Preliminary results on optical polarimetry of OJ287 blazar-type AGN ⋆

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Abstract. We perform two epoch optical polarimetry observations of the BL Lac-type AGN OJ287. The data are gathered with the Focal Reducer Rozhen 2 – FoReRo2 on the 2-m RCC telescope at NAO Rozhen, Bulgaria, on the nights of 17th and 18th November 2012. We derive polarization in R-band and position angle (P.A.). Observed variation in P.A. corresponds to rotation of the plane of polarization of 10.8 *deg* per day.
Key words: OJ287; AGN; Polarimetry; BL Lac

Introduction

The BL Lac-type object OJ287, at z=0.306, is one of the most well-studied blazars. It has a well-defined period of 12 years (Sillanpää et al. 1996) and observations on its light curve extend back to year 1891 (Valtonen & Ciprini 2011). A wide range of theoretical models has been proposed to explain its characteristically double-peaked flaring activity during outburst (Katz 1997, Sillanpää et al. 1988, Sundelius et al. 1997, Valtaoja et al. 2000). The most prominent model is of a binary black hole system with relativistic precession (Valtonen & Ciprini 2011).

An important factor in understanding the physics of such violent objects, variable on a large range of wavelengths, is their polarization behaviour. The first of the two flares during outburst is thermal (i.e. not polarized), which is shown by the lack of corresponding radio emission (Valtaoja et al. 2000). But depending on the theoretical model, the second flare could either be due to synchrotron radiation, which is polarized (Valtaoja et al. 2000), or can be unpolarized or low-polarized bremsstrahlung (Valtonen and Ciprini 2011). Therefore, polarization is indeed a key factor to distinguish among different models.

Due to the development of the observational technique and the possibilities of the internet communication between various research groups, a global-scale multiwavelength studies of AGNs became feasible (e.g. the WEBT project: http://www.oato.inaf.it/blazars/webt/). A number of multiwavelength observational campaigns have been performed in the last years (Valtaoja et al. 2000, Efimov et al. 2002, Ciprini et al. 2007, Nieppola et al. 2009, Villforth et al. 2010, Valtonen & Ciprini 2011). Results from the 2005-2010 observational campaign show that the flare during the 2005 outburst is due to bremsstrahlung radiation instead of a synchrotron one (Valtonen & Ciprini 2011). That provides strong background to the binary black hole model with ultra relativistic precession.

⋆ Based on data collected with 2-m RCC telescope with FoReRo2 at Rozhen National Astronomical Observatory.

This also allows the use of OJ287 as a test of general relativity (Valtonen et al. 2008).

Recently, OJ287 showed a peak in brightness in April 2012 (Santangelo 2012). This was not expected by any of the current models. That is why complete data of optical polarization behaviour and P.A. (Position Angle) measurements of OJ287 are important for understanding the underlying physics in this peculiar object and that motivates our work.

This article consists of four sections: after a brief introduction, section 2 provides details on the observations and data reduction. Results are displayed and discussed in Section 3. Section 4 gives conclusions and highlights the importance of new observations with our instruments using this technique.

2. Observations and data reduction

We present original two epoch polarimetrical study of OJ287 with the Focal Reducer Rozhen 2 – FoReRo2 (Jockers et al. 2000) on the 2-m Ritchey-Cretien-Coude (RCC) telescope at NAO Rozhen, Bulgaria. The observational data were taken on the nights of 17th and 18th November 2012. We used a Wollaston prism to separate the falling light into two rays at 90° from each other. Furthermore, each one of these consists of two additional rays, polarized at 45° to one another. The used color splitter transmits redder than 5800Å light into the red channel and reflects bluer than 5100Å one into the blue channel of the reducer.

Polarimetrical measurements in B are not performed, but B-band data are used for photometrical measurements (Bozhilov et al. 2013). Thus, we can perform polarization determination using Stokes equations (see Landi Degl'Innocenti and M. Landolfi (2004), chapter 1.6 and 1.7 for elaborate details). Thus, our data can be useful to complete the existing data, which could allow further differentiation among theoretical models in the future. A detailed description of the method of measurements and the calculations can be found in Geyer et al. (1996).

Table 1. Observational data

Object	average JD-2456200		total integration time sec
HD10476	49.3960	30 x 0.2 =	6
HD14433	49.4071	30 x 0.5 =	15
OJ287	49.4946	30 x 60 =	1800
OJ287	49.5233	30 x 60 =	1800
OJ287	49.5521	30 x 60 =	1800
OJ287	49.5878	30 x 60 =	1800
OJ287	49.6176	30 x 60 =	1800
OJ287	49.6465	20 x 60 =	1200
OJ287	50.4909	10 x 60 =	600
OJ287	50.5003	10 x 60 =	600
OJ287	50.5097	10 x 60 =	600

Our observations of OJ287 with R-band filter, Wollaston prism and 5100-5800 Å colour splitter on the night of 17th consisted of 5 consecutive series of

30 images and 1 series of 20 images with 60 sec exposure each. On the night of 18th we took 3 series of 10 images with the same exposure. Corrections for bias and flat field were applied. For polarization and P.A. measurements, we used the low-polarization standard star HD10476 and the high-polarization standard star HD 14433 in order to determine instrumental optical polarization, according to Stokes equations (Geyer et al. 1996). See Table 1 for details on the observational program and Table 2 for properties of the standard stars.

Table 2. Standard stars

Star	R. A. (2000)	Dec. (2000)	mV	Polarization (max)	P.A.
				%	*deg*
HD10476	01 42 29.76170	+20 16 06.6015	5.2	-	-
HD14433	02 21 55.43563	+57 14 34.4931	6.39	3.9 at lmax=0.51μm	112

3. Results and Discussion

Results for the polarization and position angle are shown in Table 3. Polarimetrical and P.A. measurements are in agreement with previous data (Takalo et al. 1994, Efimov et al. 2002, Villforth et al. 2010). Note that OJ287 polarization and P.A. are known to vary extremely rapidly, even in a matter of hours (Takalo et al. 1994).

Table 3. Polarization and P.A. measurements for OJ287 on the nights of 17 and 18 November 2012

JD-2456200	Polarization	Error	P.A.	Error
	%	%	*deg*	*deg*
49.4946	9.89	5.95	74.31	12.66
49.5233	9.93	5.99	75.55	12.25
49.5521	9.80	5.99	75.78	12.27
49.5878	9.98	6.32	75.63	12.62
49.6176	9.54	6.26	74.55	13.27
49.6465	9.57	6.08	73.56	13.35
50.4909	9.39	6.82	63.73	4.75
50.5003	9.64	7.97	65.50	4.75
50.5097	9.65	8.12	65.28	4.75

Efimov et al. (2002) argue that the plane of polarization angle rotates at a rate of about 5 *deg* per day. Our results show a change of 10.8 *deg* per day. Nevertheless, within the observation error limits this is not in contradiction with previous measurements (Efimov et al. (2002)). On Figure 1 both our results (dotted line) and the expected value from Efimov et al. (2002) (solid line) are shown. Further continued observations will definitely allow us to investigate and ameliorate knowledge on polarization and P.A. behaviour.

Conclusion

OJ287 is one of the most well-known blazars, but it is still a riddle. Numerous models have been proposed to explain its observed properties, the one being favored so far is the Binary Black Hole model of Valtonen et al. (2008). One of the key factors to distinguish among different models is namely the optical polarization (ibid.). Nevertheless, OJ287's outburst in the end of March/beginning of April 2012 was not expected, nor predicted (Santangelo 2012).

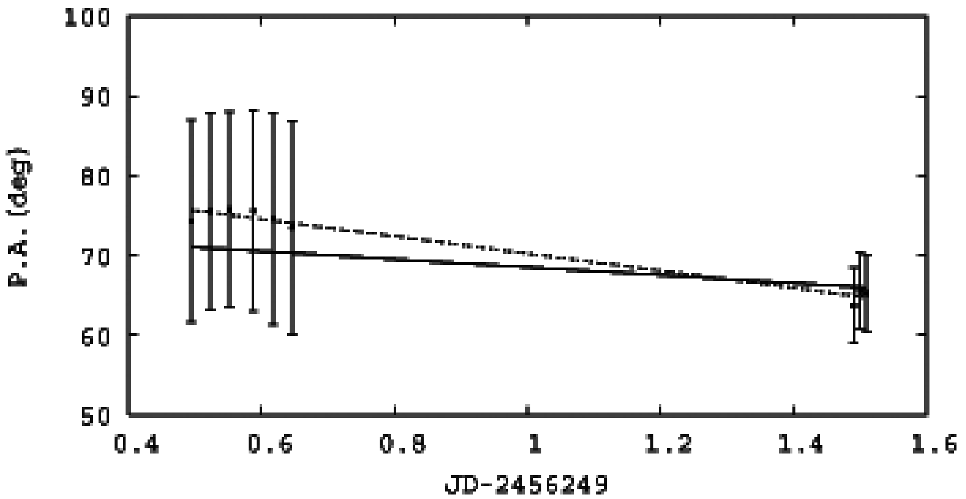

Fig. 1. P.A. for OJ287 from the nights of 17 and 18 November 2012. Observed (dotted line, 10.8 *deg* per day) and expected (solid line, 5 *deg* per day according to Efimov et al. (2002)) P.A. change are plotted

Since optical polarization measurements could be useful to distinguish among various theoretical models, our observations further complete the existing data on this peculiar object. Our original study of the optical photometry, polarization and P.A. of OJ287 on the nights of 17th and 18th November 2012 shows good correlation with previous data and gives strong background to further measurements with NAO Rozhen's focal reducer FoReRo2 on the 2-m RCC telescope. Although, the observed data are not enough at present to give a conclusion favoring or disproving one or more of the proposed models, it proved that the study is feasible with the instrumentation at NAO Rozhen. Thus, our work completes and expands current data on OJ287 with more observations being planned in near future.

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