Long-term Variability Monitoring of the z~0.8 QSO SDSS J075448.86+303355.1. Observations and photometry

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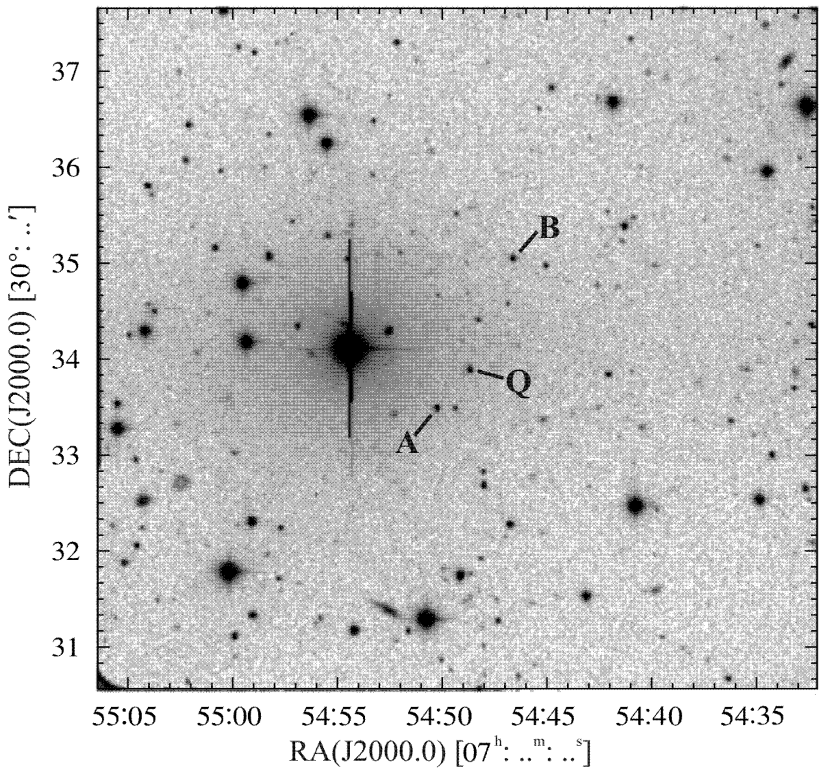
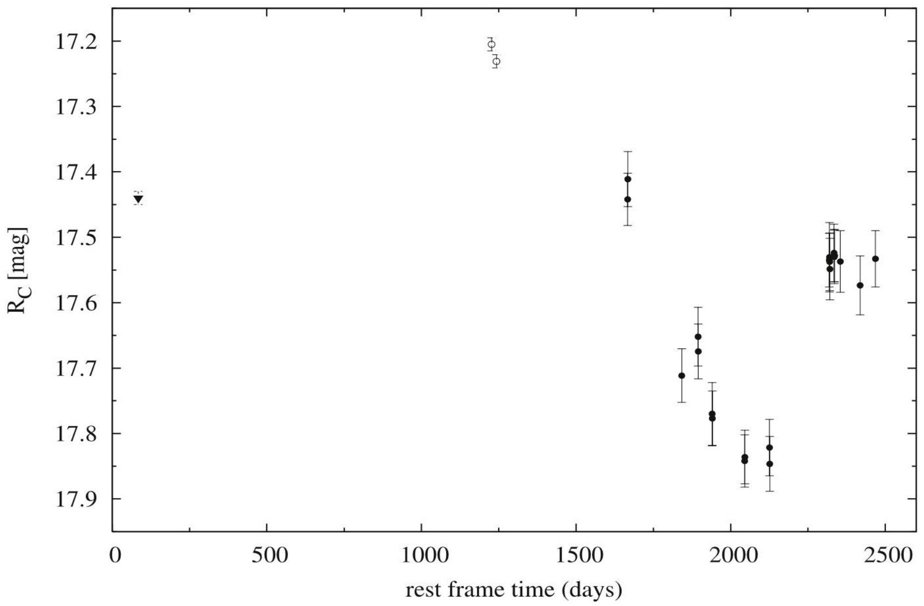
Most of the quasars show variability on short-term or long-term scales. This is established by studies of large samples of quasars but is based on very limited number of photometric measurements per individual object. The well-sampled light curves (tens of points per years) give grounds for a more precise estimation of some physical parameters of the quasars. This work is part of a campaign for long-term investigation of a dozen high-redshifted quasars. Here we report preliminary results of our 4-year optical R monitoring of the flat spectrum radio quasar SDSS J075448.86+303355.1 at redshift z=0.80 carried out with the 2-m RCC telescope at the NAO Rozhen, Bulgaria. Differential light curves of the quasar were generated relative to two nearby comparison stars imaged on the same frame. These curves indicate variability of ~0.4 mag during the time of our monitoring. When combining data from the literature the R light curve of the quasar exhibited variations with amplitude of up to 0.6 mag.

Observations

The observing period covers 4 years (end of 2003 - end of 2007). All data were obtained with the 2-m RCC telescope at NAO Rozhen, 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 – 3 arcsec with typical value of 1.5 arcsec. The images were bias subtracted and flat-fielded using standard IRAF routines. An example of R image (2006/04/01) is shown in the right. The QSO 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. ▶

Date yyyy/mm/dd	Instrument	Pixel scale [arcsec px^{-1}]	FoV [arcmin^2]	Airmass	FWHM [arcsec]	Total Integration 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

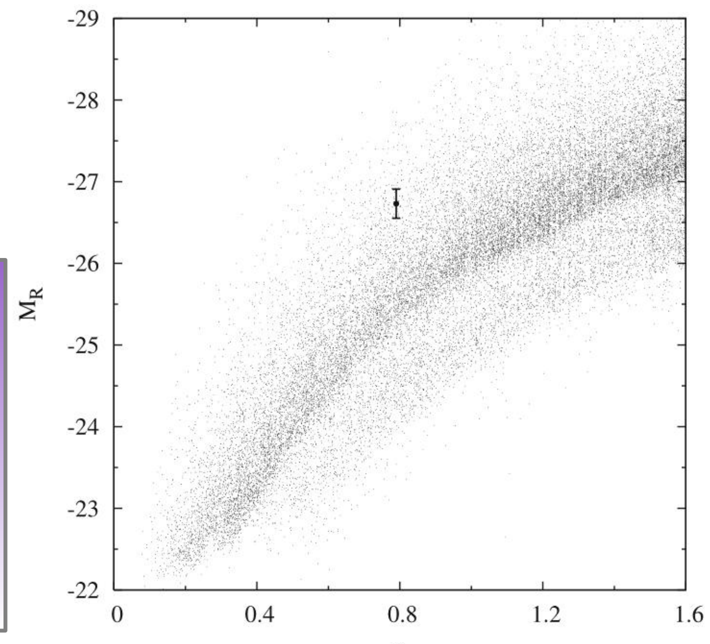




▲ Light curve of SDSS J075448.86+303355.1

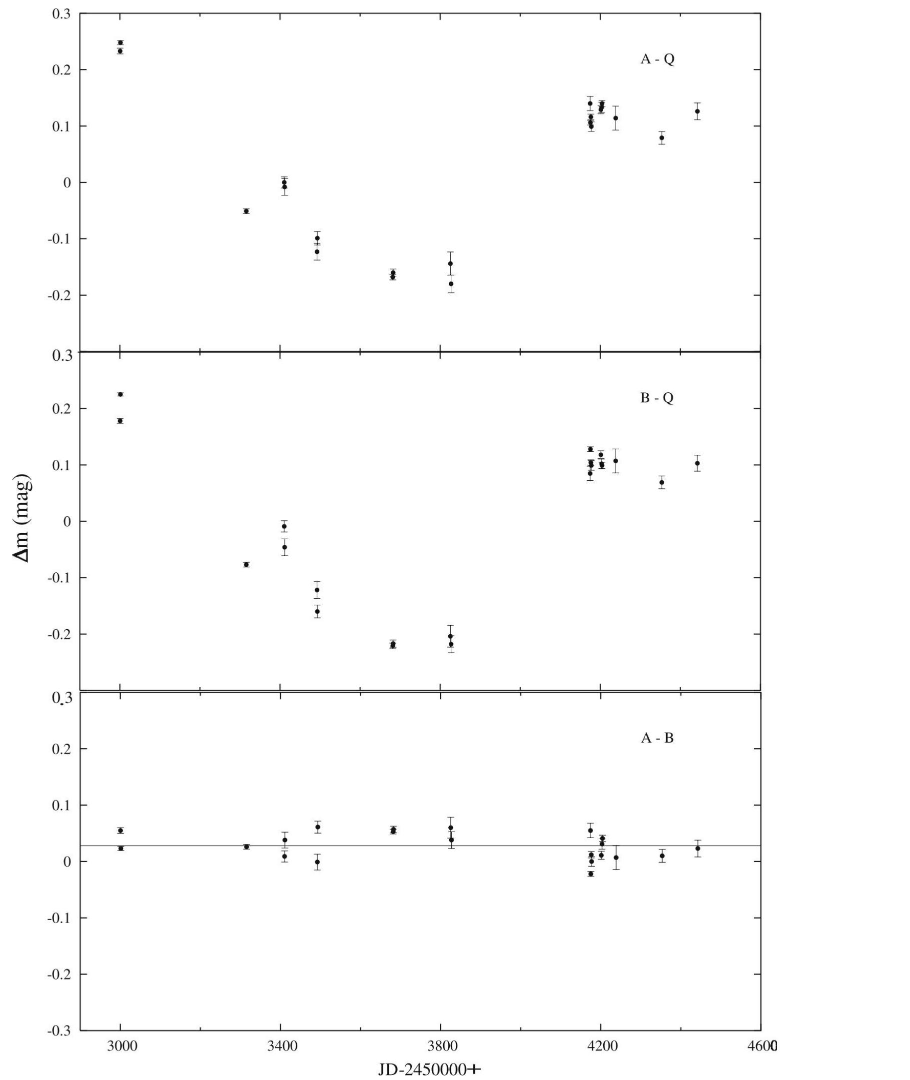
The triangle presents R_C CCD-magnitude from Helfand et al. 2001 obtained in 1996. The two open circles present the data from SDSS. Transformation of the r' SDSS magnitude of the quasar into Cousins R magnitude, considering z=0.80, was made using the dependence of the difference (R_c-r') of the redshift 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 by 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 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 us 100% probability for variability, given the maximum observed peak-to-peak variations of ~0.64 mag.

To calculate the absolute luminosity of J075448.86+303355.1, we adopted the following cosmological parameters: Ω_Λ=0.7, Ω_M=0.3, and H_0=70 km s^{-1} Mpc^{-1}. The absolute R-band magnitude, M_R, is related to the apparent magnitude, R, by $M_R = R - A_R - 5 \log d_L - 2.5 \log(1+z) - 25 + \Delta R_{kcorr}(z)$, where A_R is 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. Comparison of the absolute magnitude M_R of J075448.86+303355.1 with a sample of SDSS quasars from Schneider et al. (2005) shows that this object is one of the brightest SDSS quasar at that redshift (the bigger dot on the figure below). The apparent R magnitudes of the SDSS quasars were calculated from the SDSS r' magnitudes according to the colour transformations described by Ovcharov et al. (2008).



Differential light curves

Reference stars A and B (marked on the image to the left) were chosen to be close to the quasar and to have similar to the quasar magnitudes. Aperture photometry of the three objects was performed. The differences in the instrumental magnitudes of the quasar and every star (A and B) are shown on the top and middle panel. The differential light curves relative to the two stars indicate variability with amplitude of ~0.4 mag. The difference in the magnitudes of the comparison stars (A-B) is shown on the bottom panel. The solid line is the linear fit to the data which exhibits rms of 0.02 mag. ▼



What is coming up …

- Absolute calibration of the instrumental magnitudes of the quasar using standard stars observed in photometric nights. We expect to improve twice the light curve.
- Recalibration of secondary standard stars in the field of SDSS J075448.86+303355.1.
- More observations of the quasar obtained with 1m telescope at SAO, Russia will be added.
- Construct the structure function S(τ) of the quasar to study its variability properties.
- Short-term variability search via all-night continuous monitoring.
- Search for associated emission line objects at the redshift z=0.80 around the quasar. Observations obtained through a narrow band (FWHM=33 Å) interference filter IF672 centred at 6719 Å, very near to [OII] at z~0.80, were carried out with Photometrics AT200A camera at the 2m telescope at the Rozhen Observatory.
- 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).