmed by our spectroscopy. The system was modeled using a parametric method as implemented in the LENSTOOL ray-tracing code (Jullo et al. 2007). The group component was modeled using a generalized NFW profile, and we add the three central galaxies modeled like SIE, as perturbations to the group potential. We measured the velocity dispersion of the Brightest Group Galaxy with the code described by Cappellari & Ensellem (2004), and found σ=216 km/s. The other two galaxies were scaled using a Faber-Jackson relation. Our model predicts an image configuration that is in good agreement with observations and also shows that the deflecting mass is oriented with the same position angle as the one defined by the group members (see Fig. 2 and Fig. 3). These results stand out the importance of spectroscopic data in order to avoid complex mass distributions models that does not follow the light (see Alard 2009).

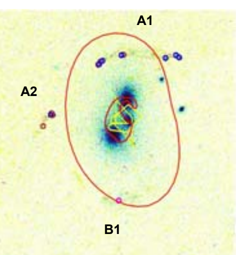

Fig. 3. Tangential critical line (red) and caustic line (yellow) for a source located at z = 1.7. The circles in brown shows the predicted positions of the multiple sub-components (blue circles) for the northern system. The magenta circle is the predicted position for the single southern arc. (N is up and E is left).

CONCLUSIONS AND FUTURE WORK

We presented preliminary results of the dynamic of 7 strong-lensing galaxy groups observed with VLT/FORS2. A first parametric model for SL2SJ02140-0532 is also shown. Our models reproduces the observed features in this system and also shows a good agreement with previous results (see Limousin et al. 2008). These preliminary results are the first step to link strong lensing, weak lensing and dynamics to get a whole picture of one group of galaxies. Taken together, these complementary studies will provide a more accurate picture of SL2SJ021408-053532 than using only one method.

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