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OPTICAL MONITORING OF THE X-RAY SOURCE QR And/RX J0019.8+2156

ŠIMON, V.[1]; SOBOTKA, P.[2]; MAREK, P.[3]; LEHKÝ, M.[3]

[1] Astronomical Institute, Academy of Sciences of the Czech Republic, 251 65 Ondřejov, Czech Republic,
e-mail: simon@asu.cas.cz

[2] MEDÚZA group of the Variable Star Section of CAS, N. Copernicus Observatory and Planetarium,
Kraví hora 2, 616 00 Brno, Czech Republic, e-mail: sobotka@meduza.org

[3] Observatory and Planetarium, Zámeček 456, 500 08 Hradec Králové, Czech Republic,
e-mail: astrohk@astrohk.cz

QR And was identified as an optical counterpart of the supersoft X-ray source RX J0019.8+2156 by Beuermann et al. (1995). It is a close eclipsing binary with the orbital period of 15.85 hours. QR And displays both a complicated orbital photometric modulation with an amplitude of about 0.5 mag and long-term variations by up to 2 mag (Greiner and Wenzel 1995, Will and Barwig 1996). In addition, rapid fluctuations on the time scale of an hour are superposed on the orbital modulation (e.g. Meyer-Hofmeister et al. 1998). The properties of QR And are commonly understood in terms of the model for the supersoft X-ray sources by van den Heuvel et al. (1992) which supposes a steady-state thermonuclear burning of the accreted matter on the surface of the white dwarf in a binary. A large part of the luminosity in the optical region is due to irradiation of the disk and the companion star by the white dwarf. The optical activity was interpreted in terms of variations of the accretion disk with a high rim (Meyer-Hofmeister et al. 1997).

QR And has been monitored in the framework of the observational campaign of the MEDÚZA group of the Variable Star Section of CAS, started in 1998. Here we report just the CCD observations in the V passband. They were obtained at Brno Observatory with Newton 400/2250 mm, equipped with the CCD camera SBIG ST-7, and at Hradec Králové Observatory using Newton 250/1250 mm and CCD camera SBIG ST-5.

Series of densely spaced measurements, covering up to several hours, were secured in most nights, the typical exposure time being 1 minute. The variable, the comparison star and the check star were placed in the same image. The typical standard deviation of the measurements is about 0.02 mag(V). The comparison star was identical to that used by Matsumoto (1996), having $V = 13.01 \pm 0.01$.

All CCD observations were folded with the orbital period according to several ephemerides. The ephemeris by Greiner and Wenzel (1995) which was valid between the years 1955–1993 did not yield good result. The primary minimum of the folded CCD light curve tended to occur too late and did not coincide with phase 0.0. Although our observations did not cover the primary minimum completely this phase shift was well visible. On the other hand, the ephemeris by Will and Barwig (1996). $T(\mathrm{min.\,I}) = 2448887.509 +$

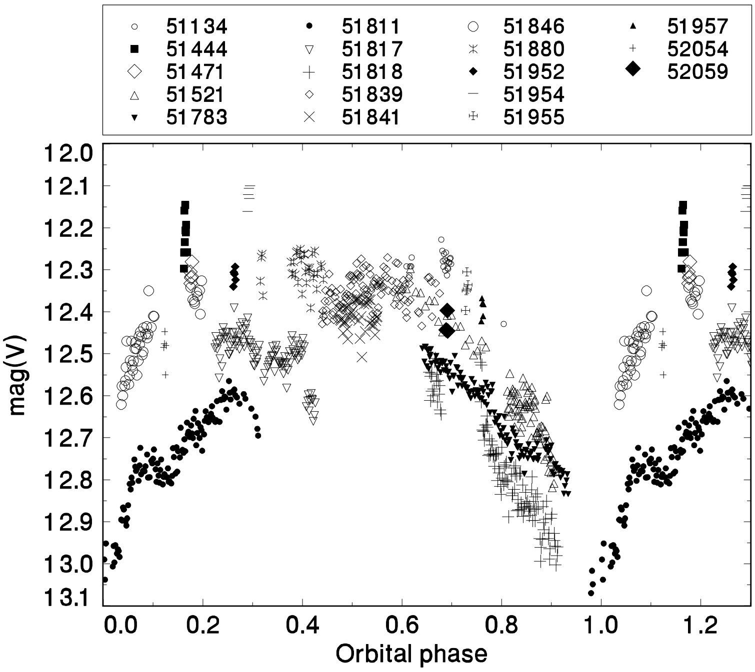

Figure 1. Orbital modulation of QR And in the V-filter over the years 1998–2001. The respective runs are resolved. The orbital ephemeris by Will and Barwig (1996) was used. See text for details

$0.6604721 \times E$, yielded better agreement (Fig. 1). It can be seen that the primary minimum of the folded light curve plausibly agrees with phase 0.0 now. Our observations therefore speak in favour of shortening the orbital period, first revealed by Will and Barwig (1996).

The scatter of the folded light curve of QR And in Fig. 1 is appreciable and also the shape of the modulation differs from the curves published previously. For example the folded light curve by Matsumoto (1996; his Fig. 1), composed of the data secured during the year 1995, displays a higher brightness before phase 0.5 than after it. On the contrary, our observations form a curve which is rather scattered within phases 0.2–0.7. This difference and scatter are caused mainly by the long-term changes, as can be seen from a comparison of the courses in the respective nights; variations as large as 0.5 mag(V) are apparent near phase 0.2 (Fig. 1). Notice the prominent variations of the rise from the primary minimum. There is a clearly apparent bump on egress at phase approx. 0.1 when the level of out-eclipse brightness is low. On the other hand, this feature is absent when QR And is generally brighter. This phenomenon may be tentatively interpreted in terms of variations of the profile of the elevated disk rim. The model by Meyer-Hofmeister et al. (1998, their Figs. 2 and 3) shows that in principle this bump may be produced if the rim is less pronounced in a lower state. The height of the rim depends on the mass transfer rate.

The amplitude of the orbital modulation in QR And over the interval covered by our observations is comparable to that of the long-term changes and it makes them less discernible. However, if we limit ourselves to the out-eclipse observations and divide the light curve into phase intervals then the long-term variations can better be assessed. Because the previous analyses revealed that the orbital light curve of QR And is asymmetric (ingress into primary eclipse is longer than egress (e.g. Will and Barwig 1996, Matsumoto 1996)) we will use the phases 0.1–0.8 only. The result is shown in Fig. 2 where each point

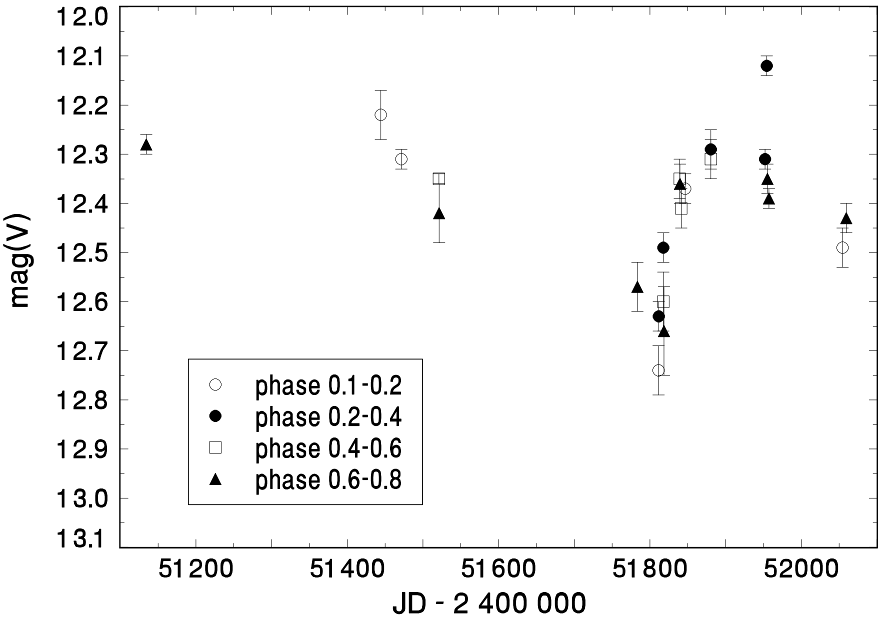

Figure 2. Long-term variations of QR And in the V-filter over the years 1998–2001. Only the out-eclipse data, divided into phase intervals, were used to suppress the influence of the orbital modulation. Each point represents the mean brightness in each bin in a given night. The error bars denote the standard deviations. See text for details

represents the mean brightness in each bin in a given night. Both the real changes and the observational noise contribute to the standard deviation of each bin, marked in Fig. 2. It can be seen that QR And underwent an episode of a shallow low state; the rapid rise from it can clearly be resolved.

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