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The optical variability of radio-loud quasars

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Abstract. The optical variability of a sample of 44 FSRQs and 18 SSRQs in the SDSS stripe 82 region is investigated by using the multi-epoch data covering nine years. The variabilities are clearly detected in each source with the amplitude in r band, from 0.18 to 3.46 mag. Twenty-five of 44 FSRQs show a bluer-when-brighter trend (BWB), while only one FSRQ shows a redder-when-brighter trend, which is in contrast to our previous results. Eight of 18 SSRQs display a BWB. We found an anti-correlation between the Eddington ratio and the variability amplitude in r band for SSRQs, which is similar to that in radio-quiet AGNs. This implies that the thermal emission from the accretion disk may be responsible for the variability in SSRQs.

Keywords. Galaxies: active, quasars: general, galaxies: photometry

1. Introduction

Active galactic nuclei (AGNs) exhibit variability at almost all wavelengths. The radido-loud quasars are divided into two populations, flat-spectrum radio quasars (FSRQs) and steep-spectrum radio quasars (SSRQs). In FSRQs, the non-thermal emission from a relativistic jet usually are dominant and Doppler boosted, due to the small viewing angle. In contrast, the SSRQs are usually lobe-dominated radio quasars, with a large viewing angle, therefore the beaming effect is not severe. Although a bluer-when-brighter trend is commonly observed in blazars, the opposite trend of redder-when-brighter has also been found, especially in FSRQs (e.g. Gu *et al.* 2006). However, it is unclear whether a redder-when-brighter trend is generally present in FSRQs. Moreover, the optical and color/spectral variations of SSRQs have been poorly studied, and the variability mechanism is largely unknown. For these sakes, we investigate the optical variability and the spectral variability for a sample of radio-loud quasars (see details in Gu & Ai 2011a,b).

2. Sample

Our sample of 62 radio-loud quasars consists of 44 FSRQs and 18 SSRQs. The initial quasar sample was selected as those quasars in both the SDSS DR7 quasar catalogue and Stripe 82 region. We cross-correlate the initial quasar sample with the Faint Images of the Radio Sky at Twenty centimeters (FIRST) 1.4-GHz radio catalogue, the Green Bank 6-cm (GB6) survey at 4.85 GHz radio catalogue, and the Parkes-MIT-NRAO (PMN) radio continuum survey at 4.85 GHz. The radio spectral index $\alpha_{\rm r}$ was then calculated between the single or integrated FIRST and/or NRAO VLA Sky Survey (NVSS) 1.4 GHz and either or both of the GB6 and PMN 4.85 GHz. We define a quasar to be a SSRQ according to its radio spectral index $\alpha_{\rm r} > 0.5$ ($f_\nu \propto \nu^{-\alpha_{\rm r}}$), and otherwise as FSRQs.

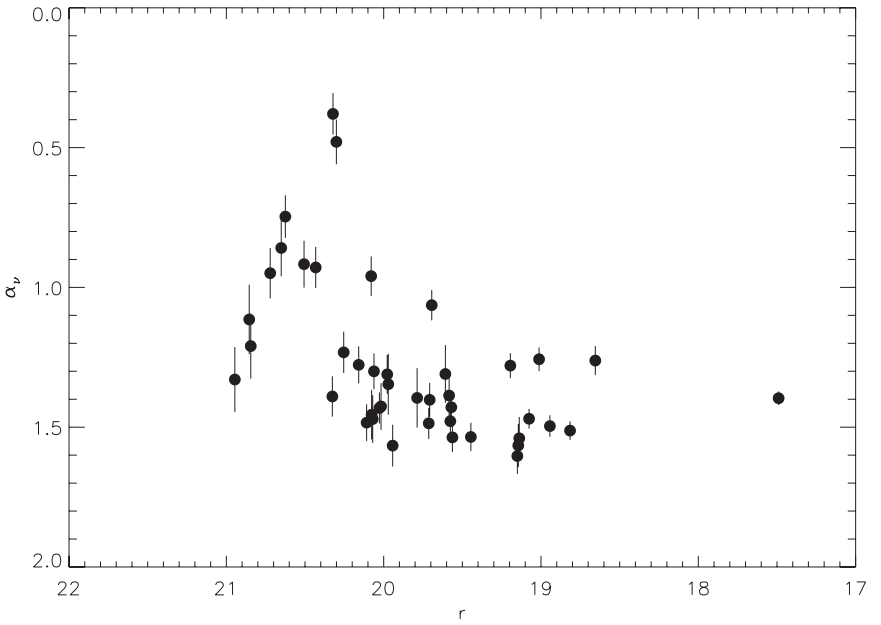

Figure 1. The relationship between the spectral index and the PSF magnitude at r band for SDSS J001130.40+005751.7. A significant anti-correlation is present, which implies a redder-when-brighter trend.

3. Results

We directly used the point-spread-function magnitudes in the CAS Stripe82 database from the photometric data obtained during the SDSS-I phase from data release 7 and the SN survey during 2005 - 2007. We found that radio-loud quasars all show more or less variations, ranging from 0.18 to 3.46 mag at r band. FSRQs show more pronounced variations than SSRQs, with $\Delta r > 1.0$ mag in four FSRQs while none in SSRQs. By performing the correlation analysis between the spectral index and r band brightness, the redder-when-brighter trend is only found in one FSRQ (SDSS J001130.400+005751.8, see Fig. 1), which could be explained by the thermal accretion disk emission. In contrast, the bluer-when-brighter trend is more common in FSRQs (25 out of 44 sources), and in SSRQs (8 of 18) as well. The results of FSRQs are in contrast to our previous results that FSRQs generally show the redder-when-brighter trend (Gu *et al.* 2006, see also Rani *et al.* 2010). For all SSRQs studied, we found an anti-correlation between the Eddington ratio and the variability amplitude in r band, which is similar to that in radio-quiet AGNs. This implies that the thermal emission from the accretion disk may be responsible for the variability in SSRQs.

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