EVOLUTION OF THE PHOTOMETRIC PROPERTIES OF THE MAGNETIC CATACLYSMIC BINARY QQ VUL IN 1986-88

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ABSTRACT. The long term activity variations of polar QQ Vul in 1986-88 are reported. Changes of the amplitude and the shape of phase eclipse curve are present. Moments of 20 minima are presented which are in a good agreement with the ephemeris by Andronov and Fuhrmann (1987, IBVS N 2976).

Keywords: Stars – binary, polars, Individual: QQ Vul

1. Introduction.

QQ Vul is one of the magnetic cataclysmic variables with relatively week magnetic pole (20×10^6 MGs). QQ Vul was discovered as a polar by Nousek et al. (1984). They derived orbital period of $P \approx 222$ min. Long-term variability has been investigated by Andronov and Yavorskij (1983). McCarthy et al.(1986) investigated two emission regions in this system - from high speed gas in the accretion flow and from the heated face of the secondary star. Osborne et al. (1986) introduced soft X–ray observations, which show presence of the two brightness minima during the orbital period. This may be possibly explained as a two–pole accretion in this system. Mukai et al. (1986) determined physical properties of the components, and explained the dips at the light curves as eclipses of the combination of the cyclotron beaming and of the occultation of the inner part of the accretion column by its outer part. They also discovered γ-velocity changes. In the second half of the 1985 year, the soft X-Ray curve of QQ Vul radically changed (Osborne, 1987). Instead of two neighbor minima, the new curve showed two unequal minima, separated by a half of period. Recently Cropper (1998) discussed week-to-week changes of the phase curve geometry, similar to our results.

2. Observations.

422 observations of QQ Vul were obtained in 1986–1988 at the Schmidt camera of the Abastumani Astrophysical Observatory by G.N.Kimeridze, I.L.Andronov, S.V.Kolesnikov and N.V.Poplavskaya (Andronov et al., 1989). All negatives were obtained during 20 nights and this material was an excellent one to obtain individual light curves. The photometric system are close to pg - the film A-500. The brightness of the comparison stars take from Andronov et al. (1983). The table of individual observations is acceptable via Internet (Halevin, 1997).

Observations were processed by the "Remove and Reduce" package (Halevin, 1996). For computing the value of the barycentric correction we took the spherical trigonometry formulae and the barycentric position expressions for the Earth in the cartesian coordinates (Soma et al., 1988).

We obtained 20 moments of minima, corresponding to the primary and secondary eclipses (Table 1, the O–C data are not listed for secondary minima). Elements are taken from Andronov and Fuhrmann (1987), where the phase zero corresponds to the photometric minima (1).

In Figure 1 we show the residuals O–C

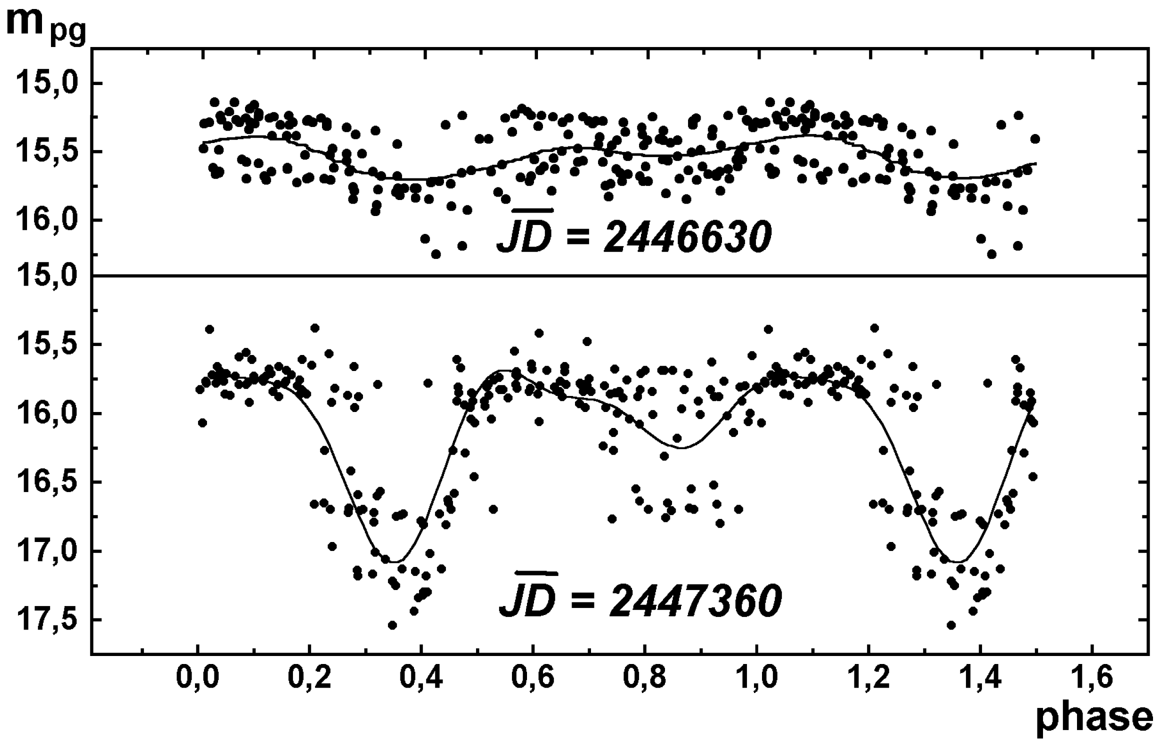

Figure 2. Phase curve of QQ Vul for two states.

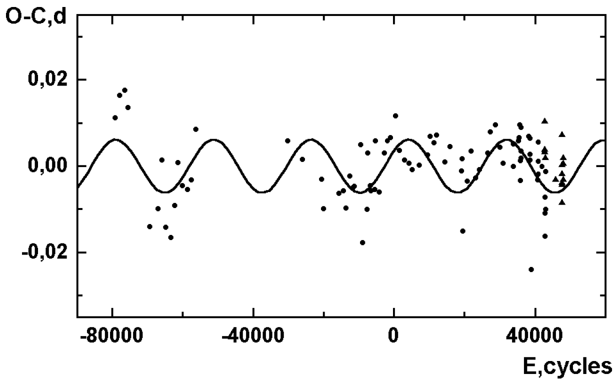

Figure 1. The O-C deviations for the primary minima of QQ Vul for the elements
$HJD = 2440000.0628 + 0.154520356 \cdot E.$ (1)
(Andronov and Fuhrmann, 1987). The curve corresponds to their sine ephemeris.

for moments of minima corresponding to this ephemeris and listed by Andronov and Fuhrmann (1987) (circles) and in Table 1 (triangles). Our points do not change the coefficients of the sine ephemeris by Andronov and Fuhrmann (1987) within their error estimates. The sine fit represents variations with some mean period and amplitude. Obviously, there are strong variations of both these parameters.

There are two photometric states of the activity with different amplitude of the variations (see unbinned phase light curves in Fig.2). In the more quiet phase the amplitude of phase curve is about $0.^m5 - 1.^m0$ during our 3 week observations in the 1986 year. In 1987 and in 1988, the brightness amplitude is about $1.^m5$. There is some dependence between the magnitude at maximum and the amplitude of the brightness variations (correlation coefficient $r = 0.723$, $r/\sigma_r = 3.6$, Fig.3). One of the possible explanations is that the greater accretion rate causes a part of the accretion stream to penetrate the magnetosphere more deeply, than at lower accretion rates, before threading along magnetic lines. The 'footpoint' of these lines occurs therefore at different latitudes, and then the accretion region would be seen at different angles.

Phase of the primary and the secondary minima is 0.35 ± 0.02 and 0.86 ± 0.05 according to the ephemeris by Cropper (1998) for the pulses of linear polarization. These values are close to 0.40 and 0.85 derived by Cropper for the observations from July, 1983 to June, 1986.

Also possible a weak trend of the width and depth of the both minima. Day-to-day changes of the maximal brightness one can see in Fig.4.

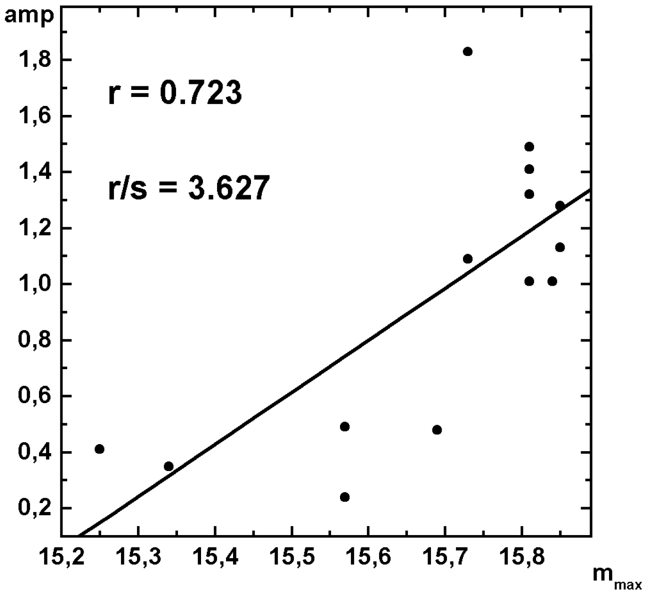

Figure 3. m_{max} vs amplitude.

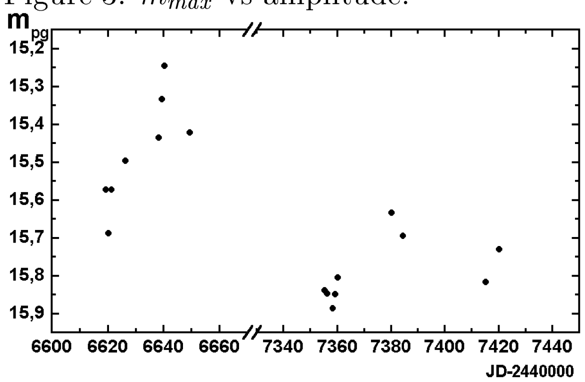

Figure 4. Variations of the maximal brightness.

3. Conclusions.

We investigated the photometric activity of magnetic cataclysmic variable QQ Vul in period of 1986–88:

(i) the amplitude is variable within $0.^{m}5$ – $1.^{m}5$, with changes of the maximal and minimal brightness, and the width of the primary and secondary minima;

(ii) the amplitude depends on the brightness at maximum nonlinearly, i.e. it is rather small for $m_{max} \leq 15.^{m}7$ and drastically increases for fainter states. One may note a year separation between the data in different states;

(iii) the variations of the phase of the mean primary eclipse may be explained by real changes of the accretion geometry in this system at times from days to years.

Table1.

HJD_{min}	σ_{min}	m_{min}	σ_m	O-C
6619.4089	0.0007	16.069	0.055	0.0031
6620.3431	0.0013	16.173	0.079	0.0102
6621.4182	0.0057	15.814	0.105	0.0037
6639.3407	0.0025	15.685	0.069	0.0017
6640.3381	0.0022	15.654	0.093	
7095.3253	0.0014	17.130	0.208	-0.0032
7355.3130	0.0061	16.429	0.272	
7355.3818	0.0015	16.853	0.121	-0.0045
7356.3205	0.0052	16.618	0.327	0.0072
7356.4680	0.0009	16.978	0.183	0.0001
7359.3189	0.0013	16.642	0.113	
7359.4018	0.0018	17.132	0.184	-0.0020
7359.4786	0.0017	16.410	0.157	
7360.3223	0.0027	16.818	0.229	-0.0086
7360.4064	0.0052	16.494	0.290	
7360.4814	0.0010	17.300	0.161	-0.0041
7415.4067	0.0044	16.501	0.209	
7418.4273	0.0017	17.226	0.263	-0.0032
7420.2866	0.0025	16.819	0.324	0.0018
7420.4398	0.0003	17.558	0.104	0.0004

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