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Optical properties of radio source 4C +08.45 ⋆

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Abstract. We present the first optical observations of the radio source 4C +08.45. It is identified with an elliptical galaxy (R = 15.92) at redshift z= 0.1250, with a comparable companion galaxy (R = 15.36; z= 0.1257) at a projected distance of 34.8 kpc. Both galaxies are normal elliptical galaxies. The galaxy identified with the radio source shows strong emission lines on top of an elliptical galaxy spectrum. The companion shows no emission lines. Based on these observations and the available radio data we believe that 4C +08.45 is a LINER type galaxy.

Key words: galaxies: active – galaxies: distances and redshifts – galaxies: photometry

1. Introduction

Radio source 4C +08.45 (1538+082) has been included in several radio surveys at different frequencies (e.g. Large et al. 1981 (408 MHz, 1.71 Jy); Griffith et al. 1995 (4.85 GHz, 0.34 Jy); White & Becker 1992 (1.4 GHz, 0.74 Jy); Gregory & Condon 1991 (4.85 GHz, 0.53 Jy); Becker et al. 1991 (4.85 GHz, 0.52Jy). At 22 GHz it has been observed in Metsähovi at the level of 1 Jy (see Teräsranta et al. 1998 concerning the Metsähovi radio observations). Combining these data one gets a radio spectrum, which shows a typical radio galaxy spectrum at low frequencies, up to 5 GHz, after which the spectrum turns up, showing a typical AGN spectrum. The different 4.85 GHz measurements indicate also small amplitude variability.

In this paper we present the first ever optical observations of this radio source. Throughout this paper we use H_0 = 50 km/s/Mpc and q_0 = 0.

2. Observations

The observations presented here were made at the Nordic Optical Telescope (NOT) on July 13, 1999. The night was non-photometric, with thin clouds and a lot of Sahara dust in the air. We used the ALFOSC instrument, with CCD #7 (0.189 arcsec/pix, gain 1.2e$^-$/ADU, readout noise 5.6e$^-$). For the direct imaging we used R-filter, and for the spectroscopic observations a $1\farcs2$ slit, with grism # 4. This gives a spectral resolution of $\Delta\lambda$ = 8.3 Å with a spectral coverage from 3500 to 9300 Å. The slit was oriented such a way, that it covered the two closeby galaxies (see Fig. 1), the rightmost one of which is 4C +08.45. First we took a 600s R-band image, at seeing of 1.2" and then two 1800s exposures in the spectroscopic mode. Twilight flat field images were taken in R-band. For the spectra we used a halogen lamp for flat fielding and HeNeAr-lamp (and sky lines) for wavelength calibration. For spectral flux calibration we observed white dwarf BD +33 2642 right after taking the spectra of 4C +08.45 at almost the same airmass. For photometric calibration for the R-band image we used the standard stars in the field of Mkn 501 (Villata et al. 1998), which was imaged after the 4C +08.45 observations. All data reduction was done using standard IRAF routines.

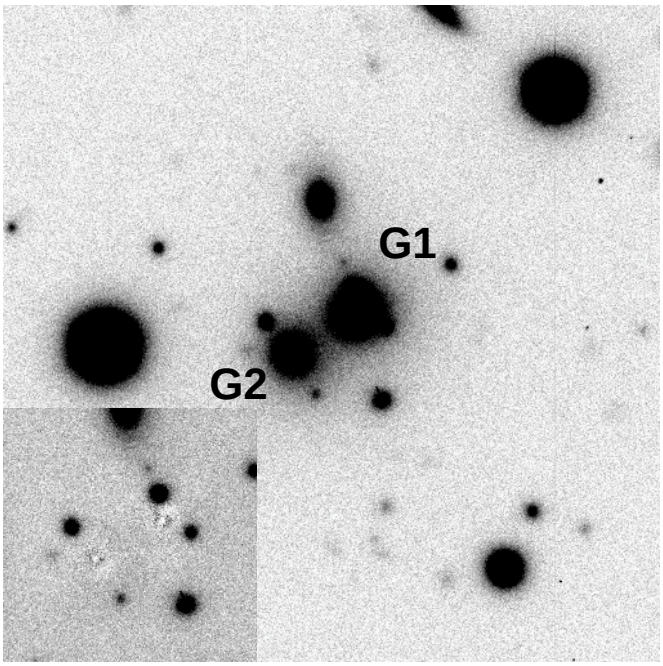

Fig. 1. The observed R-band image of the field of 4C +08.45. Field size is 96*96 arcsec. At the redshift of 0.1250 one arcsecond corresponds to 3.05 kpc. At the lower left corner shows a portion of the field after substraction of the best-fitting free β + core model

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⋆ Based on observations made with the Nordic Optical Telescope, operated on the island of La Palma jointly by Denmark, Finland, Iceland, Norway and Sweden in the Spanish Observatorio del Roque de Los Muchachos of the Instituto de Astrofisica de Canarias.

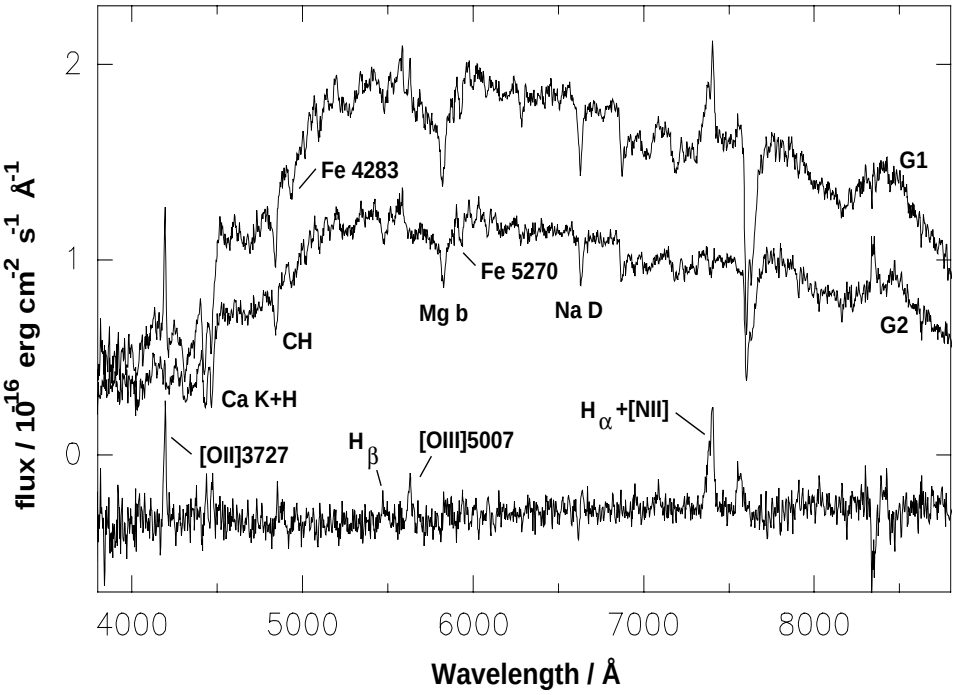

Fig. 2. The observed spectrum of galaxy G1 = 4C +08.45 and galaxy G2. At the bottom of the figure we have substracted from the G1 spectrum the scaled G2 spectrum, which was transferred to the redshift of G1. This spectrum shows clearly the emission lines in G1.

Table 1. Model fits for galaxies G1 and G2.

Model	Red. χ^2	m_{gal} (arcsec)	r_e	ϵ (deg)	PA	m_{core}
			G1			
Free β + core de Vaucouleurs	1.15	15.36	6.3	0.07	35	19.44
+ core	1.19	15.54	4.8	0.06	37	18.76
Free β	1.15	15.23	7.5	0.17	32	
de Vaucouleurs	1.65	15.62	3.4	0.06	41	
			G2			
Free β + core de Vaucouleurs	1.18	15.92	6.8	0.14	128	19.19
+ core	1.21	16.12	5.1	0.14	128	18.86
Free β	1.20	15.54	13.4	0.15	129	
de Vaucouleurs	1.65	16.28	2.7	0.10	127	

3. Analysis and results

The R-band image is shown in Fig. 1. The image reveals a small group of galaxies with 4C +08.45 at the center (galaxy G1). Another galaxy (G2) is at a projected distance of 11.″4 southwest of 4C +08.45. This corresponds to a projected physical separation of 34.8 kpc, assuming the redshift below.

The galaxy brightness profiles were modeled using two galaxy models, both with and without a central point source: the standard de Vaucouleurs (1948) profile and the "free β" model described in Nilsson et al. (1999). Results from this modeling are shown in Table 1. Pure de Vaucouleurs model gives the largest χ^2-value, the other ones give very similar χ^2-values. Models which include a point source are marginally better, but the difference is too small to make any conclusions about the existence of a point source in the nucleus of either galaxy. Due to its radio emission, we might expect to find an optical point source in G1, but our fits indicate that if such a source exists, it must be very weak, at most 5% of the total light of G1 in the R-band (see Govoni et al. 1999). We have also measured the 4000 Åbreak index (Dressler & Schectman 1987) and obtained D(4000) $\sim$ 2.0 for both galaxies. This value is normal to elliptical galaxies (see Dressler & Schectman 1987) and further supports the view that the optical nucleus in G1 must be very weak. We do not see any morphological disturbances, which would indicate recent interaction between these galaxies. Subtracting the galaxy models from the original images we cannot find any background objects, that could be considered as the radio source (Fig. 1).

Using the modeling results we calculate absolute magnitudes for the galaxies, getting M(G1)= -23.6 and M(G2)= -24.2. These are typical for low redshift radio galaxies (Colina & de Juan 1995; Govoni et al. 1999).

The observed spectra for these galaxies are shown in Fig. 2. Both galaxies show typical elliptical galaxy spectra with usual absorption lines and the Ca-break (e.g. Kennicutt 1992). The identified and measured lines are shown in Table 2. In the spectrum of 4C +08.45 we also detect strong emission lines of [OII], [OIII], H β, H α and [NII] (Fig. 2; Table 2). These emission lines indicate that galaxy G1 is an emission line galaxy (EGL; Tresse et al. 1999), probably a LINER type galaxy (e.g. Heckman 1980; Veilleux & Osterbrock 1987; Carrillo et al. 1999). The calculated H α luminosity is similar to those observed in LINERs (Heckman 1980). No emission lines can be seen in the spectrum of galaxy G2! Based on these absorption and emission lines we measured redshifts for the galaxies; G1: z= 0.1250 $\pm$ 0.0002; G2: z= 0.1257 $\pm$ 0.0002. The redshift difference trans-

Table 2. Spectroscopic line measurements for galaxies G1 and G2.

	Line	λ_{obs}	Z	FWHM (Å)
G1	[OII]	4192.7	0.1250	16
	Ca K	4425.0	0.1249	
	Ca H	4464.5	0.1250	
	CH	4839.1	0.1254	
	Mg b	5819.0	0.1242	
	H β?			40
	[OIII]			25
	Na D	6629.4	0.1250	
	H α	7381.5	0.1247	47
	N II	7404.7	0.1248	12
	Fe 5270	5926.7	0.1248	
	Fe 4283	4935.0	0.1258	
G2	Ca K	4430.3	0.1262	
	Ca H	4467.5	0.1257	
	CH	4843.1	0.1263	
	Mg b	5824.9	0.1253	
	Na D	6633.6	0.1258	
	Fe 5270	5929.2	0.1252	

lates to a velocity difference of Δ V = 180 $\pm$ 70 km/s. The first optical observations of radio source 4C +08.45 and the available radio data indicate that this object is a LINER type galaxy.

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