OPTICAL VARIABILITY OF THE RADIO SOURCE J 1128+5925

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ABSTRACT

Very recently, J 1128+5925 was found to show a strong intraday variability at radio wavelengths and might be a new source with the annual modulation of the timescale of its radio variability. Therefore, its radio variability can be best explained via interstellar scintillation. Here we present the properties of its optical variability for the first time after a monitoring program in 2007 May. Our observations indicate that in this period J 1128+5925 only showed trivial optical variability on internight timescale, and did not show any clear intranight variability. This behavior is quite different from its strong radio intraday variability. Either this object is in a quiescent state in the optical regime during this period, or it is intrinsically not so active in the optical as it is in the radio regime.

Key words: galaxies: active – quasars: individual (J 1128+5925)

1. INTRODUCTION

Blazars are the most variable subset of active galaxy nuclei (AGN). They display a range of variability timescales. The longest timescales can be much longer than one year, while the shortest may be less than one hour. A variability with a timescale of less than one day is often called intraday variability or IDV, as first reported by Heeschen (1984), Witzel et al. (1986), and Heeschen et al. (1987). Strong IDV phenomena have been observed in the radio domain in a large number of blazars. If interpreted as being source intrinsic, the short-timescale variability would require a very small emitting region and hence a very high apparent brightness temperature of 10^{16}–10^{21} K, which is far beyond the inverse-Compton limit of about 10^{12} K (Kellermann & Pauliny-Toth 1969).

Alternatively, the IDV can be explained via an extrinsic origin, e.g., via interstellar scintillation (ISS). A strong support for ISS as the origin is the so-called annual modulation of the variability timescale, which is the result of the annual changes of the relative velocity vector between the scattering screen and the Earth as the latter orbits the Sun (e.g., Dennett-Thorpe & de Bruyn 2002; Dennett-Thorpe & de Bruyn 2003). Such an annual modulation has been observed in a few IDV sources, as mentioned by Gabányi et al. (2007).

Very recently, the flat-spectrum radio quasar J 1128+5925 was found to show a strong IDV at centimeter wavelengths, and its IDV timescale displayed an annual modulation (Gabányi et al. 2007). Therefore, its IDV may be caused by ISS. In the optical domain, there is no previous report on its variability. In order to discover the properties of its optical variability and to make a comparison to those of its radio variability, we performed an optical monitoring program on this object in 2007 May. Here we present the results.

2. OBSERVATIONS AND DATA REDUCTION

The monitoring was performed with a 60/90 cm Schmidt telescope at Xinglong Station, National Astronomical Observatories of China. The Schmidt telescope is equipped with a 4096×4096 E2V CCD, which has a pixel size of 12 μm and a spatial resolution of $1.3''$pixel^{-1}. When the system is used for blazar monitoring, only the central 512×512 pixels are read out as an image. The monitoring was done in the *R*-band with exposure times ranging from 300 to 480 s, and covered the pe-
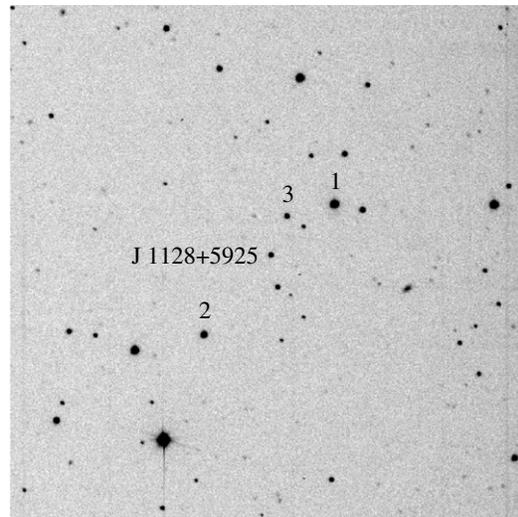

Figure 1. Finding chart of J 1128+5925. The blazar and three comparison stars are labeled. (Upwards is north, left is east).

riod 2007 May 5–29. Because of the weather conditions and observations of other targets, there are actually 11 nights of data on J 1128+5925.

The data reduction procedures include positional calibration, bias subtraction, flat fielding, extraction of instrumental aperture magnitude, and flux calibration. We adopted the radii of the aperture and the sky annuli as 3, 7, and 10 pixels, respectively, during the aperture photometry. Three stars around J 1128+5925 were selected as comparison stars, as shown in the finding chart in Figure 1. Here we used differential photometry. For each frame, the instrumental magnitudes of the blazar and the three comparison stars were extracted. The brightness of the blazar was measured relative to the average brightness of the three comparison stars. The differential magnitudes of star 3 (it has similar brightness to the blazar) relative to the average of all three stars were also calculated to verify the stable fluxes of the comparison stars and the accuracy of our measurements.

3. RESULTS

The light curve of the whole monitoring period is shown in Figure 2. It is clear that there is no strong internight variation,
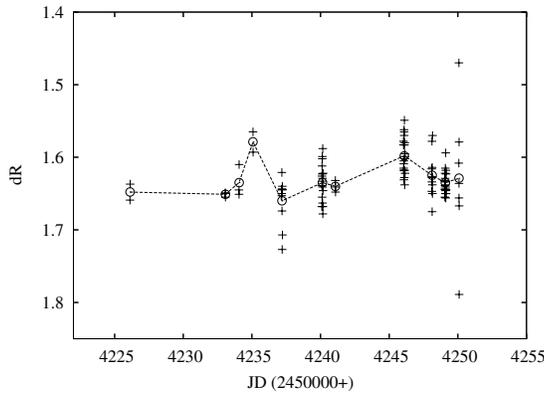
Figure 2. The light curve of all nights. The plus symbols are individual measurements, while the open circles and dashed line mark the nightly average light curve. The brightest and faintest points on the last night may be spurious measurements and were excluded from the analysis. The errors are typically 0.02 mag and are omitted for clarity.

except on JD 2,454,235, where the strongest internight variation occurred with an amplitude of 0.069±0.023 mag when adopting the definition of Wu et al. (2007).

Figure 3 displays the intranight light curves on five most intensively monitored nights. The differential magnitudes of star 3 are very stable at around $dR \sim 1.4$ with the exception of the last four points on JD 2,454,237. On this night, the relatively low signal-to-noise ratio of the last four CCD images resulted in the observed increasing brightness of star 3, and the large error bars on the light curve of the blazar.

In all five intranight light curves, the brightness of the object shows only some small-amplitude oscillations around a constant average, and it does not demonstrate any clear tendency to become brighter or fainter. In fact, the apparently random, small-amplitude oscillations on very short timescales suggest that the oscillations may be mainly due to noise. A quantitative assessment was performed on whether or not the object was variable on these five nights. We employed the frequently used criteria adopted by, e.g., Jang & Miller (1997), Stalin et al. (2006), and Hu et al. (2006). We follow the
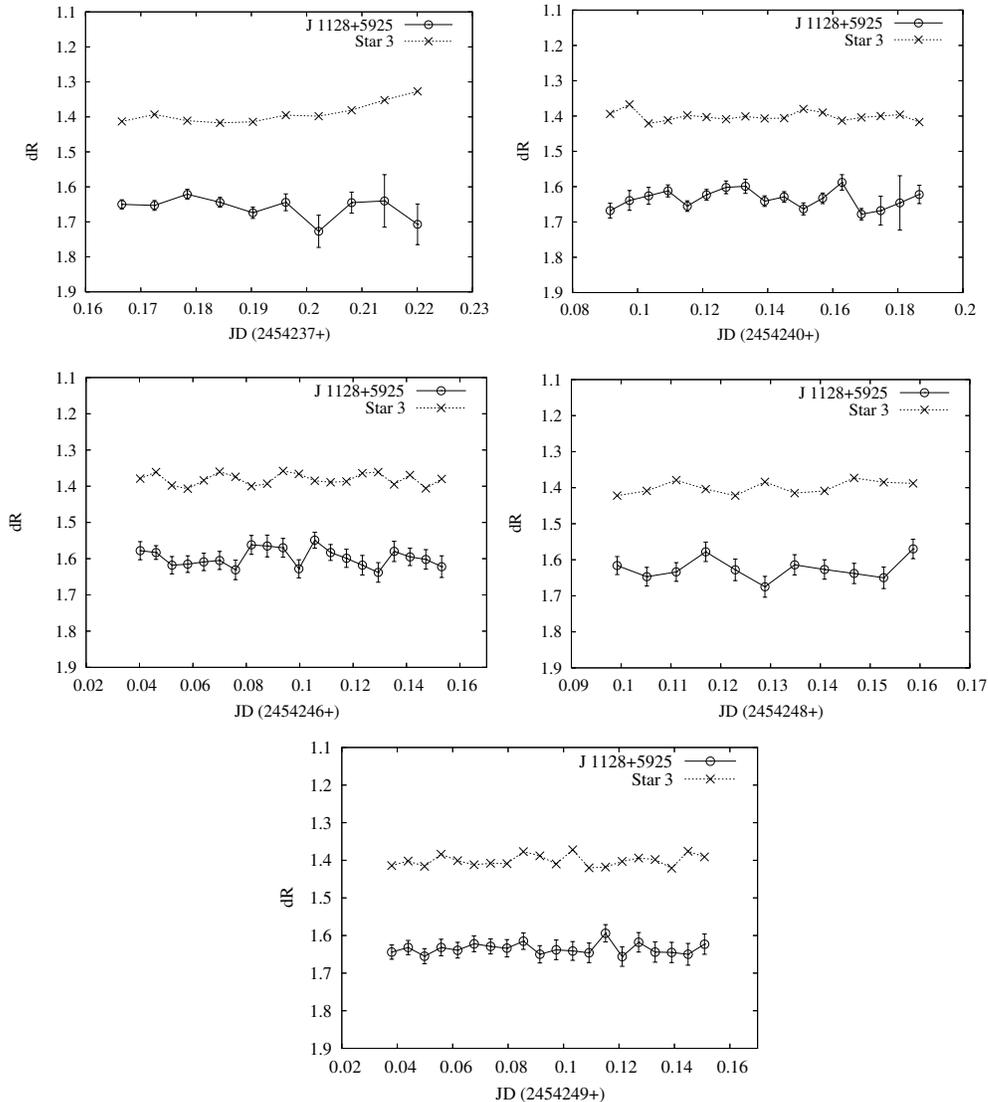
Figure 3. Intranight light curves on JDs 2,454,237, 2,454,240, 2,454,246, 2,454,248, and 2,454,249, which are the five most intensively monitored nights. The open circles and solid lines show the light curves of the blazar. The crosses and dotted lines show the light curves of star 3.

Table 1
Statistics on Five Intranight Light Curves

Julian date	No.	Duration (h)	C	Var?
2,454,237	10	1.28	1.11	N
2,454,240	17	2.28	1.96	N
2,454,246	20	2.71	1.58	N
2,454,248	11	1.43	1.72	N
2,454,249	20	2.71	1.01	N

convention of defining C such that $C = \sigma_B/\sigma_S$, where σ_B is the standard deviation of the magnitudes of the blazar and σ_S is that of the comparison star. When $C \geqslant 2.576$, the object can be claimed to be variable at the 99% confidence level. Table 1 lists the results. All five C values are less than 2.0, implying that J 1128+5925 was not variable on these five nights.

Although the monitoring periods on individual nights were only 1.28 to 2.71 h long (see Table 1), the average observed brightness actually continued on longer timescales, and in some cases might have extended till the next night (e.g., from JD 2,454,240 to 41 and from JD 2,454,248 to 50). Therefore, J 1128+5925 did not show strong variability on internight timescale, and even did not vary on intranight timescale in that period of time.

4. CONCLUSIONS AND DISCUSSIONS

We performed an optical monitoring program on J 1128+5925 in the R-band from 2007 May 5 to 29. Our monitoring results indicate that in this period J 1128+5925 only showed trivial optical variability on internight timescale, and did not show any clear intranight variability. Either this object is in a quiescent state in the optical regime during this period, or it is intrinsically not as active at optical as it is at radio wavelengths.

Some blazars that show strong IDV in radio regimes also display rapid and strong variability in optical regimes, such as S5 0716+714 (e.g., Wu et al. 2005, 2007; Montagni et al. 2006; Pollock et al. 2007). This does not seem to be the case for J 1128+5925. This object exhibits strong IDV at radio wavelengths, but not at optical wavelengths. It is easy to explain this difference if the optical and radio variabilities come from different origins: the optical variability may be intrinsic to the source (the ISS cannot change the optical flux), while the radio variability is mainly the result of ISS, as implied by the observations of Gabányi et al. (2007).

We present the first report on the optical variability of J 1128+5925 in this paper. However, because of the solar con-

junction and observations of other targets using the telescope, our monitoring did not last long. More observations are needed to know whether or not this object is always optically quiescent. Multi-band optical monitoring is also necessary to constrain its optical variability in more detail. Of particular interest would be to carry out simultaneous optical and radio monitorings on this object in order to make a more direct comparison between the variabilities at these two wavelengths. Future experiments may investigate whether there is correlated optical IDV when strong radio IDV is observed. If such correlations are detected, they will be strong evidence that both the optical and radio variability structures are intrinsic to the source, as in the case of S5 0716+714 (Quirrenbach et al. 1991; Wagner & Witzel 1995; Wagner et al. 1996). The broadband variability is also helpful in deriving for this object some basic parameters, such as the mass of the central supermassive black hole, the boosting factor of the relativistic jet, etc (e.g., Fan 2005).

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