# Long-term R-band monitoring of the z$\sim$0.8 QSO SDSS J075448.86+303355.1. First results.

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(Research report. Accepted on 01.04.2009)

**Abstract.** We present preliminary results of our long-term optical *R*-band monitoring of the flat spectrum radio quasar SDSS J075448.86+303355.1 at redshift z=0.80. The investigation is carried out with the 2m RCC telescope at the Rozhen NAO, Bulgaria, from December 2003 to December 2007. The differential light curves indicate variability of $\sim$ 0.4 mag during the time of the monitoring. When including data from the literature the *R*-band light curve of the quasar exhibites variations with amplitude of up to 0.6 mag.

**Key words:** quasars individual: SDSS J075448.86+303355.1, photometry

### Дългосрочен мониторинг във филтър R на квазара SDSS J075448.86+303355.1 със z 0.8. Първоначални резултати.

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Представяме предварителни резултати от нашия продължителен мониторинг в R-лъчи на радио-квазара SDSS J075448.86+303355.1, с плосък спектър и червено отместване z=0.80. Изследването е проведено с 2-м RCC телескоп на НАО Рожен, България, в периода между декември 2003 и декември 2007. Диференциалните криви на блясъка свидетелстват за променливост от 0.4 звездни величини за периода на изследването. При добавяне на данни от литературата, кривата на блясъка на квазара в R-лъчи показва променливост до 0.6 звездни величини.

## Introduction

Most of the quasars show variability on short-term or long-term scales. This is established by studies of large samples of quasars but is based on very limited number of photometric measurements per individual object. The well–sampled light curves (tens of points per years) give grounds for better understanding of the physics of the central engine.

This work is part of a campaign for long-term investigation of a dozen high-redshifted quasars carry out with the telescopes of Rozhen NAO.

## 1 Observations

The observing period covers 4 years (end of 2003 – end of 2007). All data were obtained with the 2m RCC telescope at Rozhen NAO, Bulgaria. In most cases, the quasar was monitored during culmination in order to minimize the airmass variations. The seeing varied in the range of 1 $\div$ 3 arcsec with typical value of 1.5 arcsec. All observational information is summarized in Table 1.

All acquired images were bias subtracted and flat-fielded using standard IRAF routines. An example of R image (2006/04/01) is shown on Fig.1. The quasar SDSS J075448.86+303355.1 is marked with Q on the image. The two reference stars A and B used for the construction of the differential curves are also shown.

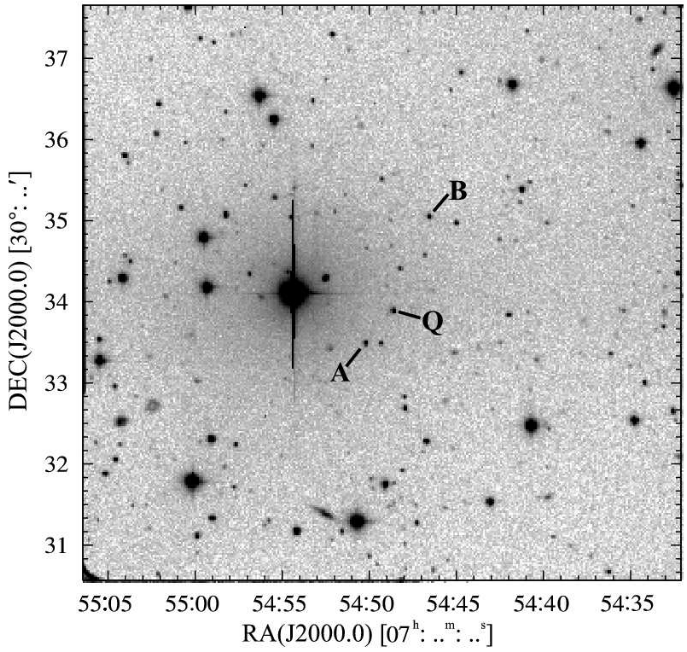


**Fig. 1.** An example of R-band image covering 7x7 arcmin$^2$ on the sky taken on April 01 2006. The quasar SDSS J075448.86+303355.1 is marked with Q. The two reference stars A and B used for the construction of the differential curves are also shown.

## 2 Differential light curves

Reference stars A and B (marked on Fig.1) were chosen to be close to the quasar and to have similar to the quasar magnitudes. Aperture photometry of the three objects was performed using APPHOT/IRAF package. The differences in the instrumental magnitudes $\Delta m$ of the quasar and every star (A and B) are shown on the top and middle panel on Fig.2. The differential light curves relative to the two stars indicate variability with amplitude of $\sim$0.4 mag. The differences in the magnitudes of the comparison stars (A-B) are shown on the bottom panel. The solid line is a linear fit to the data which exhibits rms of 0.02 mag.

**Table 1.** Observational data taken with the 2m RCC telescope at Rozhen NAO

| Date yyyy/mm/dd | Instrument | Pixel scale [arcsec px$^{-1}$] | FoV [arcmin$^2$] | Airmass | FWHM [arcsec] | Tot.Integr.Time [sec] |
|---|---|---|---|---|---|---|
| 2003/12/26 | Photometrics AT200A | 0.29 | 5.0x5.0 | 1.47 | 1.6 | 1200 |
| 2003/12/27 | Photometrics AT200A | 0.29 | 5.0x5.0 | 1.03 | 1.7 | 1200 |
| 2004/11/05 | Photometrics AT200A | 0.29 | 5.0x5.0 | 1.09 | 1.4 | 1200 |
| 2005/02/08 | VersArray 1300B | 0.26 | 5.7x5.5 | 1.09 | 3.5 | 300 |
| 2005/02/09 | VersArray 1300B | 0.26 | 5.7x5.5 | 1.02 | 3.6 | 180 |
| 2005/05/01 | VersArray 1300B | 0.26 | 5.7x5.5 | 1.43 | 1.8 | 180 |
| 2005/05/02 | VersArray 1300B | 0.26 | 5.7x5.5 | 1.52 | 1.4 | 120 |
| 2005/11/06 | VersArray 1300B | 0.26 | 5.7x5.5 | 1.03 | 1.1 | 600 |
| 2005/11/07 | VersArray 1300B | 0.26 | 5.7x5.5 | 1.30 | 0.9 | 400 |
| 2006/03/30 | VersArray 512B | 0.82 | 7.0x7.0 | 2.33 | 2.9 | 300 |
| 2006/04/01 | VersArray 512B | 0.82 | 7.0x7.0 | 1.06 | 1.6 | 300 |
| 2007/03/14 | VersArray 1300B | 0.26 | 5.7x5.5 | 1.12 | 4.3 | 120 |
| 2007/03/15 | VersArray 1300B | 0.26 | 5.7x5.5 | 1.13 | 1.8 | 120 |
| 2007/03/16 | VersArray 1300B | 0.26 | 5.7x5.5 | 1.10 | 1.8 | 120 |
| 2007/03/17 | VersArray 1300B | 0.26 | 5.7x5.5 | 1.02 | 1.2 | 180 |
| 2007/04/10 | VersArray 1300B | 0.26 | 5.7x5.5 | 1.66 | 1.3 | 300 |
| 2007/04/12 | VersArray 1300B | 0.26 | 5.7x5.5 | 1.14 | 1.4 | 180 |
| 2007/04/13 | VersArray 1300B | 0.26 | 5.7x5.5 | 1.24 | 1.5 | 600 |
| 2007/05/17 | VersArray 1300B | 0.26 | 5.7x5.5 | 2.31 | 3.3 | 300 |
| 2007/09/10 | VersArray 1300B | 0.26 | 5.7x5.5 | 1.95 | 2.0 | 300 |
| 2007/12/07 | VersArray 1300B | 0.26 | 5.7x5.5 | 1.09 | 3.4 | 300 |

## 3 Light curve of SDSS J075448.86+303355.1

The light curve of SDSS J075448.86+303355.1 is shown on Fig.3. The triangle presents $R_C$ CCD–magnitude from Helfand et al. [2001] obtained in 1996. The two open circles present the data taken from SDSS. The transformation of the $r'$ SDSS magnitudes of the quasar into *Cousins R* magnitudes, considering z=0.80, was made using the dependence of the difference ($R_C$-$r'$) of the redshift obtained by Ovcharov et al. [2008]. The filled circles present our data obtained during the 4 year monitoring. For calibration of the instrumental magnitudes were used the two reference stars A and B as their SDSS $r'$ magnitudes were converted into standard $R_C$ magnitudes using the transformation equation from Chonis & Gaskell [2008]. **Note:** This calibration is preliminary and we expect to reduce the uncertainties to less than 0.02 mag after absolute calibration with standard fields (Stetson [2000]). To test the variability of the object's luminosity a Monte Carlo simulation was carried out drawing 24 measurements from a constant source with the measured mean magnitude of the quasar $R_C$=17.59 mag. Each of these points was generated from a Gaussian distribution with the observational error of the corresponding measurement, so that the artificial datasets more faithfully represent the properties of the real observations. Regardless of whether we consider all data or restrict the sample only to our measurements, one million simulated data sets give 100% probability for variability, given the maximum observed peak-to-peak variation of ∼0.64 mag.

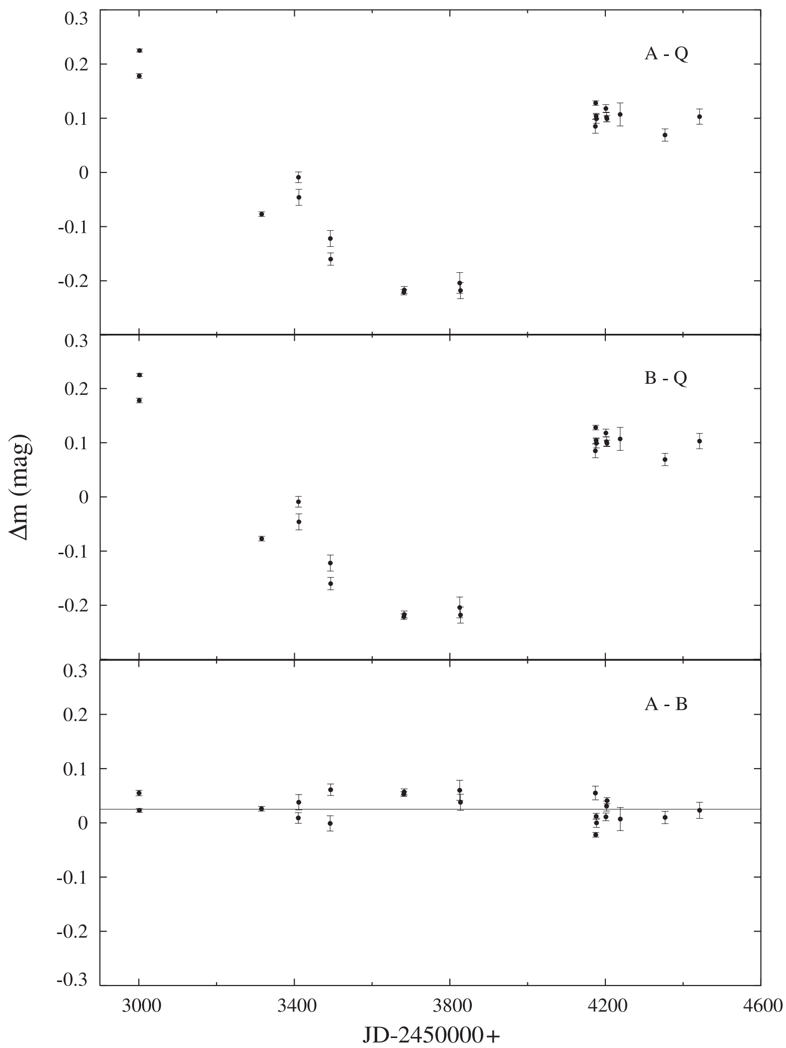


**Fig. 2.** The differences in the instrumental magnitudes of the quasar and every star (A and B) are shown on the top and middle panel. The differences in the magnitudes of the comparison stars (A-B) are shown on the bottom panel. The solid line is a linear fit to the data.

## 4 Absolute magnitude of SDSS J075448.86+303355.1

The absolute luminosity of the quasar J075448.86+303355.1 was calculated as the following cosmological parameters were adopted: $\Omega_\Lambda = 0.7$, $\Omega_M = 0.3$, and $H_0 = 70\, km\, s^{-1}\, Mpc^{-1}$. The absolute $R$-band magnitude $M_R$ is related

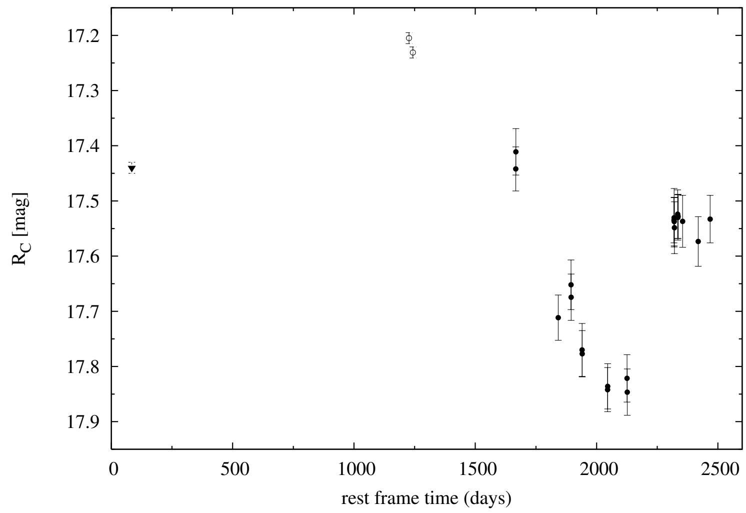


**Fig. 3.** Light curve of SDSS J075448.86+303355.1 in the rest frame. The triangle presents $R_C$ CCD–magnitude from Helfand et al. [2001]. The two open circles present SDSS data and the filled circles present our data obtained during the 4 year monitoring.

to the apparent magnitude $R$ by:

$$M_R = R - A_R - 5logd_L - 2.5log(1+z) - 25 + \Delta R_{kcorr(z)}, \qquad (1)$$

where $A_R$ is the Galactic absorption, and $d_L$ is the luminosity distance for a flat Universe (Peacock [1999]). The K-correction $\Delta R_{kcorr(z)}$ is calculated by the $R_C$-band K-correction as a function of the redshift obtained by Ovcharov et al. [2008]. Assuming $A_R = 0.154$ mag (Schlegel et al. [1998]) and the average $R_C = 17.59$ mag we obtained for the absolute luminosity of the quasar $M_R$= –26.73 mag. The comparison of this value with a sample of SDSS quasars' luminosities from Schneider et al. [2005] (Fig.4) reveals that this object is one of the brightest SDSS quasars at that redshift (J075448.86+303355.1 is marked with filled circle). The apparent $R$ magnitudes of the SDSS quasars were calculated from the SDSS $r'$ magnitudes according to the color transformations described in Ovcharov et al. [2008].

## 5 Future works

We expect to improve twice the light curve of J075448.86+303355.1 after absolute calibration of the instrumental magnitudes using standard stars observed in photometric nights. We also plan to recalibrate secondary standard stars in the field of SDSS J075448.86+303355.1 for the use of future studies. For deeper investigation of the quasar we plan to: obtain more observations of

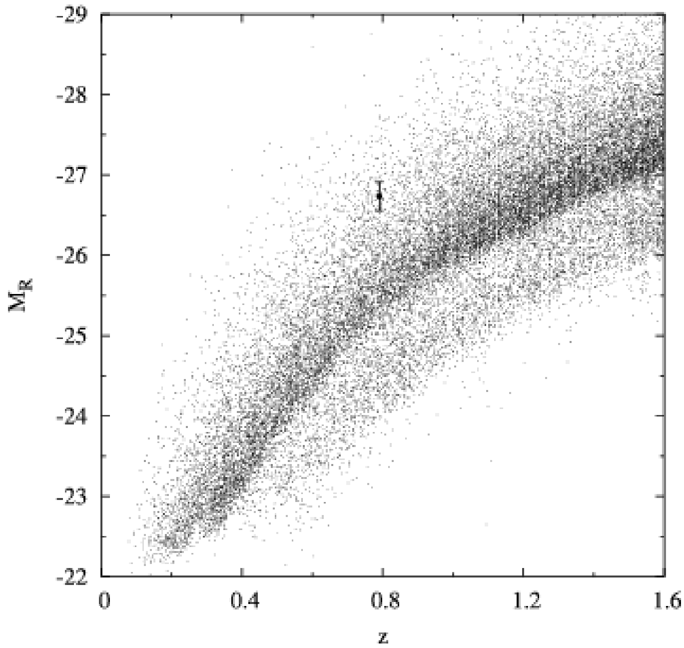


**Fig. 4.** Comparison of the absolute magnitude $M_R$ of J075448.86+303355.1 with a sample of SDSS quasars from Schneider et al. [2005] at $z$ up to 1.6. The absolute luminosity of the quasar ($M_R$ = –26.73) mag is marked with the filled circle.

the quasar; search for short-term variability via all-night continuous monitoring; construct the structure function S($\tau$) of the quasar to study its variability properties; search for associated emission line objects at the redshift z=0.80 around the quasar; calculation of the central black hole mass $M_{BH}$ using the broad emission line component of MgII and a code for decomposition of the emission lines into broad and narrow components developed by Ovcharov et al. [2005].

## 6 Summary

The variability amplitude of SDSS J075448.86+303355.1 was found to be $\sim$ 0.4 mag during the time of our monitoring and up to 0.6 mag when combining data from the literature. Although the presented results are still preliminary we can conclude with confidence that the studied quasar is a long-term variable object. We believe our future studies on the quasar would give contribution to the understanding of the physics of the central engine of the quasars.

## Acknowledgments

This work was partially supported by the following grants: DO02–340/2008 and DO02–362/2008 of the Bulgarian Science Foundation. P.N. would like to acknowledge the limited support from grant VU-F-201-06 with the Bulgarian NSF.

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