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ON THE PERIOD OF QQ VULPECULAE : NEW MINIMA FROM OLD PLATES

QQ Vul is an AM Her-type system with the longest known period. However, the value of this period was not known so precisely, as it is needed to accurate phase determination.

In this paper we present the previous results of the re-examination of the observations from Moscow (Andronov and Yavorskij 1983) and Sonneberg (Fuhrmann, 1984) plate collections. The modified version of the program published by Andronov (1985) was adopted for the period search and light curve approximation using the cubic spline functions.

The values of $P=0.1545207^d \pm 3\cdot10^{-7}$ (M) and $P=0.1545204^d \pm 3\cdot10^{-7}$ (S) were derived for all Moscow (M) and Sonneberg (S) observations. No peaks were seen at the periodograms near the positions of the previously published periods. The derived moments of "normal" minima are the moments of time, nearest to the mean time of the observations in a fixed season, which have the corresponding phase. The accuracy of the moments of minima was usually $0.001-0.002^d$, but never larger than 0.005^d. All the available moments of minima are presented in Table I, together with 19 minima published by Andronov e.a. (1986 a, b) and 3 minima derived from the photoelectric light curves published by Nousek e.a. (1984) and Mukai e.a. (1986). The following linear elements were obtained using the least-square method :

$$\text{Min. HJD} = \underset{\pm 8}{2440000.0628} + \underset{\pm 22}{0^d.154520356}\cdot E \qquad \text{(A)}$$

The residuals from this ephemeris are shown in Fig.1. Assuming the cyclic variation of them, one may obtain the best fit formula :

$$\text{Min.HJD} = \underset{\pm 7}{2440000.0633} + \underset{\pm 18}{0^d.154520351}\cdot E + \underset{\pm 96}{0^d.00618}\cdot\cos(2\pi(E-E_o)/P_E) \qquad \text{(C)}$$

where $E_o=4125\pm692$, $P_E=27712\pm 945$. The phase of the periodic variations may also be written as $2\pi(t-t_o)/P_t$, where $t_o=2440637\pm107$, and $P_t=4282\pm146$.

As in other polars, the cyclic changes of (O-A) might be interpreted by the "swinging dipole" model (Andronov, 1982,1986; Campbell, 1984). The amplitude of the changes of the orientation of the magnetic axis of the white

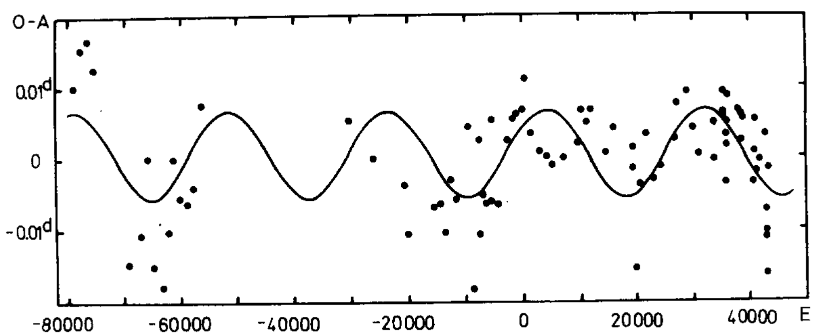

Figure 1

dwarf, is 14±2°, that is nearly the same as the value of 17° observed in AM Herculis (Andronov, 1982). But the cycle duration is four times longer as compared with 1100^d in AM Herculis. These "swingings" may cause the changes of the photometric and spectral characteristics of QQ Vul observed by Mukai et al. (1986).

It must be pointed out that we observe the cyclic but not periodic changes in (O-A) and in other characteristics, Not only the cycle, but the amplitude is variable as well. So the equation (C) corresponds only to the mean value of the cycle length. One of the possible explanations might be connected with the long term changes of the characteristics of the secondary's atmosphere (Wenzel and Fuhrmann 1983). The large dispersion of O-C of $0.006^d = 0.04^P$, as one may see from photographic and photoelectric observations, is also characteristic for polars, because of the heterogeneities of the accretion flow which lead to the rapid changes in the accretion column's structure. However, this phenomenon has to be investigated using statistical methods in future works.

It might be noted that in the third "long-period" polar H 0538+ 608 recently discovered by Remillard e.a.(1986), the shapes of the polarization and photometric curves underwent changes, which are much more pronounced compared with other polars. The possible explanation might be that the white dwarf in this object is still synchronizing, but not synchronized (eg.Andronov, 1986), so the "waltz" stage is not become yet to a "swing" stage.

Table I

T	D - R	D - C	E	Rem.	T	D - R	D - C	E	Rem.
27779.677	0.0101	0.0039	-79086	S^{*}_{*}	41578.495	0.0063	0,0052	10215	M_{*}
27979.477	0.0153	0.0093	-77793	S_{*}	41752.947	0.0048	0,0053	11344	M
28190,244	0.0165	0.0114	-76429	S_{*}	41879,810	0.0066	0,0082	12165	M
28345.842	0.0125	0,0083	-75422	S	42241.536	0.0005	0.0049	14506	M_{*}
29294,724	-0,0149	-0.0113	-69281	S_{*}	42453.696	0,0041	0.0093	15879	M_{*}
29647.189	-0.0108	-0,0052	-67000	S	42978.905	-0,0016	0,0043	19278	M
29823,508	0.0004	0.0065	-65859	S_{*}	42984,007	0.0012	0.0071	19311	M
29990.529	-0.0151	-0,0089	-64778	S	43034.673	-0,0155	-0.0097	19639	M_{*}
30221.689	-0,0175	-0.0119	-63282	S_{*}	43217,173	-0.0040	0,0010	20820	M
30389.042	-0.0101	-0.0052	-62199	S	43372.473	0.0031	0.0070	21825	M_{*}
30523.021	-0.0002	0,0038	-61332	S_{*}	43572.107	-0.0032	-0.0008	23117	M
30730,382	-0.0055	-0.0031	-59990	S	43746.717	-0.0012	-0.0003	24247	M
30937.593	-0.0063	-0,0057	-58649	S_{*}	44101,345	0.0026	0.0003	26542	M_{*}
31103.241	-0.0041	-0.0050	-57577	S	44222.803	0.0076	0.0044	27328	M
31310.310	0.0076	0.0049	-56237	S	44457,830	0.0091	0.0043	28849	M_{*}
35342,516	0.0051	0.0046	-30142	S_{*}	44656.538	0.0040	-0.0018	30135	M
35990.261	0.0008	-0.0045	-25950	S	44798.384	0.0003	-0,0058	31053	M
36814.777	-0.0038	-0.0085	-20614	S_{*}	45231,818	0,0047	-0.0009	33858	N
36907.946	-0.0106	-0,0143	-20011	S	45232,740	-0.0004	-0.0060	33864	N
37583.358	-0.0070	-0.0056	-15640	S	45460.509	0,0056	0.0012	35338	S
37791.343	-0.0064	-0.0033	-14294	S	45485.542	0.0063	0.0021	35500	S
37904,757	-0.0104	-0.0064	-13560	S_{*}	45501.615	0.0092	0.0051	35604	S
38061.448	-0.0030	0.0020	-12546	M	45530.502	0.0009	-0.0030	35791	Ab
38177.490	-0.0058	-0.0003	-11795	S	45530.652	-0.0037	-0.0075	35792	Ab
38264.640	-0.0052	0.0006	-11231	S_{*}	45562.490	0.0031	-0,0005	35998	Ab
38533.824	0.0043	0.0105	- 9489	M	45562.650	0,0086	0.0050	35999	Ab
38629,295	-0.0183	-0.0122	- 8871	S_{*}	45563.570	0.0015	-0,0021	36005	Ab
38825.389	-0.0106	-0.0051	- 7602	S_{*}	45908.619	0,0066	0.0058	38238	Mu
38836.682	0.0024	0.0078	- 7529	M	45961,305	0.0011	0.0009	38579	Ab
38946,693	-0.0051	-0.0002	- 6817	M	45963,315	0.0024	0.0021	38592	Ab
38982.386	-0.0063	-0.0016	- 6586	S_{*}	45969.345	0.0061	0.0059	38631	Ab
39159.312	-0,0061	-0.0026	- 5441	M_{*}	46006.275	0.0057	0.0058	38870	Ab
39168,131	0.0053	0.0087	- 5384	S	46296,455	-0.0035	-0.0008	40748	Ab
39341.491	-0.0066	-0.0046	- 4262	M_{*}	46324.270	-0,0022	0.0007	40928	Ab
39584,715	0.0024	0.0022	- 2688	M	46328.295	0.0053	0,0082	40954	Ab
39726.413	0,0052	0.0038	- 1771	M_{*}	46328.445	0.0008	0.0037	40955	Ab
39853,275	0.0060	0.0035	-950	M	46489.454	-0.0004	0.0037	41997	Ab
40081.352	0,0110	0.0068	526	M_{*}	46621.418	0.0032	0.0031	42851	Aa
40239.882	0.0031	-0.0020	1552	M	46626,352	-0.0075	-0.0025	42883	Aa
40466.252	0.0008	-0,0052	3017	M_{*}	46638,241	-0.0165	-0.0115	42960	Aa
40660.947	0.0002	-0.0060	4277	M	46639.328	-0,0112	-0,0061	42967	Aa
40797,387	-0.0013	-0.0073	5160	M_{*}	46653.399	-0,0015	0.0036	43058	Aa
41119.563	-0.0002	-0.0049	7245	M	46655.399	-0.0103	-0.0052	43071	Aa
41492.732	0.0021	0.0002	9660	M					

Remarks:

S,M - Mean minima from Sonneberg and Moscow Plates;

* - observations from two or three subsequent seasons were used

N - minima from Nousek e.a.(1984)

Mu - Mukai e.a.(1986)

Aab - Andronov (1986ab)

Because of its longest known period, QQ Vulpeculae is in some sense the intermediate object between "classical" and "intermediate" polars. So further simultaneous multicolour observations might clarify the details of the structure and evolution of magnetic close binaries.

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