Intra-night optical monitoring of a sample of X-ray/radio selected AGNs: first results

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Abstract. We present first results from the intra-night optical monitoring of a sample of X-ray/radio selected AGNs. We discuss the results for the radio-quiet quasar PG 0157+001. The quasar showed no intra-night optical variability during our monitoring. We obtained a rough estimate of 38 % for the quasar duty cycle.
Key words: quasars: individual (PG 0157+001) – techniques: photometric

Introduction

Flux variability is a common property of active galactic nuclei (AGNs). It could be efficiently used to study the structure and physical processes in AGNs; for example, the time scale of the flux variations could constrain the size of the emitting region and the viscosity parameter of AGN accretion disks (e.g., Siemiginowska & Czerny 1989; Xie et al. 2009). The time scales of AGN variability could be divided into intra-night (minutes to hours), short-term (days to weeks), and long-term (months to years).

Intra-night optical variability (INOV) in radio-loud AGNs is a well established phenomenon and is widely believed to be connected with physical processes in relativistic jets. On the other hand, INOV is rare in radio-quiet AGNs, with duty cycles[1] much lower than those in radio-loud AGNs (Carini et al. 2007). However, some studies suggest that INOV in quasars does not depend on their radio properties (e.g., Stalin et al. 2005; Ramírez et al. 2009).

The nature of the observed INOV of radio-quiet AGNs is not clear yet. For instance, Czerny et al. (2008) associated it with the presence of a weak blazar component. However, Joshi et al. (2012) found no evidence of this hypothesis. Increasing the number of radio-quiet AGNs monitored intra-nightly could be very helpful in specifying the nature and characteristics, including the duty cycle, of their INOV, as well as in comparing their INOV properties with those of radio-loud AGNs. In this context, we undertook a long-term intra-night optical monitoring programme of a sub-sample of radio-quiet AGNs selected from the RBSC-NVSS sample (Bauer et al. 2000). Here we present the first results concerning the quasar PG 0157+001.

1 PG 0157+001 (Mrk 1014, $z = 0.163110$, $r_{\rm SDSS} = 15\overset{\rm m}{.}58$)

The intra-night optical monitoring of this radio-quiet quasar was performed on Oct. 2$^{\rm nd}$, 2010, with the 4096×4096 FLI PL16803 CCD camera attached to the 50/70 cm Schmidt telescope (with a scale of $1\overset{''}{.}079$/px) of the Rozhen

[1] Duty cycle is the fraction of time when an object displays intra-night variability (Romero et al. 1999).

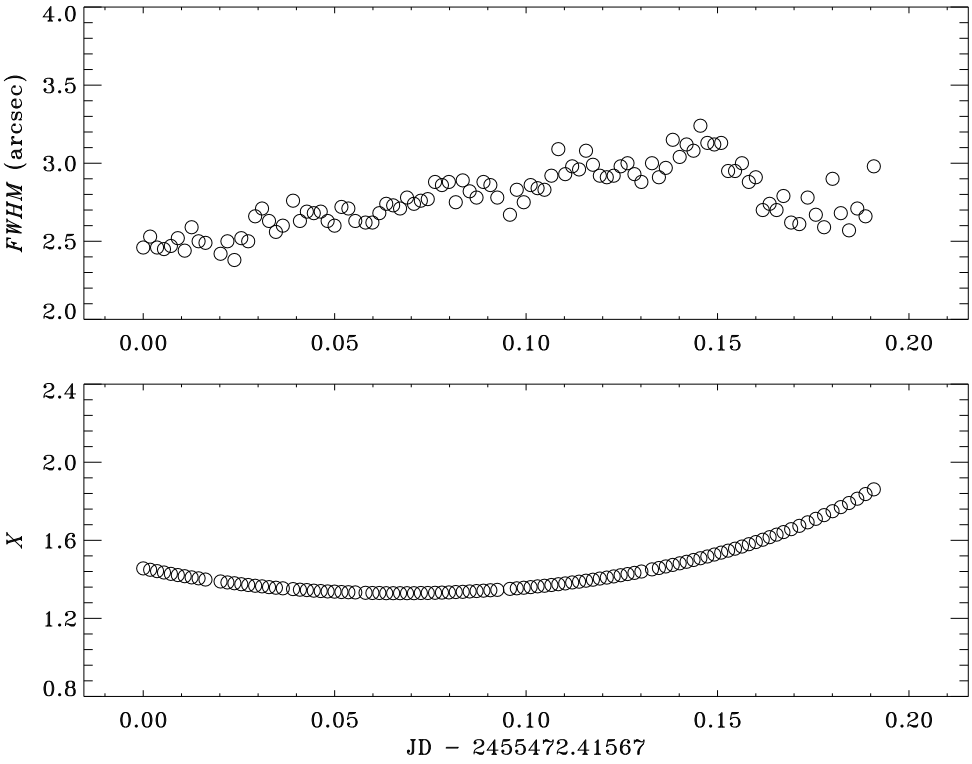

Fig. 1. Seeing and airmass distribution during the intra-night monitoring.

National Astronomical Observatory (NAO), Bulgaria. The duration of the monitoring was $4\overset{\mathrm{h}}{.}58$ through Cousins R filter – we collected a total of 101 data points with typical exposure times 150 – 180 s. The median $FWHM$ is $2\overset{''}{.}76$ (with a standard deviation about the median of $0\overset{''}{.}19$). The target culmination was at airmass of 1.329. The distribution of the $FWHM$ and airmass during the intra-night monitoring are shown in Fig. 1.

We selected 8 reference stars (denoted as R1 – R8 in Fig. 2) and a control one (marked as C) in the field of PG 0157+001 (marked as T). The reference stars were chosen to be bright, while the control star – close in brightness to the target. Neither the reference stars, nor the control one coincide with known variable stars according to SIMBAD. The flux measurements were performed using DAOPHOT package (Stetson 1987) run under IDL 7. The aperture radius was fixed to $5''$.

We computed the ensemble magnitude, m_{ens}, of the reference stars adding up the individual stellar fluxes. The differential light curves (DLCs) of the target, $m_{\mathrm{T}} - m_{\mathrm{ens}}$, and control star, $m_{\mathrm{C}} - m_{\mathrm{ens}}$, with respect to the ensemble magnitude are shown in Fig. 3. Both DLCs show no correlation with the seeing, as well as with the airmass variations. The weighted standard deviation about the weighted mean is $0\overset{\mathrm{m}}{.}014$ for the target DLC and $0\overset{\mathrm{m}}{.}012$ for the

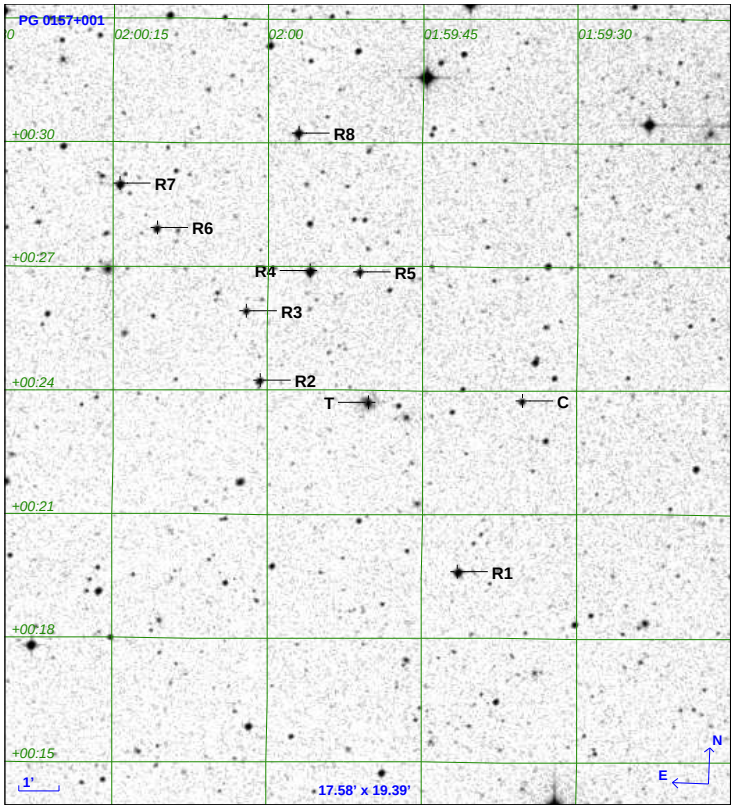

Fig. 2. Finding chart for PG 0157+001 (T), control star (C), and reference stars (R1 – R8), numbered in order of increasing declination.

control star DLC. We performed F-test to search for INOV of the target following Howell et al. (1988):

$$F_{\rm test} = \frac{\sigma^2_{\rm T-ens}}{\Gamma^2 \sigma^2_{\rm C-ens}},$$

where $\sigma^2_{\rm T-ens}/\sigma^2_{\rm C-ens}$ is the variance of the target/control star DLC and the Γ^2 factor accounts for the different brightness of the target and control star (see Howell et al. 1988). To reject the null hypothesis (which states that the target is not variable) at the confidence level $\alpha = 0.05$, we must have $F_{\rm test} > F(1-\alpha; n_{\rm T}-1; n_{\rm C}-1)$, where $n_{\rm T}$ and $n_{\rm C}$ are the number of data points of the target and control star DLCs, respectively. We got $F_{\rm test} = 0.907$, which is less than the corresponding critical value $F(0.95; 100; 100) = 1.392$. Therefore, PG 0157+001 does not show INOV at this confidence level.

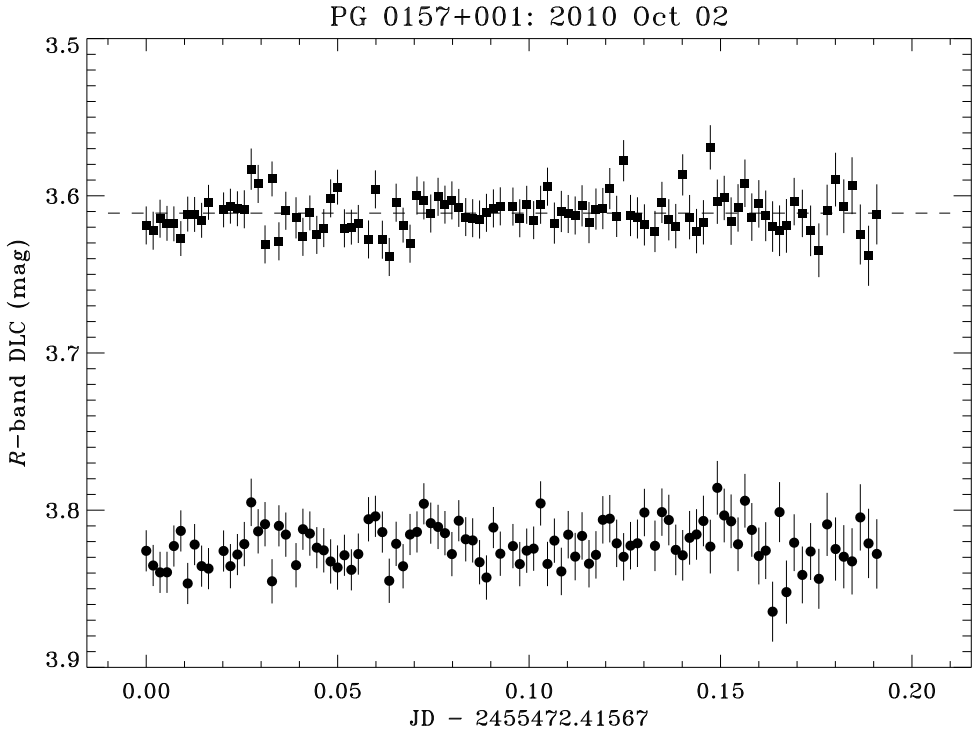

Fig. 3. DLCs of the target (filled circles) and control star (filled squares). The dashed line marks the weighted mean value of the control star DLC.

2 Discussion

We have presented the results of the intra-night optical monitoring of the radio-quiet quasar PG 0157+001. It showed no variability.

In previous intra-night monitoring campaigns of PG 0157+001 (Jang & Miller 1997; de Diego et al. 1998; Ramírez et al. 2009), INOV was detected only by the first authors (with an amplitude of about $0\overset{\mathrm{m}}{.}08$). Taking into account the first two campaigns, as well as ours, we estimated a duty cycle of 38 % (we did not consider Ramírez et al.'s campaign as they did not list the monitoring duration).

Leipski et al. (2006) reported a weak jet-like radio feature in PG 0157+001, which could be helpful in explaining the possible INOV of this quasar.

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