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Observations Of The Double Quasar 0957+561 At The Rozhen NAO Following The JOMPQ Collaboration

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Light of a distant quasar, passing very close to the gravitational potential of a foreground galaxy, will be bent. The closer the ray passes to the center of mass of the galaxy the larger the effect will be. In special cases the image of the quasar will be split into two or more images and this is called macrolensing (Refsdal, 1964a). The first macrolensing system detected on cosmological scales was the Double or Twin Quasar 0957+561 (Walsh et al., 1979).

The photometric monitoring of brightness variations in gravitationally lensed quasars should permit the evaluations of cosmological parameters, such as Hubble parameter, the age and structure of the Universe, the mass distribution in distant galaxies, and the physical behavior of quasars (e.g., Refsdal, 1964b). To all these goals were devoted the MEGAPHOT (Schramm & Borgeest, 1993) and the Joint Optical Monitoring Program of Quasars (JOMPQ, Schramm et al., 1994) collaborations.

Following the Joint Proposal for a Photometric Quasar Monitoring Project we observed the Double Quasar 0957+561 during the night of Mar 13/14, 1994 using the 2-m telescope of the Rozhen National Astronomical Observatory, Bulgaria. The light detector was the ST-6 CCD camera (375×242 pixels, 23×27 μm pixel size, gain of 6.7 electrons/ADU, read-out noise of 30 electrons RMS/px; see also Georgiev et al., 1994) attached at the $f/8$ Ritchey-Chrétien focus of the telescope (plate scale of 12.892 arcsec/mm). A total of five Cousins R band frames were secured with the integration times of 60, 2×100, 300, and 500 sec.

We obtained additional observational material for 0957+561 using the same setup during the nights of Nov 6/7 (a single R band frame of 120 sec integration time) and Nov 7/8, 1996 (two R band frames of 300 and 900 sec integration times).

For both observing runs the seeing was 1.0-1.5 arcsec with no any clouds. Sets of twilight R band flat fields and dark current frames of corresponding integration times were obtained to be median combined.

The primary data reduction consists of the dark current, flat field, and cosmic ray hits corrections and was made in the usual way using the ESO-MIDAS package run on DEC work-station. The reduced 0957+561 frames were cleaned of contaminating objects (faint cluster galaxies) by fitting to them a 2-D Moffat function and subtracting the fitted model. For each frame the modal background value was then estimated and subtracted.

The total instrumental magnitudes of the objects of interest were derived through the least-squares fitting to them – on the cleaned and sky subtracted frames – a combination of 2-D Moffat functions. The Moffat shape and orientation parameters were assumed to be one and the same for the fitted objects as we have to fit either stars or star-like objects (the quasar images). The influence of the elliptical galaxy-lens on the B image magnitudes was not taken into account, so, they are probably overestimated.

As a local standard stars we used the southern, sS, and the western, wS, stars marked on Fig. 1. Their R band magnitudes were derived using the star H (R = 14.619 ± 0.011 mag; Serra-Ricart et al., 1999); it falls in our field of view (1.85×1.40 arcmin) only for the night of Nov 6/7, 1996 (see Fig. 1). The derived R band magnitudes are 18.620 ± 0.031 mag for sS and 18.957 ± 0.046 mag for wS. Using these stars we calculated the weighted mean zero point for each frame, which was then used to derive the quasar image magnitudes. The results from our photometry are listed in Table 1 and presented in Fig. 1, right panel, where an example of the fitting residual is shown. The reduced frames were sent also to the Hamburg observatory for detailed analysis.

We thank Dr. K.-J. Schramm, Hamburg, the initiator of this program, Dr. R. West, ESO, for making available the ST-6 CCD camera at the Rozhen NAO, V. Ivanova, Sofia, for kindly giving us a part of her observational time, and B. Komitov, Sofia, for the help at the telescope.

Table 1: Cousins *R* band light curve of the Double Quasar 0957+561 A and B images derived by us at the Rozhen NAO. The integration times are listed as well.

MJD	*T* [sec]	*m*A [mag]	σA [mag]	*m*B [mag]	σB [mag]
49425.05789	100	17.135	0.086	17.074	0.086
49425.05993	500	17.222	0.036	17.120	0.036
49425.06818	100	17.250	0.044	17.197	0.044
49425.07024	300	17.174	0.032	17.100	0.032
50394.66181	120	17.210	0.036	17.135	0.036
50395.63750	900	17.250	0.031	17.099	0.031
50395.64931	300	17.216	0.059	17.084	0.059

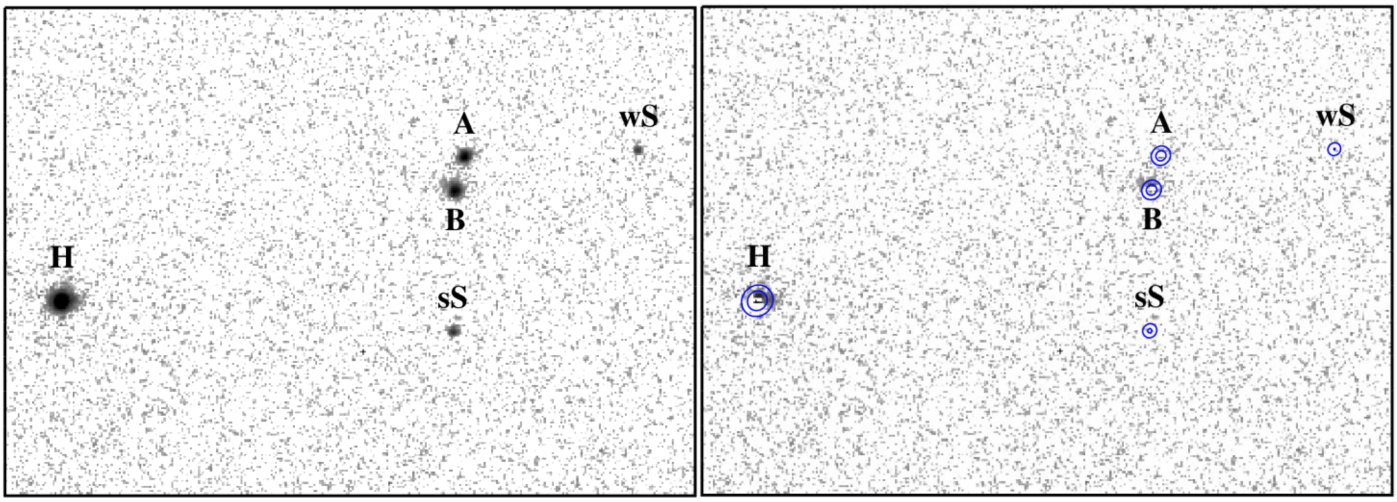

Figure 1: *Left panel:* Double Quasar field imaged on Nov 6/7, 1996. The quasar images are marked as A and B; their separation is about 6.2 arcsec. The stars used for the photometric calibration are marked as well. *Right panel:* residual frame obtained after the subtraction of the fitted combination of 5 Moffat functions; the reduced χ^2 of the fit is 1.09. The fitted model contour levels at $1\times\sigma_{sky}$ and $10\times\sigma_{sky}$ (σ_{sky} = 18.3 ADU) are overplotted to mark the object positions. The galaxy-lens residuals could be seen North of the B image. For both panels North is at the top, East to the left and a Gaussian filter of σ = 1 px was applied to suppress the noise.

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