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PERIOD CHANGES OF RR LYRAE STARS II, TW HER, VZ HER, AV PEG AND TU UMA

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PERIOD CHANGES OF RR LYRAE STARS II.
TW HER, VZ HER, AV PEG AND TU UMA

ABSTRACT

Photographic and photoelectric observations obtained at Konkoly Observatory during the past 35 years are presented. Using all available observations the O-C diagrams of TW Her, VZ Her, AV Peg and TU UMa are constructed. The period of TW Her is constant whereas that of VZ Her, AV Peg and TU UMa is changing. The periods of VZ Her and AV Peg show an increase at a rate of $+1.144 \times 10^{-10}$ day/cycle = 8.20 ms/year and $+1.846 \times 10^{-10}$ day/cycle = 14.92 ms/year, respectively whereas the period of TU UMa is decreasing at a rate of -0.710×10^{-10} day/cycle = -4.02 ms/year. Superimposed on the parabolic O-C diagrams of AV Peg and TU UMa are cyclic variations which may result from the duplicity of these stars.

INTRODUCTION

In a previous paper (*Oláh* and *Szeidl*, 1978) we commenced the systematic evaluation of photographic and photoelectric observations obtained at Konkoly Observatory on single periodic field RR Lyrae stars during the past 45 years. In the present paper we have extended the investigation to the RR Lyrae type stars TW Her, VZ Her, AV Peg and TU UMa. Using our observations we were able to derive accurate times of maximum light of these variable stars.

In order to construct precise and detailed O-C diagrams of these stars we collected all the available moments of maxima and attempted to treat them critically and rigorously.

As a general rule, because visual observations are inferior to photoelectric observations, the visual observations carried out since the photoelectric technique was introduced have not been taken into account in calculating the new elements of light variation.

In addition, the photographic maxima were, in many cases, poorly determined. The reason for this was that photographic plates with long exposure

times taken for discovery or survey purposes were used too. Usually these plates were obtained sporadically and were not well distributed in time; moreover, the brightness data of the variable stars determined from these photographs badly defined the light curves especially near the maximum light.

Over the past 25 years a number of photoelectric observations have been obtained by different authors. In general, these observations were carried out in order to study the physical properties of the stars, but these authors did not determine the observed epochs of maximum. The accurate observations, however, gave us a good chance to fix new times of maximum light.

In subsequent papers we plan to publish our results on further RR Lyrae variables.

OBSERVATIONS

The 16 cm astrograph of Konkoly Observatory was used to obtain photographic observations of the stars VZ Her and AV Peg. Table 1 summarizes the most important data of the photographic observations published here. Kodak Eastman and Guilleminot Superfulgur plates were used and the typical exposure times were 2-5 minutes.

Table 1

VZ Her			AV Peg		
Plate No.	J.D.	No. of obs.	Plate No.	J.D.	No. of obs.
H 2103, 2104	2433427	28	H 2330	2433884	19
2134	2433475	37	2747	2434598	13
2293	2433836	21	2751	2434600	25
2449	2434154	18	3213	2435343	24
2763	2434605	25	3255	2435393	28
3203	2435339	14	3264	2435395	26
3563	2435991	18		total	: 135
	total	: 161			

A number of plates were obtained for TW Her as well but the series of one of the neighbouring stars (BD $+30^{\circ}3078$) blended with the series of the variable star on the multiple exposure plates thereby preventing TW Her from being measured on these plates.

Up till 1957, photoelectric observations were made in integrated light; since 1958, the UBV system has been utilized. The 60 cm Newton telescope at

Budapest was used for the observations except for those made in 1982 and 1983. These observations were obtained with the 50 cm Cassegrain telescope at Konkoly Observatory's Piszkésteto" mountain station.

The photomultipliers and filters used are described elsewhere (*Oláh* and *Szeidl*, 1978).

Most of the photoelectric observations were obtained by Prof. L. Detre, Drs. L. Csank, G. Paál, and the present authors.

The photoelectric observations have been transformed into the UBV system in the traditional way (see e.g. *Hardie*, 1962). The log of the photoelectric observations of TW Her, VZ Her, AV Peg and TU UMa made at Konkoly Observatory is reproduced in Table 2.

Table 2

star	year	kind of obs.	No.	star	year	kind of obs.	No.
TW Her	1959	pe ΔV	157	AV Peg	1972	pe ΔV	18
		pe ΔB	110			pe ΔB	18
	1969	pe ΔV	34		1973	pe ΔV	31
		pe ΔB	34			pe ΔB	31
	1978	pe ΔV	50		1978	pe ΔV	49
		pe ΔB	55			pe ΔB	52
	1983	pe ΔV	38		1979	pe ΔV	21
		pe ΔB	38			pe ΔB	22
		pe ΔU	39		1982	pe ΔV	24
						pe ΔB	24
VZ Her	1958	pe ΔV	103		1983	pe ΔV	69
		pe ΔB	105			pe ΔB	70
	1959	pe ΔV	135			pe ΔU	67
		pe ΔB	84				
	1969	pe ΔV	64	TU UMa	1957	pe Δm*	114
		pe ΔB	64		1958	pe ΔV	163
		pe ΔU	18			pe ΔB	178
	1978	pe ΔV	41		1959	pe ΔV	68
		pe ΔB	42			pe ΔB	71
					1978	pe ΔV	19
AV Peg	1954	pe Δm*	50			pe ΔB	22
	1959	pe ΔV	226		1979	pe ΔV	35
		pe ΔB	126			pe ΔB	36
	1969	pe ΔV	15		1983	pe ΔV	23
		pe ΔB	16			pe ΔB	20
						pe ΔU	18

The photographic and photoelectric observations obtained at Konkoly Observatory are given in Tables 11-14.

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*in integrated light

TW HERCULIS

The variability of the star TW Her = 93.1910 = HV 3279 was discovered by *Cannon* (1910) on Harvard photographs. *Zinner* (1922) was the first to observe the star visually and he published two dates when the star was near maximum brightness (10.3 magn.). These times have been included in the list of times of maximum (Table 4).

Thorough visual observations of TW Her were carried out by *Hoffmeister* (1922) in the years 1917-1920 and he determined the RR Lyrae type character of its light variations and derived the elements:

$$\text{J.D.max.hel.} = 2421545.2376 + 0^{d}.3995977 \cdot E$$

On the basis of further photographic observations in 1925, *Hoffmeister* (1927) rediscussed the elements of light variations and confirmed his previous results. He gave the new formula:

$$\text{J.D.max.hel.} = 2421545.2376 + 0^{d}.39959954 \cdot E$$

The large amplitude of the rapid light variation of the star makes it an easy object for visual observations. Hence TW Her tended to be very popular among visual observers, and a great number of visual observations have been collected in the past sixty years. In particular the Soviet astronomers (*Batyrev*, 1951b; *Bogdanov*, 1972; *Lange*, 1938, 1959, 1960, 1961; *Nachapkin*, 1938; *Soloviev*, 1935a, b, c, 1936a, d, 1937; *Soloviev* and *Shakovskoj*, 1958; *Steinman*, 1958; *Tsessevich*, 1966) were very active. The BAV group (*Braune* and *Hübscher*, 1967; *Braune*, *Hübscher* and *Mundry*, 1970, 1972, 1979; *Braune* and *Mundry*, 1973, 1982; *Domke* and *Pohl*, 1952; *Hübscher* and *Mundry*, 1984) *and Ahnert* (1967, 1970, 1971) supplemented this series of visual observations.

Mention is made of the photographic observations of *Alania* (1954, 1956). Because the exposure times he used were fairly long and the light curves were not well defined the dates of maximum given by him are unreliable and cannot be used for investigating the changes in the period of TW Her.

Photoelectric observations were carried out by *Fitch* et al. (1966), *Sturch* (1966), *Epstein* (1969) and *Stepien* (1972). Although *Sturch*, *Epstein* and *Stepien* did not give any moments of maximum we were able to determine reliable maxima from their observations for the years 1963, 1966 and 1967.

The photoelectric photometry of this star was taken up at Konkoly Ob-

servatory in 1959. The comparison star used in our photometry (indicated by "c" in Figure 1) was the same as used by *Sturch* (1966). The brightness and colours of *Stepien*'s (1972) comparison star and of some neighbouring stars measured on one night are also given in Table 3. The identification chart of these objects is shown in Figure 1.

Table 3

Magnitudes and colours of comparison stars of TW Her

star	V	B-V	U-B	References
a = BD +30°3081	10.097	+0.388	+0.035	Stepien (1972)
b = BD +30°3080	10.277	+0.953		present study
c	10.554	+0.266	-0.004	Sturch (1966)
d	10.580	+0.969		present study
e	11.420	+0.561		present study
f	12.109	+0.339		present study

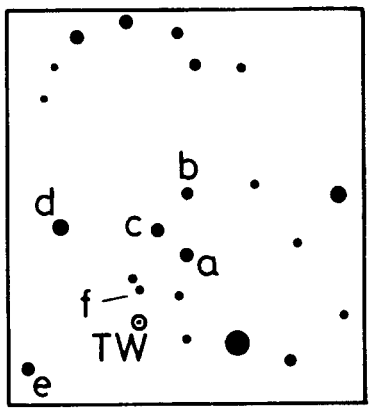

Figure 1: Identification chart of TW Her

The photoelectric observations obtained at Konkoly Observatory (in the sense: variable minus comparison star "c") are given in Table 11 and shown in Figure 2. A comparison of the photoelectric light curves obtained by *Fitch* et al. (1961), *Sturch* (1966), *Epstein* (1969), and *Stepien* (1972) with those published in the present paper provides proof of the stable character of the light variation of TW Her: any kind of light curve variation, i.e. Blazhko effect, is out of the question.

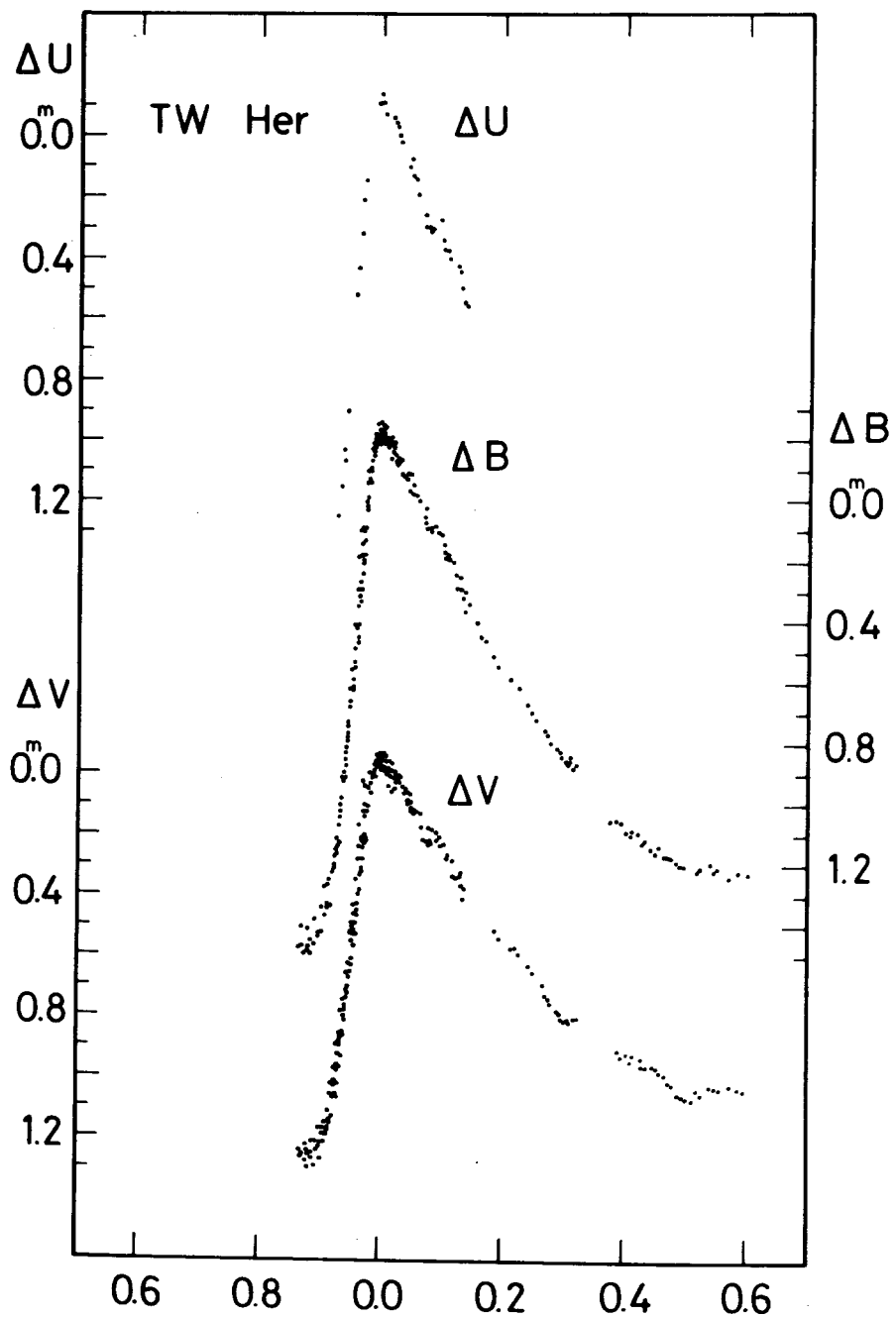

Figure 2: Light curves of TW Her

Table 4

year	J.D.max.hel.	O - C_1	O - C_2	E	method	w	Reference
1912	2419714.271	+0.0047	+0.0049	-4582	vis	1	Zinner (1922)
1913	20092.283	-0.0050	-0.0048	-3636	vis	1	-"-
1917	21545.253	+0.0190	+0.0191	0	vis	1	Hoffmeister (1922)
1918	21642.732	-0.0044	-0.0043	+ 244	vis	1	-"-
	21665.523	+0.0094	+0.0095	301	vis	1	-"-
	21669.510	+0.0004	+0.0005	311	vis	1	-"-
	21721.453	-0.0046	-0.0046	441	vis	1	-"-
	21731.448	+0.0004	+0.0004	466	vis	1	-"-
	21749.438	+0.0083	+0.0084	511	vis	1	-"-
	21820.560	+0.0015	+0.0016	689	vis	1	-"-
1919	22191.382	-0.0054	-0.0053	1617	vis	1	-"-
1920	22607.371	-0.0001	-0.0001	2658	vis	1	-"-
1925	24376.403	+0.0023	+0.0021	7085	pg	2	Hoffmeister (1927)
	24380.401	+0.0043	+0.0041	7095	pg	2	-"-
	24386.394	+0.0033	+0.0031	7110	pg	2	-"-
	24406.369	-0.0017	-0.0019	7160	pg	2	-"-
	24408.365	-0.0037	-0.0039	7165	pg	2	-"-
	24410.360	-0.0067	-0.0069	7170	pg	2	-"-
1927	24967.407	-0.0023	-0.0025	8564	vis	1	Tsessevich (1966)
	25067.304	-0.0053	-0.0055	8814	vis	1	-"-
	25069.303	-0.0043	-0.0045	8819	vis	1	-"-
	25071.300	-0.0053	-0.0055	8824	vis	1	-"-
	25077.300	+0.0007	+0.0005	8839	vis	1	-"-
	25083.287	-0.0063	-0.0065	8854	vis	1	-"-
	25085.298	+0.0067	+0.0065	8859	vis	1	-"-
	25087.288	-0.0013	-0.0015	8864	vis	1	-"-
	25089.286	-0.0013	-0.0015	8869	vis	1	-"-
	25091.281	-0.0043	-0.0045	8874	vis	1	-"-
	25093.281	-0.0023	-0.0025	8879	vis	1	-"-
	25095.273	-0.0083	-0.0085	8884	vis	1	-"-
	25097.275	-0.0043	-0.0045	8889	vis	1	-"-
	25099.281	+0.0037	+0.0035	8894	vis	1	-"-
	25103.270	-0.0033	-0.0035	8904	vis	1	-"-
	25107.264	-0.0053	-0.0055	8914	vis	1	-"-
1933	27309.463	-0.0025	-0.0029	14425	visN	1	Lange (1938)
1934	27599.1755	-0.0001	-0.0005	15150	visN	1	Soloviev (1935a, b)
1935	27969.202	-0.0033	-0.0037	16076	visN	1	Soloviev (1935c, 1936a, d)
1936	28373.203	+0.0020	+0.0015	17087	visN	1	Soloviev (1937)
	28394.784	+0.0046	+0.0041	17141	visN	1	Soloviev,Shakovskoj (1958)
	28403.508	-0.0626	-0.0631	17163	visN	0	Nachapkin (1938)
1942	30616.1602	+0.0038	+0.0032	22700	vis	1	Tsessevich (1966)
1949	33122.444	-0.0042	-0.0051	28972	vis	1	Batyrev (1951b)
	33191.184	+0.0046	+0.0037	29144	vis	1	-"-
	33203.169	+0.0016	+0.0007	29174	vis	1	-"-
	33211.166	+0.0066	+0.0057	29194	vis	1	-"-
	33217.161	+0.0076	+0.0067	29209	vis	1	-"-
1951	33829.362	+0.0212	+0.0203	30741	pg	0	Alania (1954)
	33858.517	+0.0054	+0.0045	30814	vis	1	Domke, Pohl (1952)
	33872.504	+0.0064	+0.0054	30849	vis	1	-"-
	33898.4795	+0.0079	+0.0069	30914	vis	1	-"-
1953	34577.393	+0.0008	-0.0002	32613	pg	0	Alania (1954)
1955	35364.248	+0.0432	+0.0421	34582	pg	0	Alania (1956)
1957	36090.6842	+0.0064	+0.0053	36400	visN	1	Steinman (1958)

Table 4 (cont.)

year	J.D.max.hel.	O - C_1	O - C_2	E	method	w	Reference
1959	2436756.4066	-0.0050	-0.0062	38066	vis	0	Lange (1959)
	36756.4144	+0.0028	+0.0017	38066	pe	3	present paper
	36758.4059	-0.0037	-0.0049	38071	vis	0	Lange (1959)
	36758.4105	+0.0009	-0.0003	38071	pe	3	present paper
	36760.4006	-0.0070	-0.0082	38076	vis	0	Lange (1959)
	36760.4101	+0.0025	+0.0014	38076	pe	3	present paper
	36762.4010	-0.0046	-0.0058	38081	vis	0	Lange (1959)
	36776.3917	+0.0001	-0.0011	38116	pe	3	present paper
	36784.3767	-0.0069	-0.0081	38136	vis	0	Lange (1959)
1960	37130.4288	-0.0085	-0.0097	39002	vis	0	Lange (1960)
	37134.4272	-0.0061	-0.0073	39012	vis	0	-"-
	37136.4263	-0.0050	-0.0062	39017	vis	0	-"-
	37142.4178	-0.0075	-0.0087	39032	vis	0	-"-
	37144.4160	-0.0073	-0.0085	39037	vis	0	-"-
	37158.4066	-0.0027	-0.0039	39072	vis	0	-"-
	37164.4019	-0.0014	-0.0026	39087	vis	0	-"-
	37170.3930	-0.0043	-0.0055	39102	vis	0	-"-
1961	37494.4695	-0.0035	-0.0047	39913	vis	0	Lange (1961)
	37496.4670	-0.0040	-0.0052	39918	vis	0	-"-
	37518.4453	-0.0037	-0.0049	39973	vis	0	-"-
	37520.4396	-0.0074	-0.0086	39978	vis	0	-"-
	37522.4417	-0.0033	-0.0045	39983	vis	0	-"-
1962	37781.3834	-0.0024	-0.0037	40631	vis	0	Tsessevich (1966)
	37789.3763	-0.0015	-0.0028	40651	vis	0	-"-
	37809.3651	+0.0073	+0.0060	40701	vis	0	-"-
	37813.3563	+0.0025	+0.0012	40711	vis	0	-"-
	37817.3551	+0.0053	+0.0040	40721	vis	0	-"-
	37841.3332	+0.0074	+0.0061	40781	vis	0	-"-
	37847.3290	+0.0092	+0.0079	40796	vis	0	-"-
	37869.2963	-0.0016	-0.0028	40851	vis	0	-"-
	37871.3002	+0.0044	+0.0031	40856	vis	0	-"-
	37872.4926	-0.0020	-0.0033	40859	vis	0	-"-
	37873.2944	+0.0006	-0.0007	40861	vis	0	-"-
	37878.4891	+0.0004	-0.0008	40874	vis	0	-"-
	37881.2878	+0.0020	+0.0007	40881	vis	0	-"-
	37883.2845	+0.0006	-0.0006	40886	vis	0	-"-
	37884.4816	-0.0011	-0.0023	40889	vis	0	-"-
	37899.2738	+0.0059	+0.0047	40926	vis	0	-"-
	37903.2650	+0.0011	-0.0002	40936	vis	0	-"-
	37925.2374	-0.0045	-0.0058	40991	vis	0	-"-
	37943.2207	-0.0032	-0.0045	41036	vis	0	-"-
	37955.2040	-0.0079	-0.0092	41066	vis	0	-"-
	37959.2030	-0.0049	-0.0062	41076	vis	0	-"-
	37961.2018	-0.0041	-0.0054	41081	vis	0	-"-
	37963.2006	-0.0033	-0.0046	41086	vis	0	-"-
1963	38179.3919	+0.0044	+0.0031	41627	vis	0	-"-
	38181.3924	+0.0069	+0.0056	41632	vis	0	-"-
	38207.3591	-0.0004	-0.0018	41697	vis	0	-"-
	38209.3630	+0.0055	+0.0042	41702	vis	0	-"-
	38221.3489	+0.0034	+0.0020	41732	vis	0	-"-
	38223.3438	+0.0003	-0.0011	41737	vis	0	-"-
	38229.3374	-0.0001	-0.0015	41752	vis	0	-"-
	38231.3407	+0.0052	+0.0038	41757	vis	0	-"-

Table 4 (cont.)

year	J.D.max.hel.	O - C_1	O - C_2	E	method	w	Reference
1963	2438233.3324	-0.0011	-0.0025	41762	vis	0	Tsessevich (1966)
	38235.3365	+0.0050	+0.0036	41767	vis	0	-"-
	38243.724	+0.0009	-0.0005	41788	pe	3	Sturch (1966)
	38259.3038	-0.0037	-0.0051	41827	vis	0	Tsessevich (1966)
	38263.3096	+0.0060	+0.0047	41837	vis	0	-"-
	38267.2995	-0.0001	-0.0014	41847	vis	0	-"-
	38269.2943	-0.0033	-0.0046	41852	vis	0	-"-
	38271.2932	-0.0024	-0.0037	41857	vis	0	-"-
	38273.2908	-0.0028	-0.0041	41862	vis	0	-"-
	38275.2901	-0.0015	-0.0028	41867	vis	0	-"-
	38283.2800	-0.0036	-0.0049	41887	vis	0	-"-
	38285.2765	-0.0051	-0.0064	41892	vis	0	-"-
	38289.2789	+0.0013	0.0000	41902	vis	0	-"-
	38293.2810	+0.0074	+0.0061	41912	vis	0	-"-
	38295.2728	+0.0012	-0.0001	41917	vis	0	-"-
	38297.2778	+0.0082	+0.0069	41922	vis	0	-"-
1964	38559.811	+0.0042	+0.0028	42579	pe	3	Fitch et al. (1966)
1965	38855.530	+0.0191	+0.0177	43319	vis	0	Braune, Hübscher (1967)
	38915.451	+0.0001	-0.0013	43469	vis	0	-"-
	38931.443	+0.0081	+0.0067	43509	vis	0	-"-
	39027.348	+0.0090	+0.0077	43749	vis	0	-"-
	39053.322	+0.0090	+0.0077	43814	vis	0	-"-
	39055.313	+0.0020	+0.0007	43819	vis	0	-"-
	39057.3135	+0.0045	+0.0032	43824	vis	0	-"-
1966	39233.539	+0.0064	+0.0050	44265	vis	0	Braune et al. (1970)
	39263.507	+0.0044	+0.0030	44340	vis	0	Ahnert (1967, 1970)
	39285.489	+0.0084	+0.0070	44395	vis	0	Braune et al. (1970)
	39289.876	-0.0002	-0.0016	44406	pe	3	Epstein (1969)
	39387.376	-0.0026	-0.0041	44650	vis	0	Braune et al. (1970)
	39389.387	+0.0104	+0.0089	44655	vis	0	-"-
1967	39631.9350	+0.0011	-0.0004	45262	pe	3	Stepien (1972)
	39707.8592	+0.0013	-0.0002	45452	pe	3	-"-
1968	40065.512	+0.0120	+0.0105	46347	vis	0	Braune et al. (1970)
	40073.491	-0.0010	-0.0025	46367	vis	0	-"-
1969	40419.5467	+0.0010	-0.0005	47233	pe	3	present paper
1970	40740.428	+0.0034	+0.0019	48036	vis	0	Ahnert (1971)
	40804.368	+0.0074	+0.0059	48196	vis	0	Braune et al. (1972)
1971	41074.493	+0.0027	+0.0012	48872	vis	0	-"-
	41166.404	+0.0057	+0.0041	49102	vis	0	Bogdanov (1972)
	41186.384	+0.0057	+0.0041	49152	vis	0	-"-
	41194.391	+0.0207	+0.0191	49172	vis	0	-"-
	41240.331	+0.0067	+0.0051	49287	vis	0	Braune et al. (1972)
1972	41558.408	+0.0020	+0.0004	50083	vis	0	Braune, Mundry (1973)
	41576.399	+0.0110	+0.0094	50128	vis	0	-"-
1977	43401.359	-0.0027	-0.0045	54695	vis	0	Braune et al. (1979)
1978	43717.4447	-0.0007	-0.0025	55486	pe	3	present paper
	43755.4085	+0.0011	-0.0007	55581	pe	3	-"-
1981	44742.420	+0.0004	-0.0015	58051	vis	0	Braune, Mundry (1982)
	44770.396	+0.0044	+0.0025	58121	vis	0	-"-
1982	45162.397	-0.0023	-0.0043	59102	vis	0	Hübscher, Mundry (1984)
	45226.330	-0.0054	-0.0073	59262	vis	0	-"-
	45238.323	-0.0004	-0.0023	59292	vis	0	-"-
1983	45546.4153	+0.0003	-0.0017	60053	pe	3	present paper

The list of maxima observed by different authors is presented in Table 4. The letter "N" indicates that the maximum is a normal one. The abbreviations "vis","pg","pe" refer to visual, photographic and photoelectric observations, respectively; w gives the weight of the time of maximum which was taken into account in the period analysis, all the published dates before 1959 were used in our analysis except the times of maximum given by *Alania* (1954, 1956) (see the comment above) and the epoch of *Nachapkin* (1938). *Nachapkin*'s observations were reanalysed by *Soloviev* and *Shakovskoj* (1958) and they gave a more reliable epoch.

Since reliable and well-defined photoelectric maxima have been available from 1959, from this time onwards only these epochs were taken into account in investigating the possible period changes of the star; all visual observations after 1958 have been neglected.

Throughout the years the ephemeris given by *Tsessevich* (1966) has been used for calculating the O-C values:

$$C_1 = \text{J.D. max.hel.} = 2421545.2340 + 0^d.399600104 \cdot E$$

The $O-C_1$ values are given in the third column of Table 4.

A quadratic fit of the O-C diagram yields the elements:

$$\text{J.D.max.hel.} = \underset{\pm.0009}{2421545.2333} + \underset{\pm.000000086}{0^d.399600221} \cdot E \; \underset{\pm.016}{-0^d.015 \times 10^{-10}} \cdot E^2$$

Since the error of the quadratic term exceeds the value itself, this solution shows that a linear fit of the O-C diagram gives satisfactory results:

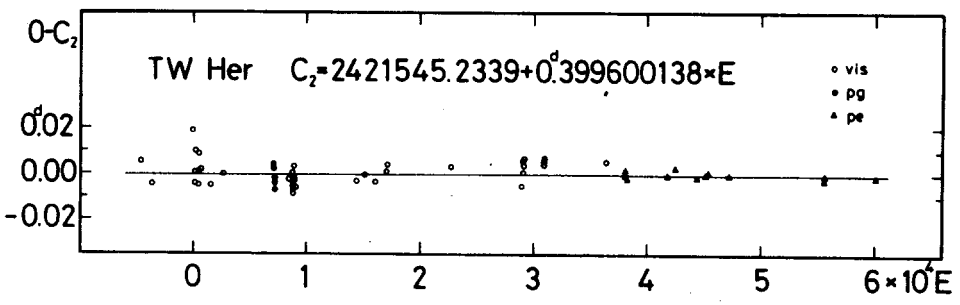

Figure 3: O-C diagram of TW Her

$$C_2 = \text{J.D.max.hel.} = 2421545.2339 + 0^d.399600138 \cdot E$$
$$\pm.0007 \quad \pm.000000022$$

The $O-C_2$ values in Table 4 were calculated by this formula. This analysis shows that the period of TW Her has not undergone noticeable period changes during the past 70 years. The constancy of its period can be taken for granted.

VZ HERCULIS

The variable star VZ Her = 38.1919 (= BV 281) was discovered by *Wolf* (1919) on photographic plates taken at Heidelberg. *Leiner* (1920) determined the RR Lyrae type variability and gave the following elements from his visual observations:

$$\text{J.D.max.hel.} = 2422388.496 + 0^d.44032 \cdot E$$

Later *Haas* (1926) obtained some photographic observations but they were very few and cannot be used to determine a reliable moment of maximum light.

Tsessevich (1926) and then *Florja* (1934a) observed the star visually. *Tsessevich* gave the new formula:

$$\text{J.D.max.hel.} = 2422388.500 + 0^d.44032425 \cdot E$$

while *Florja* found that the period was linearly increasing:

$$\text{J.D.max.hel.} = 2425004.458 + 0^d.44032419 \cdot E + 0^d.987 \times 10^{-10} \cdot E^2$$

New and very accurate photographic observations were obtained by *Balázs* (1936). She found no changes in the period of the star, and according to her:

$$\text{J.D.max.hel.} = 2425004.4614 + 0^d.44032425 \cdot E$$

Payne-Gaposchkin (1954) made use of the Harvard photographs and derived a normal maximum for the years around 1940. From our list of maxima (Table 6) This very uncertain point has been omitted.

Tsessevich (1943, 1966) supplemented his previous visual observations with new ones and carried out a detailed investigation of the changes in the

period of VZ Her. He stated that the period changed abruptly around J.D. 2427250 (summer 1933), and before that time the elements were:

$$\text{J.D.max.hel.} = 2425004.4590 + 0^{d}.44032394 \cdot E$$

and since that time the formula:

$$\text{J.D.max.hel.} = 2425004.4456 + 0^{d}.44032631 \cdot E$$

has been valid.

Strohmeier and *Bauernfeind* (1968) investigated the star on Bamberg archive plates and determined some 80 instances of light maximum back to the beginning of this century. The O-C's of these maxima have a very large scatter therefore we have taken only the mean maxima from their table.

Photoelectric observations were made by *Sturch* (1966), *Fitch* et al. (1966) and *Butler* et al. (1982). *Fitch* et al. gave two times of light maximum; *Sturch* and *Butler* et al., however, did not publish any time of maximum. Their observations do not cover the light curve around the maximum therefore we fitted the mean photoelectric V light curve obtained at Konkoly Observatory into their observations and in this way we were able to determine two epochs of maximum: one for the year 1964 (from *Sturch*'s observations) and one for the year 1976 (from *Butler* et al.'s observations).

At Konkoly Observatory VZ Her was photographically observed in 1950, 1951, 1952, 1953, 1955 and 1957 (Table 12a). The comparison stars used were taken from *Balázs* (1936). The star was first observed photoelectrically in 1958 on J.D. 2436363. Our photoelectric observations are given in Table 12b, c, d, and are presented in Figure 5. For these observations BD $+36^{\circ}2836$ was used as a comparison star. Secondary comparison stars were also observed. The identification chart of the comparison stars is shown in Figure 4 and their brightness and colours are given in Table 5.

All the observed maxima are listed in Table 6. It is clear from previous investigations that all the maxima cannot be satisfied with one period. *Tsessevich* (1966) stated that with two periods, one before J.D. 2427250 and one after it, the O-C diagram of VZ Her can be well interpreted.

In order to construct the whole O-C diagram we used the mean value of *Tsessevich*'s (1966) two periods:

$$C_1 = \text{J.D.max.hel.} = 2425004.4590 + 0^{d}.44032512 \cdot E$$

Table 5

Comparison stars for VZ Her

star	V	B-V	U-B	Reference
a = BD $+36^{\circ}2836$ (main)	10.947	+0.510	+0.050	Sturch (1966)
b (secondary)	11.290	+0.522		present study
c (secondary)	11.355	+0.564		present study

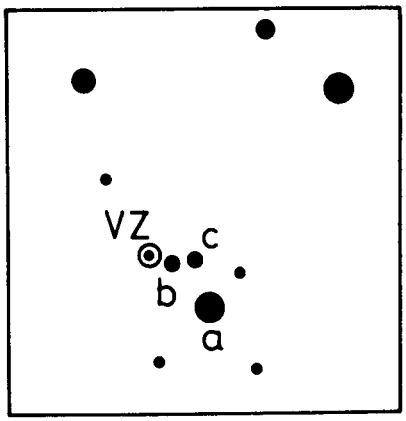

Figure 4: Identification chart of VZ Her

The O-C diagram of VZ Her is shown in Figure 6.

The photoelectric observations made in the 60's and 70's show that *Tsessevich*'s assumption is not correct: the O-C diagram cannot be represented by two straight lines.

The period of the star has increased continuously and we supposed in our calculation that since the observations of *Leiner* (i.e. since 1920) the period has changed linearly. Following our procedure we used the visual observations only before photoelectric observations existed. The O-C's of *Strohmeier* and *Bauernfeind*'s (1968) photographic maxima exhibited a very large scatter therefore they were simply omitted when calculating the elements. The new formula with the quadratic term is:

$$C_2 = \text{J.D.max.hel.} = \underset{\pm.0004}{2425004.4581} + \underset{\pm.000000044}{0^d.440324431}\cdot E + \underset{\pm.011}{0^d.572\times10^{-10}}\cdot E^2$$

These new elements well represent all the observed maxima (except those of *Strohmeier* and *Bauernfeind*). Consequently the period of VZ Her has changed by $+1.144\times10^{-10}$ day/cycle = $+8.199\times10^{-3}$ sec/year in the past 60 years.

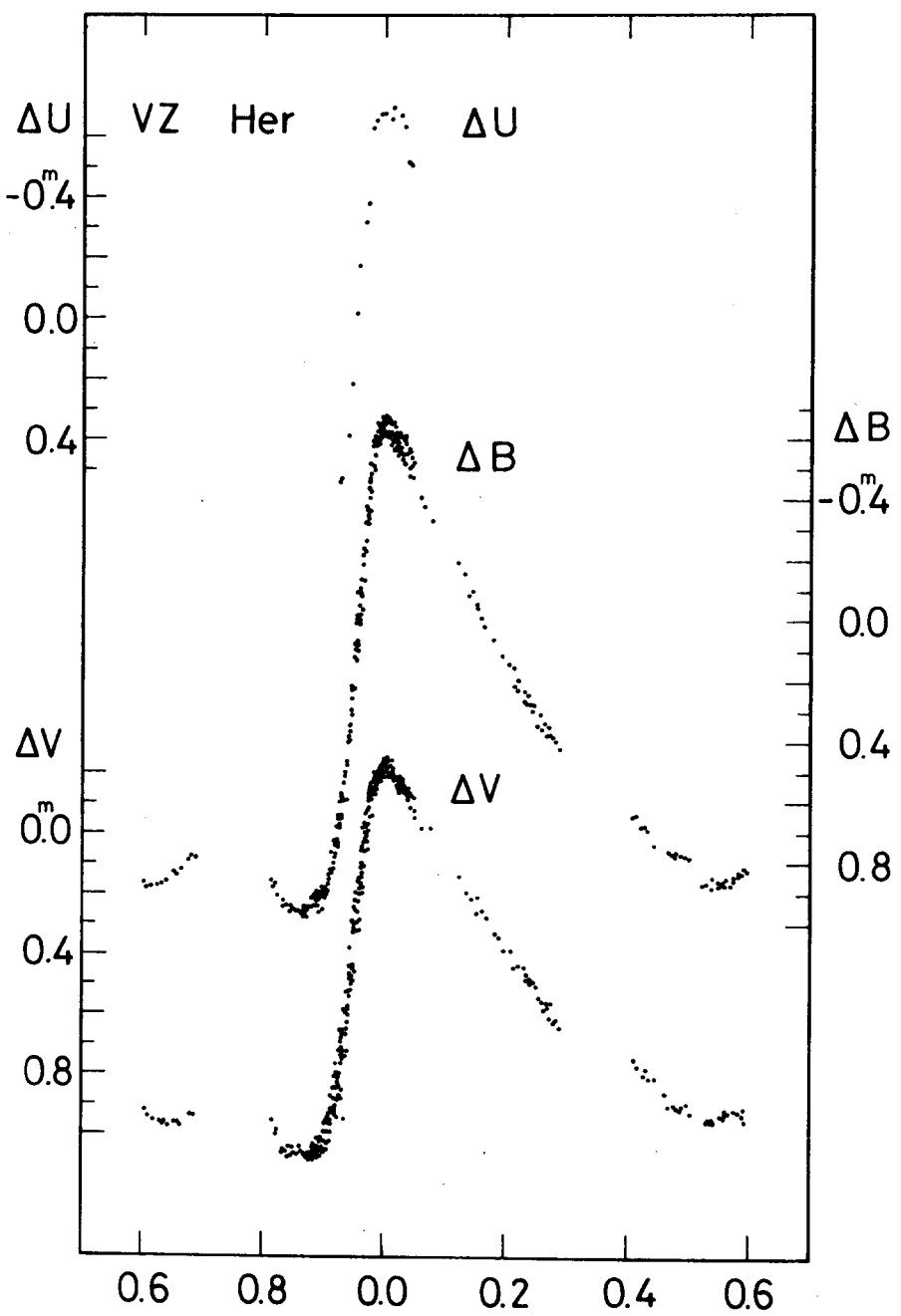

Figure 5: Light curves of VZ Her

Table 6

year	J.D.max.hel.	O - C_1	O - C_2	E	method	w	Reference
1901	2415663.534	+0.1321	+0.0926	-21214	pgM	0	Strohmeier,Bauernfeind(1968)
1902	15800.915	+0.1317	+0.0932	20902	pgM	0	-"-
1909	18521.609	+0.0567	+0.0351	14723	pgM	0	-"-
1916	21028.789	+0.0255	+0.0155	9029	pgM	0	-"-
1920	22388.496	+0.0085	+0.0033	5941	vis	1	Leiner (1920)
1923	23544.809	+0.0278	+0.0258	3315	pgM	0	Strohmeier,Bauernfeind(1968)
1926	24786.500	+0.0019	+0.0025	495	visN	1	Tsessevich (1926, 1943)
1927	24970.550	-0.0040	-0.0031	- 77	vis	1	Tsessevich (1943)
	25086.357	-0.0025	-0.0015	+ 186	vis	1	-"-
1928	25325.455	-0.010	+0.0004	729	vis	1	-"-
1930	26066.520	-0.0032	-0.0010	2412	vis	1	-"-
	26185.847	-0.0043	-0.0020	2683	vis	1	-"-
1931	26546.476	-0.0016	+0.0010	3502	vis	1	-"-
1932	26921.659	+0.0244	+0.0272	4354	pgM	0	Strohmeier,Bauernfeind(1968)
	26967.425	-0.0034	-0.0006	4458	vis	1	Tsessevich (1943)
1933	27274.328	-0.0070	-0.0041	5155	vis	1	Florja (1934a)
1934	27614.287	+0.0210	+0.0240	5927	visN	0	Soloviev (1935d)
	27667.573	+0.0277	+0.0307	6048	pgM	0	Strohmeier,Bauernfeind(1968)
1935	27973.567	-0.0043	-0.0013	6743	visN	1	Soloviev (1936b, f, 1941)
	27989.421	-0.0020	+0.0010	6779	pg	2	Balázs (1936)
	27993.382	-0.0039	-0.0010	6788	pg	2	-"-
	27996.466	-0.0022	+0.0008	6795	pg	2	-"-
	28003.511	-0.0024	+0.0006	6811	pg	2	-"-
	28045.341	-0.0033	-0.0004	6906	pg	2	-"-
	28075.284	-0.0024	+0.0005	6974	pg	2	-"-
1937	28616.891	+0.0047	+0.0074	8204	pgM	0	Strohmeier,Bauernfeind(1968)
1938	29015.811	-0.0090	-0.0074	9110	pgM	0	-"-
	29089.353	-0.0021	+0.0002	9277	vis	0	Parenago (1947)
1940	29712.894	+0.0385	+0.0402	10693	pgM	0	Strohmeier,Bauernfeind(1968)
1942	30612.440	+0.0003	+0.0007	12736	vis	0	Tsessevich (1943, 1948)
1943	30941.363	+0.0004	+0.0002	13483	vis	0	-"-
1950	33427.446	+0.0078	+0.0009	19129	pg	2	present paper
	33475.443	+0.0093	+0.0023	19238	pg	2	-"-
1951	33836.510	+0.0097	+0.0015	20058	pg	2	-"-
	33856.324	+0.0091	+0.0008	20103	pg	2	Alania (1954)
	33897.278	+0.0129	+0.0044	20196	vis	0	Tsessevich (1957)
1953	34605.320	+0.0121	+0.0008	21804	pg	2	present paper
1955	35339.344	+0.0141	-0.0003	23471	pg	2	-"-
1956	35693.367	+0.0157	-0.0004	24275	vis	0	Tsessevich (1957)
1957	35991.470	+0.0186	+0.0011	24952	pg	2	present paper
1958	36363.5445	+0.0184	-0.0010	25797	pe	3	-"-
	36364.4256	+0.0188	-0.0006	25799	pe	3	-"-
	36405.3750	+0.0180	-0.0016	25892	pe	3	-"-
	36420.3465	+0.0184	-0.0013	25926	pe	3	-"-
1959	36758.5192	+0.0214	0.0000	26694	pe	3	-"-
	36781.407	+0.0123	-0.0093	26746	vis	0	Lange (1959)
	36792.413	+0.0102	-0.0114	26771	vis	0	-"-
	36793.303	+0.0196	-0.0021	26773	vis	0	-"-
	36807.3980	+0.0242	+0.0024	26805	pe	3	present paper
1962	37818.383	+0.0227	-0.0048	29101	vis	0	Tsessevich (1966)
	37848.335:	+0.0326:	+0.0049:	29169	vis	0	-"-
	37851.408	+0.0233	-0.0044	29176	vis	0	-"-
	37855.373	+0.0254	-0.0023	29185	vis	0	-"-
	37869.468	+0.0300	+0.0022	29217	vis	0	-"-

Table 6 (cont.)

year	J.D.max.hel.	O - C_1	O - C_2	E	method	w	Reference
1962	2437873.427	+0.0260	-0.0018	29226	vis	0	Tsessevich (1966)
	37878.270:	+0.0255:	-0.0024:	29237	vis	0	-"-
	37885.320	+0.0303	+0.0024	29253	vis	0	-"-
	37900.285	+0.0242	-0.0038	29287	vis	0	-"-
	37903.365	+0.0219	-0.0061	29294	vis	0	-"-
1964	38577.952	+0.0308	-0.0014	30826	pe	3	Sturch (1966)
1965	38888.826	+0.0353	+0.0011	31532	pe	3	Fitch et al. (1966)
	38936.821	+0.0349	+0.0003	31641	pe	3	-"-
1969	40403.546	+0.0369	-0.0081	34972	vis	0	Derivyagin et al. (1981)
	40418.5239	+0.0438	-0.0013	35006	pe	3	present paper
	40419.4048	+0.0440	-0.0011	35008	pe	3	-"-
1976	42954.821	+0.0682	+0.0021	40766	pe	3	Butler et al. (1982)
1978	43721.4313	+0.0724	-0.0007	42507	pe	3	present paper
1981	44761.495	+0.0882	+0.0049	44869	vis	0	Braune, Mundry (1982)
	44820.495	+0.0846	+0.0007	45003	vis	0	-"-
	44854.396	+0.0806	-0.0037	45080	vis	0	-"-
1982	45105.405	+0.1043	+0.0174	45650	vis	0	Hübscher, Mundry, (1984)
	45227.359	+0.0882	+0.0001	45927	vis	0	-"-

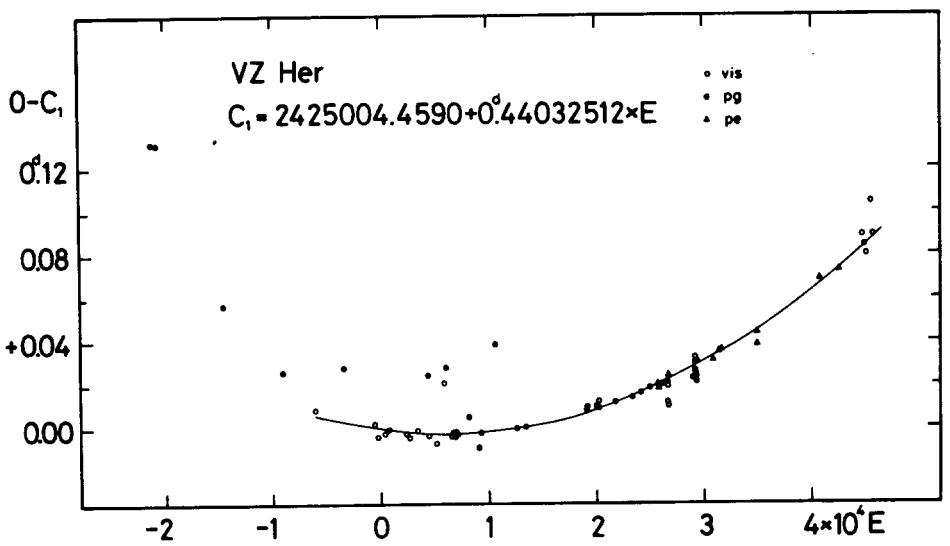

Figure 6: O-C diagram of VZ Her

AV PEGASI

The variability of the star AV Peg = BD $+21^{0}4633$ (9.5) = 90.1931 = HV 6181 was discovered by *Hoffmeister* (1931) on Sonneberg plates. When publishing his results *Hoffmeister* indicated the RR Lyrae type characteristics of its light variation.

Florja (1932) definitely determined the RR Lyrae type of the star and based on his 266 visual observations, gave the preliminary elements:

$$J.D.max.hel. = 2426582.302 + 0^{d}.3903859 \cdot E$$

Later, *Florja* (1933) published 20 times of light maximum using his own and *Tsessevich*'s visual observations, but he also gave a normal maximum based on this observational material. We have given only this time of maximum in the list of light maxima of AV Peg (Table 8). In a later work *Florja* (1934b) recalculated the light elements and gave:

$$J.D.max.hel. = 2426582.302 + 0^{d}.3903698 \cdot E$$

Dombrovsky (1936) gave a new ephemeris with quadratic term:

$$J.D.max.hel. = 2426582.3015 + 0^{d}.39037167 \cdot E - 0^{d}.72 \times 10^{-9} \cdot E^{2}$$

From three year observations he stated, oddly enough, that the period was decreasing by 1.44×10^{-9} day/cycle = 0.116 sec/year. On the other hand *Balazs* (1934) found no definite change in the period within three years.

In Table 8 we have listed, where possible, the visual normal maximum instead of the long list of maxima observed. *Batyrev* (1950) gave three while *Sacharov* (1964) gave 18 individual maxima, but in Table 8 their normal maxima are given.

Grigor'ev (1975) measured the star on the plates of Odessa Observatory and from 144 observations ha gave nine maxima which are erroneous; we have therefore omitted them from Table 8.

Wenske (1981) observed the star visually on 23 nights in the years 1963-1966 and photoelectrically in integrated light on 35 nights in the years 1967-1973 and 1975, but the times of maximum light have not been given. (*Wenske* published only the epochs of a certain point on the rising branch.)

Times of photoelectric maximum were published by *Fitch* et al. (1966). The excellent observations of *Paczynski* (1965) allowed another one to be determined. Further times of photoelectric maxima could be determined from *Sturch*'s (1966), *Jones*'s (1966) and *Penston*'s (1973) observations by fitting *Paczynski*'s light curve into their photoelectric data.

Photographic observations were made at Konkoly Observatory between 1951 and 1955 (Table 13a) and six times of light maximum could be determined from these data. We chose the same comparison stars as used by *Balázs* (1934).

The first photoelectric observations were obtained at Konkoly Observatory in integrated light in 1954. As a comparison star for these observations (Table 13b) BD $+21^{\circ}4632$ was used. UBV observations were commenced in 1959. The comparison star used was the star "b" shown in the identification chart (Figure 7). The brightness and colours of comparison stars used in this paper and by others are given in Table 7.

Table 7

Magnitudes and colours of comparison stars of AV Peg

star	V	B-V	U-B	Reference
a = BD $+21^{\circ}4632$	9.34	+0.67	+0.14	Paczynski (1965)
	9.35	+0.66	+0.02	Jones (1966)
	9.345	+0.653	+0.120	Sturch (1966)
b	10.39	+0.24	+0.11	present study
c	10.74	+1.72		Jones (1966)

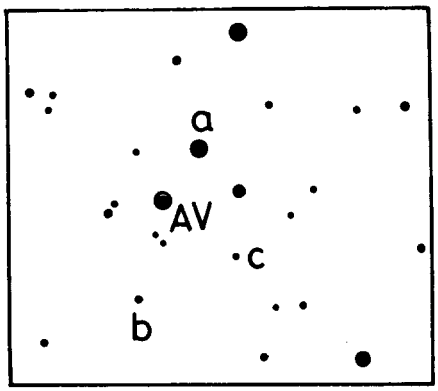

Figure 7: Identification chart of AV Peg

The photoelectric observations made at Konkoly Observatory are given in the sense: variable minus "b" in Table 13c, d, e, and are plotted against phase in Figure 8. From our photoelectric observations 12 times of maximum light could be derived for the years 1954, 1959 (2), 1969, 1972, 1973, 1978 (2), 1979, 1982 and 1983 (2).

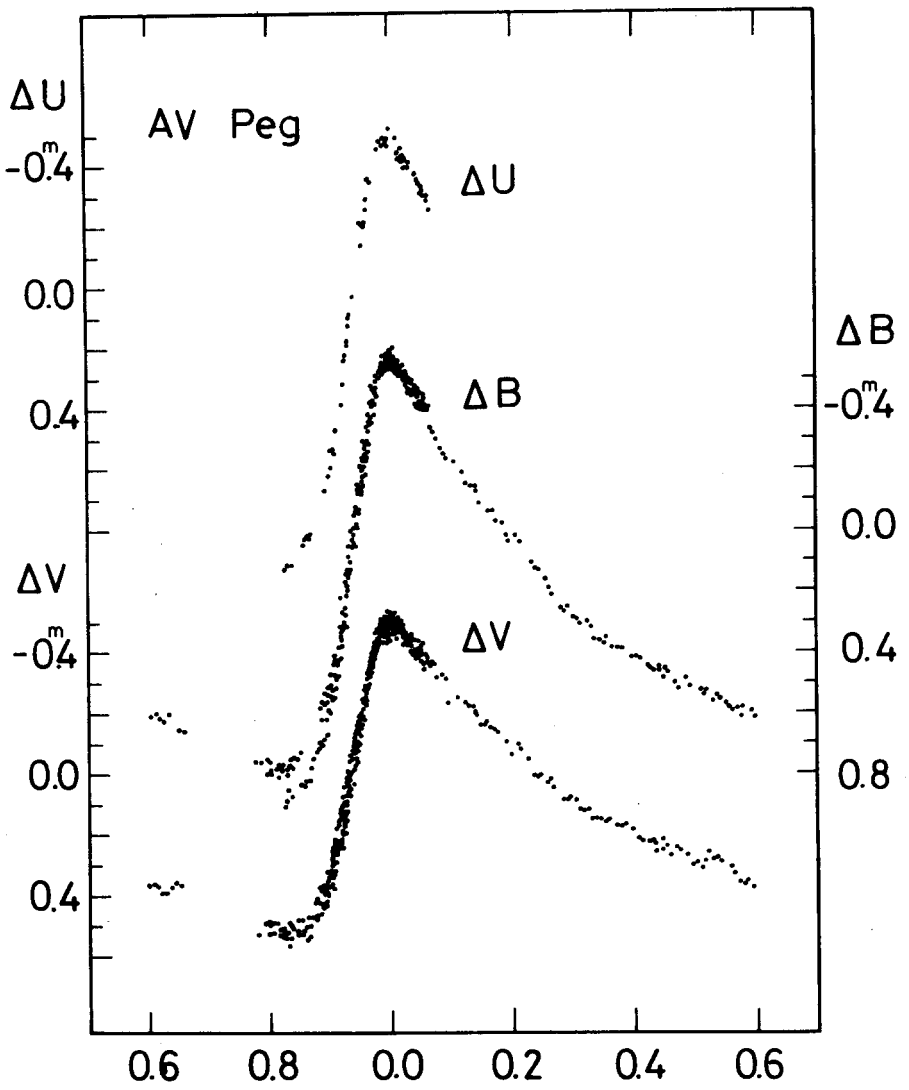

Figure 8: Light curves of AV Peg

Table 8

year	J.D.max.hel.	O - C_1	O - C_2	E	method	w	Reference
1903	2416347.713	+0.0790	+0.0150	-26218	pgN	2	Payne-Gaposchkin (1954)
1910	18950.26	+0.0422	+0.0049	-19551	pgN	2	Tsessevich (1966)
1931	26582.302	-0.0015	-0.0079	0	visN	1	Florja (1932, 1933)
	26652.561	-0.0087	-0.0152	+ 180	pgN	2	Payne-Gaposchkin (1954)
1932	26970.329	-0.0003	-0.0071	994	vis	1	Okunev (1933)
1933	27312.293	+0.0012	-0.0059	1870	vis	1	Tsessevich (1966)
1934	27616.773	-0.0058	-0.0135	2650	vis	1	Dombrovsky (1936)
	27631.228	+0.0055	-0.0021	2687	visN	1	Soloviev (1935a, b)
	27653.4746	+0.0012	-0.0065	2744	pg	2	Balázs (1934)
	27655.4263	+0.0010	-0.0067	2749	pg	2	-"-
	27660.5002	+0.0001	-0.0076	2762	pg	2	-"-
1935	27981.388	+0.0054	-0.0030	3584	visN	1	Soloviev (1936b, c)
	28098.495	+0.0020	-0.0067	3884	visN	1	Soloviev, Shakovskoj (1958)
	28866.355	+0.0080	-0.0028	5851	visN	1	-"-
1949	33215.468	+0.0306	-0.0062	16992	visN	1	Batyrev (1950)
1950	33527.377	+0.0355	-0.0040	17791	vis	1	Batyrev (1951a)
	33529.324	+0.0307	-0.0089	17796	vis	1	-"-
	33532.457	+0.0407	+0.0012	17804	vis	1	-"-
	33575.391	+0.0343	-0.0057	17914	vis	1	-"-
	33642.144	+0.0343	-0.0063	18085	vis	1	-"-
1951	33884.5675	+0.0393	-0.0036	18706	pg	2	present paper
	33888.478	+0.0461	+0.0032	18716	vis	1	Domke, Pohl (1952)
	33898.627	+0.0455	+0.0026	18742	vis	1	-"-
	33910.339	+0.0465	+0.0034	18772	vis	1	-"-
	33912.283	+0.0386	-0.0045	18777	vis	1	-"-
	33917.3645	+0.0453	+0.0022	18790	vis	1	-"-
	33926.340	+0.0424	-0.0008	18813	vis	1	-"-
	33928.291	+0.0415	-0.0017	18818	vis	1	-"-
1952	34244.495	+0.0474	+0.0011	19628	pg	2	Alania (1954)
	34252.304	+0.0491	+0.0027	19648	pg	2	-"-
1953	34598.5638	+0.0524	+0.0026	20535	pg	2	present paper
	34600.5138	+0.0506	+0.0007	20540	pg	2	-"-
1954	35069.3505	+0.0552	+0.0004	21741	pe	3	-"-
1955	35343.4000	+0.0664	+0.0085	22443	pg	2	-"-
	35393.3620	+0.0612	+0.0029	22571	pg	2	-"-
	35395.3124	+0.0598	+0.0014	22576	pg	2	-"-
1957	36051.555	+0.0937	+0.0277	24257	pg	0	Huth (1966)
	36055.475	+0.1100	+0.0439	24267	pg	0	-"-
	36085.497	+0.0737	+0.0072	24344	pg	0	-"-
	36146.3994	+0.0787	+0.0115	24500	vis	0	Steinman (1958)
1958	36461.440	+0.0923	+0.0212	25307	pg	0	Huth (1966)
1959	36795.5826	+0.0798	+0.0045	26163	pe	3	present paper
	36804.5635	+0.0822	+0.0068	26186	pe	3	-"-
	36808.477	+0.0921	+0.0166	26196	pg	0	Huth (1966)
	36817.479	+0.1156	+0.0400	26219	pg	0	-"-
	36840.491	+0.0959	+0.0200	26278	pg	0	-"-
	36851.431	+0.1056	+0.0295	26306	pg	0	-"-
	36867.414	+0.0835	+0.0072	26347	pg	0	-"-
	36876.391	+0.0820	+0.0056	26370	visN	0	Ahnert (1960)
	36903.356	+0.1116	+0.0349	26439	pg	0	Huth (1966)
1960	37136.366	+0.0719	-0.0079	27036	vis	0	Lange (1960)
1961	37497.468	+0.0835	-0.0013	27961	vis	0	Lange (1961)
	37501.372	+0.0838	-0.0010	27971	vis	0	-"-
	37519.328	+0.0828	-0.0022	28017	vis	0	-"-

Table 8 (cont.)

year	J.D.max.hel.	O - C_1	O - C_2	E	method	w	Reference
1961	2437528.312:	+0.0884:	+0.0032:	28040	vis	0	Lange (1961)
1962	37669.243	+0.0965	+0.0094	28401	pg	0	Huth (1966)
	37868.317	+0.0828	-0.0071	28911	vis	0	Tsessevich (1966)
	37869.546	+0.1407	+0.0508	28914	pg	0	Huth (1966)
	37871.441	+0.0839	-0.0061	28919	vis	0	Tsessevich (1966)
	37873.398	+0.0890	-0.0010	28924	vis	0	-"-
	37885.501	+0.0906	+0.0005	28955	pg	0	Huth (1966)
	37896.437	+0.0963	+0.0060	28983	visN	0	Sacharov (1964)
	37898.393	+0.1005	+0.0101	28988	vis	0	Tsessevich (1966)
	37900.342	+0.0976	+0.0073	28993	vis	0	-"-
	37902.292	+0.0958	+0.0054	28998	vis	0	-"-
	37903.461	+0.0937	+0.0033	29001	pg	0	Huth (1966)
	37910.499	+0.1051	+0.0145	29019	pg	0	-"-
	37916.343	+0.0935	+0.0029	29034	vis	0	Tsessevich (1966)
	37917.545	+0.1244	+0.0338	29037	pg	0	Huth (1966)
	37918.288	+0.0867	-0.0039	29039	vis	0	Tsessevich (1966)
	37923.377	+0.1009	+0.0102	29052	vis	0	-"-
	37925.322	+0.0941	+0.0034	29057	vis	0	-"-
	37932.347	+0.0924	+0.0016	29075	vis	0	-"-
	37939.374:	+0.0928:	+0.0019:	29093	vis	0	-"-
	37943.271	+0.0861	-0.0048	29103	vis	0	-"-
1963	38268.487	+0.1256	+0.0299	29936	pg	0	Huth (1966)
	38286.422	+0.1036	+0.0077	29982	pg	0	-"-
	38288.403	+0.1328	+0.0368	29987	pg	0	-"-
	38293.8375	+0.1021	+0.0061	30001	pe	3	Paczynski (1965)
	38324.325	+0.1409	+0.0444	30079	pg	0	Huth (1966)
	38340.681	+0.1015	+0.0047	30121	pe	3	Fitch et al. (1966)
1964	38592.502	+0.1351	+0.0345	30766	pg	0	Huth (1966)
	38619.8013	+0.1086	+0.0077	30836	pe	3	Sturch (1966)
	38642.464	+0.1300	+0.0287	30894	pg	0	Huth (1966)
	38651.4215	+0.1090	+0.0076	30917	pe	3	Jones (1966)
	38651.437	+0.1245	+0.0231	30917	pg	0	Huth (1966)
	38658.839	+0.1095	+0.0080	30936	pe	3	Fitch et al. (1966)
	38686.549	+0.1034	+0.0014	31007	pg	2	Harding, Penston (1966)
	38703.723	+0.1012	-0.0010	31051	pe	3	Fitch et al. (1966)
1965	39023.446	+0.1127	+0.0056	31870	pg	0	Huth (1966)
	39025.395	+0.1099	+0.0027	31875	pg	0	-"-
	39034.398	+0.1344	+0.0271	31898	pg	0	-"-
	39055.459	+0.1156	+0.0079	31952	vis	0	Braune, Hübscher (1967)
	39057.420	+0.1247	+0.0170	31957	vis	0	-"-
	39059.351	+0.1039	-0.0038	31962	pg	0	Huth (1966)
	39059.361:	+0.1139:	+0.0062:	31962	vis	0	Braune, Hübscher (1967)
	39061.322	+0.1230	+0.0153	31967	vis	0	-"-
	39063.278:	+0.1272:	+0.0194:	31972	vis	0	-"-
1966	39403.283	+0.1216	+0.0085	32843	vis	0	Braune et al. (1970)
	39406.4055	+0.1212	+0.0080	32851	vis	0	-"-
1969	40506.4775	+0.1360	+0.0044	35669	pe	3	present paper
1970	40836.340	+0.1375	0.0000	36514	vis	0	Braune et al. (1972)
	40848.445	+0.1411	+0.0034	36545	vis	0	-"-
	40859.378	+0.1438	+0.0059	36573	vis	0	-"-
1971	41131.854	+0.1429	+0.0001	37271	pe	3	Penston (1973)
	41233.350	+0.1432	-0.0015	37531	vis	0	Braune et al. (1972)
	41240.375	+0.1416	-0.0032	37549	vis	0	-"-
	41249.358	+0.1461	+0.0012	37572	vis	0	-"-

Table 8 (cont.)

year	J.D.max.hel.	O - C_1	O - C_2	E	method	w	Reference
1971	2441267.317	+0.1482	+0.0029	37618	vis	0	Braune et al. (1972)
1972	41566.340	+0.1493	-0.0016	38384	vis	0	Braune, Mundry (1973)
	41576.499	+0.1587	+0.0077	38410	vis	0	-"-
	41589.3759	+0.1535	+0.0022	38443	pe	3	present paper
	41598.3545	+0.1536	+0.0022	38466	vis	0	Braune, Mundry (1973)
	41616.308	+0.1502	-0.0016	38512	vis	0	-"-
	41650.270	+0.1501	-0.0023	38599	vis	0	-"-
	41652.228	+0.1563	+0.0039	38604	vis	0	-"-
	41657.297	+0.1505	-0.0020	38617	vis	0	-"-
	41664.320	+0.1469	-0.0058	38635	vis	0	-"-
	41682.297	+0.1670	+0.0140	38681	vis	0	-"-
1973	41931.340	+0.1551	-0.0026	39319	vis	0	Braune et al. (1977)
	41963.3545	+0.1595	+0.0011	39401	pe	3	present paper
	41981.307	+0.1550	-0.0037	39447	vis	0	Braune et al. (1977)
	41990.290	+0.1596	+0.0007	39470	vis	0	-"-
	42008.251	+0.1636	+0.0044	39516	vis	0	-"-
	42047.284	+0.1598	-0.0001	39616	vis	0	-"-
1974	42272.534	+0.1675	+0.0031	40193	vis	0	-"-
1975	42414.231	+0.1609	-0.0063	40556	vis	0	-"-
	42632.448	+0.1621	-0.0094	41115	vis	0	Braune et al. (1981)
	42641.449	+0.1847	+0.0130	41138	vis	0	-"-
	42664.469	+0.1729	+0.0008	41197	vis	0	Braune et al. (1979)
1976	43019.312	+0.1714	-0.0079	42106	vis	0	-"-
	43074.370	+0.1875	+0.0071	42247	vis	0	-"-
1977	43391.344	+0.1826	-0.0044	43059	vis	0	-"-
	43400.324	+0.1842	-0.0030	43082	vis	0	-"-
	43414.375	+0.1819	-0.0056	43118	vis	0	Braune et al. (1981)
1978	43722.3850	+0.1915	-0.0025	43907	pe	3	present paper
	43765.3261	+0.1921	-0.0028	44017	pe	3	-"-
	43790.321	+0.2035	+0.0080	44081	vis	0	Braune et al. (1981)
	43795.388	+0.1957	+0.0001	44094	vis	0	-"-
1979	44133.4508	+0.1998	-0.0031	44960	pe	3	present paper
1980	44545.300	+0.2107	-0.0013	46015	vis	0	Braune, Mundry (1981)
1981	44879.460	+0.2156	-0.0039	46871	vis	0	Braune, Mundry (1982)
	44886.483	+0.2120	-0.0076	46889	vis	0	-"-
1982	45230.4074	+0.2222	-0.0054	47770	pe	3	present paper
	45280.3785	+0.2261	-0.0026	47898	vis	0	Braune et al. (1983)
1983	45561.450	+0.2326	-0.0026	48618	vis	0	Hübscher, Mundry (1984)
	45566.5223	+0.2302	-0.0052	48631	pe	3	present paper
	45622.3449	+0.2301	-0.0066	48774	pe	3	-"-
	45645.385	+0.2385	+0.0013	48833	vis	0	Hübscher, Mundry (1984)

The investigation of the period changes of AV Peg has a long history. *Steinman* (1958) was the first to notice that the period was increasing. In his formula *Tsessevich* (1964) had already given a possible quadratic term:

$$\text{J.D.max.hel.} = 2426582.3035 + 0^d.39036805 \cdot E + 1^d.12\text{x}10^{-10} \cdot E^2,$$

which means that according to him, the period of AV Peg has been increasing by $2.24\text{x}10^{-10}$ day/cycle = 0.018 sec/year.

In order to investigate the period changes of the star in more detail we listed the published maxima in Table 8 with some exceptions (see above). The $O-C_1$ values have been calculated with the formula:

$$C_1 = \text{J.D.max.hel.} = 2426582.3035 + 0^d.39036805 \cdot E$$

A second order least squares solution to the $O-C_1$ values yields the following elements with quadratic term:

$$C_2 = \text{J.D.max.hel.} = \underset{\pm.0010}{2426582.3099} + \underset{\pm.00000007}{0^d.39036827} \cdot E + \underset{\pm.015}{0^d.923 \times 10^{-10}} \cdot E^2$$

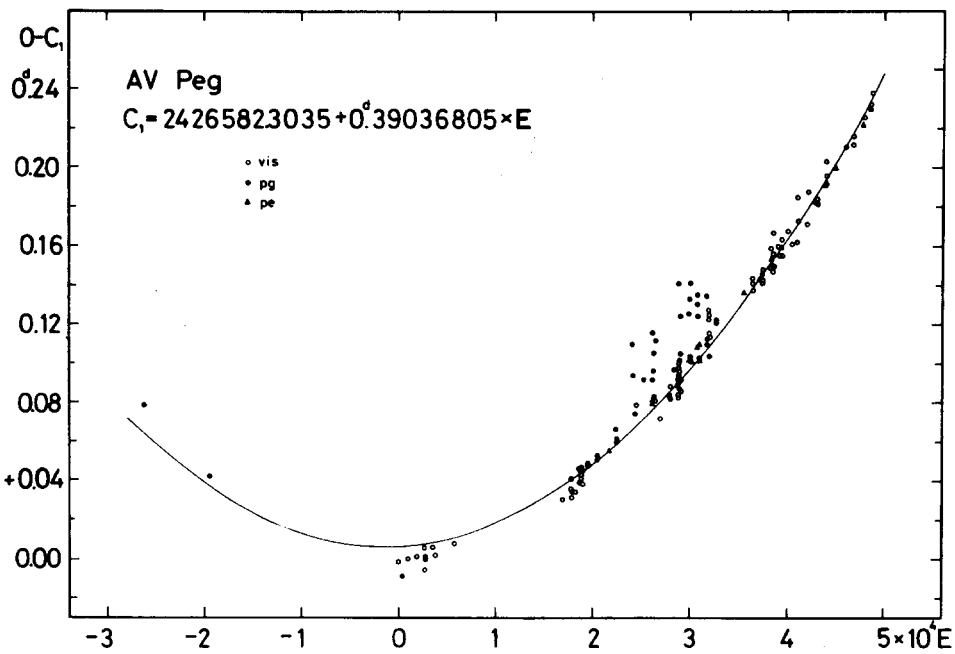

Figure 9a: $O-C_1$ diagram of AV Peg

The systematic deviations of the $O-C_2$ values from the C_2-C_1 parabola show that a cyclic variation is superposed on the linear period change. But we can assume that the period of the star has changed at a rate of $(1.846 \pm 0.030) \times 10^{-10}$ day/cycle = (0.01492 ± 0.00024) sec/year during the past 50 years.

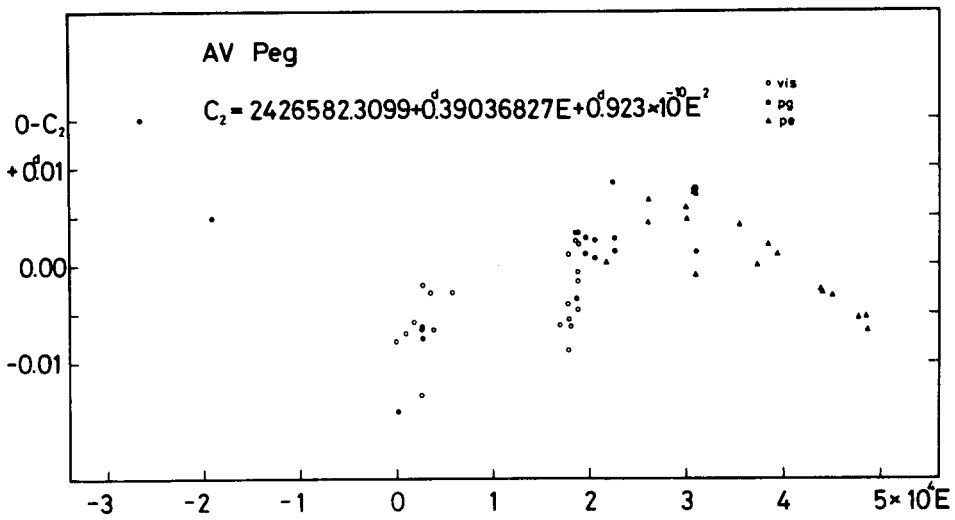

Figure 9b: $O-C_2$ diagram of AV Peg

Balázs (1934) found no light curve changes in her photographic material, and there is no indication for it in the literature. Nevertheless our photographic material suggests that a small variation in the heights of maxima may occur. Our photoelectric observations definitely show that real changes of the light curve are present. The changes are especially conspicious on the rising branches. The variation in the height of maximum probably does not exceed 0.05 magnitude.

TU URSAE MAIORIS

This relatively bright RR Lyrae type variable (TU UMa = BD $+30^{\circ}2162$ (8.7) = 1.1929) was discovered by *Guthnick* and *Prager* (1929) on Babelsberg plates. They determined the type of variability and gave the preliminary elements (*Prager*, 1929):

J.D.max.hel. = 2425006.480 + $0^{d}.557650 \cdot E$

Subsequently the star was studied visually by *Kukarkin* (1929, 1940), *Jacchia* (1929, 1931), *Tsessevich* (1930, 1966, 1974), *Mustel* (1934), *Soloviev*

(1935a, b, c, 1936a, e, 1939), *Dombrovsky* (1936), *Ahnert* (1959), *Oburka* (1967), *Berdnikov* (1973, 1977), *Blasberg* (1981) and by members of the BAV group (*Braune* and *Mundry*, 1973, 1982; *Braune*, *Hübscher* and *Mundry*, 1970, 1977, 1979, 1981, 1983; and *Pohl*, 1955).

Robinson (1933) investigated the star on old Harvard photographs taken before its discovery and determined a time of maximum light for the year 1914. In this way he lengthened the time interval by 15 years and could derive very accurate elements of light variation:

$$\text{J.D.max.hel.} = 2420160.447 \pm .003 + 0^d.55765826 \pm .00000047 \cdot E$$

which value was slightly corrected by *Soloviev* (1939):

$$\text{J.D.max.hel.} = 2425760.451 + 0^d.5576588 \cdot E$$

Poehnitzsch (1951) investigated the star on 322 Sonneberg patrol plates made in 1929-1950. He found no noticeable change in the period of TU UMa and derived essentially the same elements obtained by *Soloviev*:

$$\text{J.D.max.hel.} = 2425760.451 + 0^d.5576593 \cdot E$$

At the same time *Silva* (1951) supplemented the previous observations with his own visual observations and made a thorough investigation of the period changes of TU UMa. He found that the period was decreasing at a rate of 0.806×10^{-9} day/cycle = 0.0456 sec/year and the times of heliocentric maximum can be obtained by the formula:

$$\text{J.D.max.hel.} = 2425760.441 + 0^d.557665 \cdot E - 4^d.03 \times 10^{-10} \cdot E^2$$

Photographic maxima were published by *Payne-Gaposchkin* (1954) and *Alania* (1954). *Boenigk* (1957) carried out photographic photometry of the star in order to study its colour variations. The photographic observations were published and made the determination of a time of light maximum possible.

The star has been photoelectrically observed since 1957. Using these observations the period changes of the star can be studied in detail. *Geyer* (1961), *Preston* et al. (1961), *Preston* and *Paczynski* (1964), *Fitch* et al. (1966) and *Sturch* (1966) made UBV observations. *Fitch* et al. (1966) and *Geyer* (1961) each published a maximum, but from *Fitch* et al.'s data another time of

light maximum could be determined. The excellent and very accurate observations of *Preston* et al. (1961) and *Preston* and *Paczynski* (1964) made the determination of three new epochs possible. *Sturch*'s (1966) observations were somewhat unluckily distributed in phase and could not be used for timing the maximum.

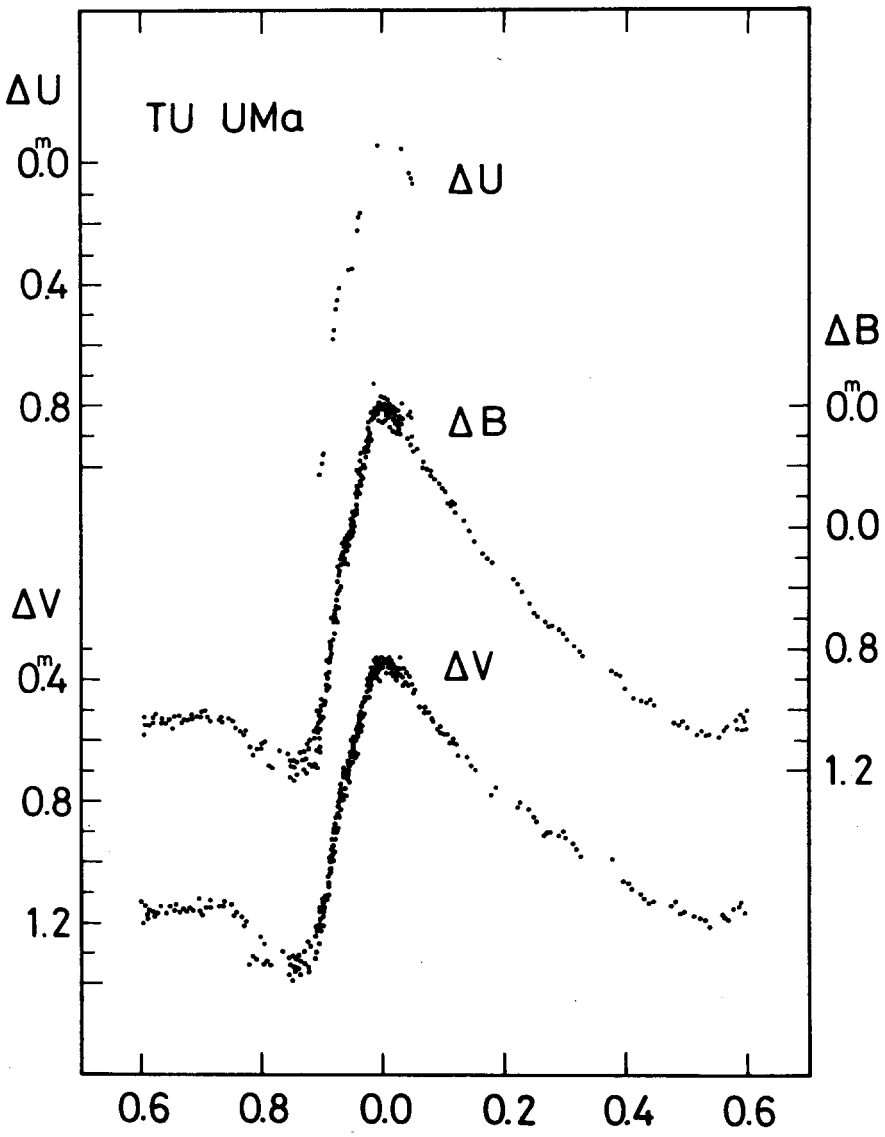

Figure 10: Light curves of TU UMa

Epstein (1969) and *Butler* et al. (1982) carried out their photometry in the uvby system. The observations of *Epstein* were lacking at maximum so no time of maximum could be deduced from these data. Fortunately, *Butler* et al. observed the star around the light maximum and we were able to determine a time of maximum from their observations.

Photoelectric observations of TU UMa were commenced at Konkoly Observatory in 1957. First the photometry was carried out in integrated light, but since 1958 the observations have been obtained in the UBV system. As the comparison star we used BD $+30^{\circ}2165$ (8.4) (V = 8.97, B-V = +0.51, U-B = +0.05 adopted from *Geyer*, 1961; or V = 8.941, B-V = +0.558, U-B = +0.067 taken from *Sturch*, 1966). The photoelectric observations made at Konkoly Observatory are given in Table 14a-d in the sense: variable minus BD $+30^{\circ}2165$, and are plotted against phase in Figure 10. The time of maximum light is chosen as phase 0.

Although the period of TU UMa is nearly the same as the period of RR Lyrae, there is no evidence of Blazhko effect in TU UMa which is very striking in RR Lyrae. The small differences in the height of maximum light (especially in blue light) are rather a consequence of the error in transformation into the UBV system.

The times of light maxima published or derived from observations are collected and listed in Table 9. The photoelectric and photographic maxima are taken into account using the weightings 3 and 2, respectively, while for the early visual observations w=1 was used. The visual observations made since 1957 (the first photoelectric observations) are not included in the study of period changes. A least squares solution led to the linear elements:

$$C_1 = \text{J.D.max.hel.} = 2425760.4559 + 0^{d}.55765860 \cdot E$$
$$\pm.0021 \quad \pm.00000011$$

or the second oder approximation yields:

$$C_2 = \text{J.D.max.hel.} = 2425760.4519 + 0^{d}.55765962 \cdot E - 0^{d}.355 \times 10^{-10} \cdot E^2$$
$$\pm.0020 \quad \pm.00000020 \quad \pm.061$$

During the course of the last 70 years the period of TU UMa has decreased at a rate of 0.710×10^{-10} day/cycle = 0.0040 sec/year. The $O-C_1$ and $O-C_2$ values are also given in Table 9 and are plotted against epoch number in Figure 11a,b.

Cycles with a length of 23 years may be superimposed in the parabola. This may be a consequence of the duplicity of the star.

Table 9

year	J.D.max.hel.	O - C_1	O - C_2	E	method	w	Reference
1914	2420160.447	-0.0012	+0.0166	-10042	pgN	2	Robinson (1933)
1927	25006.480	-0.0215	-0.0160	- 1352	pgN	2	Guthnick, Prager (1929)
1929	25732.544	-0.0290	-0.0249	- 50	visN	1	Kukarkin (1929)
	25760.450	-0.0059	-0.0019	0	visN	1	Jacchia (1929)
1930	26066.595	-0.0155	-0.0120	+ 549	visN	1	Tsessevich (1966)
1933	27248.291	+0.0020	+0.0035	2668	visN	1	Mustel (1934)
1934	27593.480	+0.0003	+0.0013	3287	visN	1	Soloviev (1935a, b)
	27620.810	+0.0050	+0.0060	3336	visN	1	Dombrovsky (1936)
1935	27894.613	-0.0024	-0.0018	3827	visN	1	Soloviev (1935c)
1938	29040.610	+0.0062	+0.0054	5882	pgN	2	Payne-Gaposchkin (1954)
1946	32101.038	+0.0038	+0.0008	11370	visN	1	Silva (1951)
1952	34082.382	-0.0132	-0.0165	14923	vis	1	Pohl (1955)
	34091.311	-0.0067	-0.0100	14939	vis	1	-"-
	34121.420	-0.0113	-0.0146	14993	vis	1	-"-
1953	34451.5555	-0.0097	-0.0130	15585	vis	1	-"-
	34455.459	-0.0098	-0.0131	15592	vis	1	-"-
	34478.322	-0.0108	-0.0141	15633	vis	1	-"-
	34478.345	+0.0122	+0.0089	15633	pgN	2	Alania (1954)
	34484.4605	-0.0065	-0.0098	15644	vis	1	Pohl (1955)
	34498.400	-0.0085	-0.0118	15669	vis	1	-"-
1957	35925.4628	+0.0059	+0.0032	18228	pe	3	present paper
	35934.3850	+0.0056	+0.0028	18244	pe	3	-"-
	35955.572	+0.0016	-0.0012	18282	pgN	2	Boenigk (1957)
	35963.3834	+0.0058	+0.0030	18296	pe	3	present paper
	35992.3810	+0.0051	+0.0023	18348	pe	3	-"-
1958	36230.5029	+0.0068	+0.0041	18775	pe	3	-"-
	36231.6175	+0.0061	+0.0034	18777	pe	3	-"-
	36264.5207	+0.0074	+0.0048	18836	pe	3	-"-
	36278.4617	+0.0069	+0.0043	18861	pe	3	-"-
	36288.5010	+0.0084	+0.0058	18879	pe	3	-"-
1959	36604.6944	+0.0094	+0.0070	19446	pe	3	-"-
	36611.3818	+0.0049	+0.0025	19458	pe	3	Geyer (1961)
	36659.357	+0.0214	+0.0191	19544	vis	0	Ahnert (1959)
	36674.9590	+0.0090	+0.0066	19572	pe	3	Preston et al. (1961)
	36677.7450	+0.0067	+0.0043	19577	pe	3	-"-
1963	38038.9910	+0.0080	+0.0068	22018	pe	3	Preston, Paczynski (1964)
1964	38510.755	-0.0071	-0.0079	22864	pe	3	Fitch et al. (1966)
	38516.3843	+0.0456	+0.0448	22874	vis	0	Oburka (1967)
	38532.529	+0.0182	+0.0174	22903	vis	0	-"-
	38544.774	-0.0053	-0.0060	22925	pe	3	Fitch et al. (1966)
1966	39233.468:	-0.0197:	-0.0196:	24160	vis	0	Braune et al. (1970)
	39266.4555	+0.0660	+0.0661	24219	vis	0	-"-
1972	41376.549	-0.0207	-0.0174	28003	visN	0	Berdnikov (1977)
	41394.3875	-0.0273	-0.0240	28035	vis	0	Braune, Mundry (1973)
	41395.502	-0.0281	-0.0248	28037	vis	0	-"-
1973	41766.352	-0.0210	-0.0171	28702	vis	0	Braune et al. (1977)
	41776.388	-0.0229	-0.0189	28720	vis	0	-"-
	41781.411	-0.0188	-0.0148	28729	vis	0	-"-
	41805.369	-0.0401	-0.0361	28772	vis	0	Tsessevich (1974)
1975	42521.417	-0.0258	-0.0204	30056	vis	0	Braune et al. (1977)
	42530.351	-0.0143	-0.0089	30072	vis	0	-"-
1976	(42822.495	-0.0834	-0.0774	30596	pe	0)	Braune et al. (1979)
	42835.387	-0.0176	-0.0115	30619	vis	0	-"-
	42840.387	-0.0365	-0.0304	30628	vis	0	-"-

Table 9 (cont.)

year	J.D.max.hel.	O - C_1	O - C_2	E	method	w	Reference
1976	2442840.414	-0.0095	-0.0034	30628	pe	3	Braune et al. (1979)
	42859.373	-0.0109	-0.0048	30662	vis	0	-"-
	42869.402	-0.0197	-0.0136	30680	vis	0	-"-
	42899.519	-0.0163	-0.0101	30734	vis	0	-"-
	42954.729	-0.0145	-0.0082	30833	pe	3	Butler et al. (1982)
1979	43954.6141	-0.0113	-0.0028	32626	pe	3	present paper
	43977.488	-0.0014	+0.0072	32667	vis	0	Braune et al. (1981)
1980	44364.4777	-0.0268	-0.0173	33361	visN	0	Blasberg (1981)
1981	44717.491	-0.0113	-0.0010	33994	vis	0	Braune, Mundry (1982)
1983	45403.432:	+0.0096	+0.0217	35224	vis	0	Braune et al. (1983)
	45471.4485	-0.0083	+0.0040	35346	pe	3	present paper

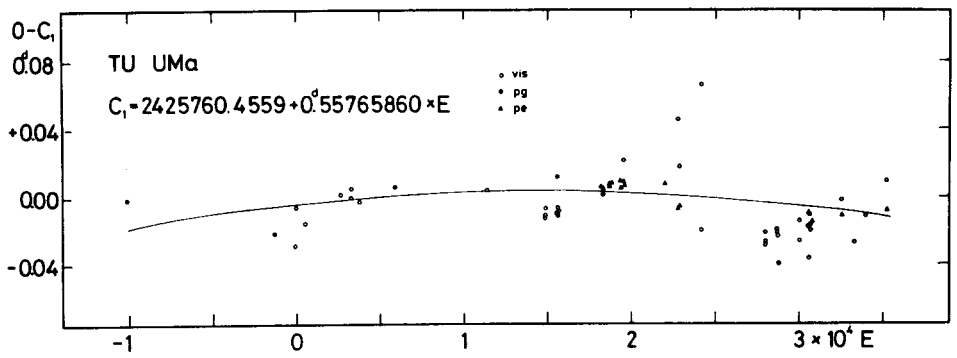

Figure 11a: O-C_1 diagram of TU UMa

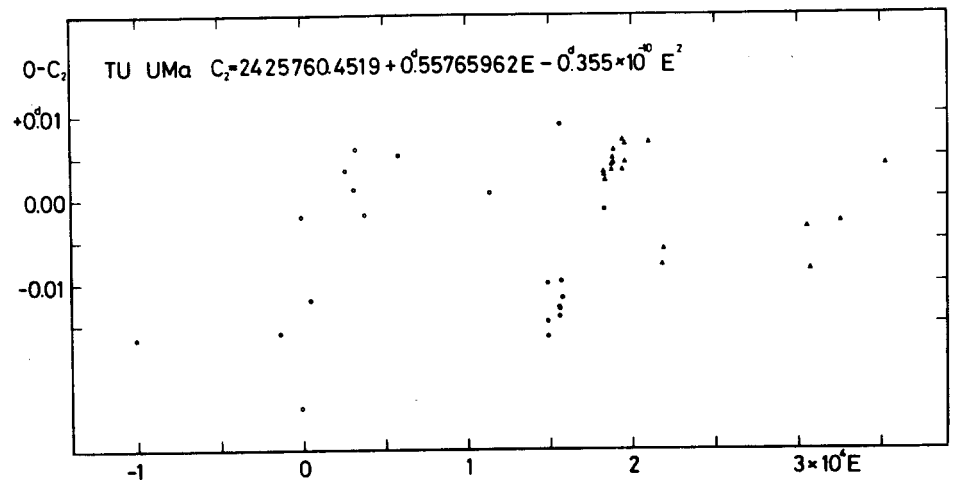

Figure 11b: O-C_2 diagram of TU UMa

CONCLUSIONS

In our previous paper (*Oláh* and *Szeidl*, 1978) and here we have discussed the period changes of a total of nine RR Lyrae type variable stars (AT And, SU Dra, TW Her, VZ Her, RR Leo, TT Lyn, AV Peg, AR Per and TU UMa). Table 10 summarizes the most important results on period changes.

Table 10

Parameters of period changes

star	period	As	period changes	time base	remark
AV Peg	$0^d.390$	0	$(+4.73\pm0.08)\cdot10^{-10}$ day/day	$75\times10^3\cdot P_{AV}$	cyclic var.
TW Her	0.400	2	constant	$65\times10^3\cdot P_{TW}$	
AR Per	0.426	0	$(+0.55\pm0.07)\cdot10^{-10}$ day/day	$63\times10^3\cdot P_{AR}$	
VZ Her	0.440	4	$(+2.60\pm0.05)\cdot10^{-10}$ day/day	$50\times10^3\cdot P_{VZ}$	
RR Leo	0.452	8	$(+8.68\pm0.57)\cdot10^{-10}$ day/day	$55\times10^3\cdot P_{RR}$	cyclic var.
TU UMa	0.558	6	$(-1.27\pm0.22)\cdot10^{-10}$ day/day	$45\times10^3\cdot P_{TU}$	cyclic var.
TT Lyn	0.597	10	constant	$11\times10^3\cdot P_{TT}$	
AT And	0.617	3	abrupt: $+710\times10^{-8}$ and -544×10^{-8} days	$43\times10^3\cdot P_{AT}$	
SU Dra	0.660	10	constant	$40\times10^3\cdot P_{SU}$	fluctuations

Even though it is untimely to conclude on any trend of changes in the periods from the few observational data, nevertheless it is striking that there is only one decreasing period.

It is worth mentioning that there are cyclic variations superimposed on the parabolic O-C diagrams of three stars: RR Leo, AV Peg and TU UMa, and the cycle lengths are 25000 P_{RR} ≃ 11300 days ≃ 31 years; 60000 P_{AV} ≃ 23400 days ≃ 64 years and 15000 P_{TU} ≃ 8400 days ≃ 23 years, respectively (see Figure 8 in the paper of *Oláh* and *Szeidl*, 1978, and Figures 9b and 11b of this paper). The very long cyclic variations can probably be explained by the duplicity of these stars (*Coutts*, 1971), but random fluctuations of cumulative nature in the periods may also present an explanation (*Balázs* and *Detre*, 1965).

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Table 11a

Photoelectric yellow observations of TW Her

J.D.	ΔV	J.D.	ΔV	J.D.	ΔV	J.D.	ΔV
2436756		2436758		2436761		2436776	
.4026	+0.232	.4110	-0.028	.4257	+1.022	.3974	-0.013
.4074	+0.062	.4124	.029	.4284	1.031	.4004	+0.009
.4153	-0.067	.4138	-0.019	.4312	1.035	.4011	.010
.4234	0.000	.4173	+0.020	.4382	1.020	.4018	.004
.4255	+0.022	.4188	.013	.4444	1.036	.4032	.003
.4279	.041	.4216	.029	.4472	+1.040	.4086	.046
.4335	.108	.4271	+0.066			.4096	.067
.4363	.123			2436776		.4107	.093
.4390	.132	2436760		.3547	+1.225	.4117	.098
.4446	.166	.3591	+1.253	.3554	1.216	.4128	.122
.4474	.179	.3632	1.256	.3569	1.209	.4138	.121
.4502	.190	.3653	1.250	.3573	1.186	.4147	+0.129
.4585	.264	.3740	1.145	.3596	1.189		
.4613	.285	.3761	1.112	.3608	1.170	2440419	
.4668	.321	.3802	1.013	.3617	1.172	.5137	+1.172
.4696	.379	.3823	0.977	.3638	1.128	.5151	1.144
.4890	.516	.3844	.868	.3650	1.054	.5177	1.057
.4918	.538	.3886	.701	.3659	1.057	.5190	1.016
.5002	.576	.3907	.625	.3687	0.930	.5209	0.896
.5029	.570	.3927	.566	.3694	.873	.5218	.880
.5057	.589	.3969	.320	.3701	.813	.5227	.854
.5113	.632	.3990	+0.212	.3707	.767	.5246	.766
.5140	.653	.4052	-0.004	.3714	.738	.5255	.717
.5168	.691	.4073	.031	.3721	.719	.5264	.652
.5224	.732	.4094	.031	.3745	.656	.5283	.608
.5244	.739	.4136	.047	.3752	.627	.5292	.523
.5257	.756	.4157	.010	.3758	.609	.5302	.506
.5299	.784	.4177	-0.002	.3765	.567	.5321	.464
.5313	.791	.4226	+0.031	.3772	.528	.5330	.394
.5327	.807			.3779	.489	.5338	.379
.5355	.809	2436761		.3786	.452	.5357	.199
.5369	.812	.3649	+0.913	.3807	.331	.5366	.190
.5382	.810	.3670	.931	.3814	.283	.5375	.099
.5410	.805	.3712	.921	.3821	.217	.5399	.037
.5424	+0.804	.3732	.948	.3828	.201	.5408	+0.015
		.3753	.919	.3835	.140	.5417	-0.029
2436758		.3795	.935	.3842	.124	.5436	.042
.3789	+1.053	.3816	.962	.3849	.105	.5445	.036
.3819	1.032	.3837	.963	.3872	.033	.5454	.041
.3858	0.924	.3878	.954	.3879	.005	.5475	.071
.3895	.774	.3899	.961	.3886	+0.010	.5484	.060
.3909	.717	.3920	.979	.3890	-0.020	.5493	.061
.3937	.550	.3962	.991	.3900	.026	.5519	.022
.3951	.517	.3982	1.011	.3907	.032	.5533	.028
.3965	.466	.4003	1.020	.3914	.021	.5547	-0.011
.3992	.309	.4045	1.053	.3932	.030	.5568	+0.003
.4006	.210	.4066	1.055	.3939	.030	.5582	.002
.4020	.121	.4087	1.059	.3946	.016	.5596	+0.008
.4055	+0.013	.4146	1.065	.3953	.016		
.4069	-0.008	.4173	1.036	.3960	.016	2443717	
.4083	-0.018	.4201	+1.051	.3967	-0.001	.3949	+0.262

Table 11a (cont.)

J.D.	ΔV	J.D.	ΔV	J.D.	ΔV	J.D.	ΔV
2443717		2443717		2443755		2445546	
.3976	+1.276	.4508	+0.042	.4061	-0.050	.4255	+0.018
.3990	1.299	.4528	.055	.4090	.042	.4268	.031
.4018	1.259	.4535	.050	.4102	.058	.4318	.039
.4032	1.296	.4556	+0.046	.4129	.022	.4332	.058
.4060	1.235			.4143	-0.010	.4345	.065
.4074	1.265	2443755				.4358	.092
.4185	1.024	.3558	+1.236	2445546		.4372	.129
.4199	0.972	.3595	1.220	.3868	+0.963	.4423	.183
.4223	.862	.3612	1.242	.3881	.893	.4436	.217
.4230	.773	.3643	1.210	.3895	.866	.4450	.223
.4251	.671	.3662	1.207	.3908	.777	.4463	.221
.4258	.670	.3689	1.165	.3921	.743	.4476	.229
.4278	.487	.3705	1.166	.3977	.427	.4530	.218
.4285	.460	.3770	1.020	.3990	.349	.4543	.206
.4313	.280	.3784	0.964	.4004	.239	.4556	.234
.4341	.223	.3819	.854	.4017	+0.164	.4570	.233
.4369	+0.038	.3838	.801	.4113	-0.035	.4583	.280
.4390	-0.012	.3866	.651	.4126	.051	.4639	.338
.4417	.045	.3912	.486	.4139	.073	.4652	.344
.4424	.041	.3926	.428	.4153	.063	.4666	.341
.4445	.039	.3957	.246	.4215	.046	.4679	.368
.4452	.044	.3973	.130	.4228	.037	.4692	+0.415
.4473	-0.032	.4002	+0.015	.4241	-0.007		

Table 11b

Photoelectric blue observations of TW Her

J.D.	ΔB	J.D.	ΔB	J.D.	ΔB	J.D.	ΔB
2436756		2436756		2436758		2436758	
.4015	+0.203	.4821	+0.461	.3778	+1.267	.4257	-0.081
.4061	-0.065	.4877	.511	.3812	1.218		
.4085	.148	.4904	.545	.3828	1.152	2436760	
.4146	.198	.4988	.582	.3848	1.037	.3580	+1.468
.4160	.210	.5043	.614	.3888	0.871	.3622	1.486
.4224	.173	.5099	.668	.3902	.766	.3642	1.494
.4245	.116	.5127	.694	.3930	.615	.3709	1.420
.4265	.089	.5154	.725	.3944	.528	.3729	1.365
.4321	.035	.5210	.756	.3958	.469	.3750	1.333
.4349	.021	.5237	.771	.3985	.288	.3792	1.202
.4377	-0.016	.5251	.795	.3999	.206	.3813	1.159
.4432	+0.025	.5288	.816	.4013	+0.091	.3834	1.042
.4488	.086	.5306	.829	.4048	-0.101	.3875	0.778
.4543	.139	.5320	.844	.4062	.158	.3896	.681
.4571	.180	.5348	.856	.4076	.178	.3917	.592
.4599	.203	.5362	.863	.4103	.205	.3959	.328
.4654	.250	.5376	.855	.4117	.200	.3979	.178
.4682	.299	.5403	.882	.4131	.184	.4000	+0.030
.4710	.342	.5417	+0.864	.4166	.174	.4042	-0.150
.4765	.399			.4180	.139	.4063	.187
.4793	+0.447	2436758		.4202	-0.125	.4084	-0.201

Table 11b (cont.)

J.D.	ΔB	J.D.	ΔB	J.D.	ΔB	J.D.	ΔB
2436760		2440419		2443717		2443755	
.4125	−0.184	.5250	+0.787	.4282	+0.487	.4138	−0.197
.4146	.187	.5259	.746	.4303	.346		
.4167	.176	.5278	.632	.4310	.314	2445546	
.4216	−0.126	.5287	.589	.4331	.178	.3872	+1.107
		.5297	.552	.4338	.091	.3886	1.001
2436761		.5316	.454	.4358	+0.006	.3899	0.976
.3597	+1.053	.5325	.404	.4365	−0.057	.3912	.894
.3639	1.052	.5334	.272	.4386	.098	.3925	.852
.3660	1.054	.5352	.142	.4393	.170	.3981	.413
.3701	1.091	.5361	.100	.4414	.195	.3995	.289
.3722	1.103	.5370	+0.022	.4421	.223	.4008	.185
.3743	1.083	.5394	−0.113	.4442	.236	.4022	+0.095
.3784	1.092	.5403	.135	.4449	.257	.4117	−0.179
.3805	1.129	.5412	.189	.4469	.246	.4131	.261
.3826	1.120	.5431	.208	.4476	.239	.4144	.212
.3868	1.144	.5440	.209	.4497	.211	.4157	.227
.3889	1.156	.5449	.203	.4504	.201	.4219	.182
.3909	1.136	.5470	.207	.4525	.190	.4232	.209
.3951	1.165	.5479	.237	.4532	.161	.4246	.187
.3972	1.168	.5488	.225	.4553	.145	.4259	.128
.3993	1.174	.5512	.208	.4560	−0.137	.4273	.136
.4034	1.186	.5526	.193			.4322	.070
.4055	1.198	.5540	.186	2443755		.4336	.093
.4076	1.200	.5561	.147	.3550	+1.401	.4349	.088
.4159	1.216	.5575	.129	.3596	1.413	.4363	.053
.4187	1.212	.5589	−0.139	.3643	1.381	.4376	−0.003
.4243	1.194			.3690	1.342	.4427	+0.056
.4271	1.220	2443717		.3724	1.268	.4441	.071
.4298	1.208	.3928	+1.467	.3736	1.249	.4454	.094
.4368	1.243	.3969	1.490	.3764	1.222	.4467	.101
.4430	1.224	.3983	1.471	.3776	1.173	.4481	.087
.4508	+1.232	.4011	1.446	.3810	1.033	.4534	.104
		.4025	1.466	.3830	0.919	.4547	.113
2440419		.4053	1.435	.3875	.658	.4561	.169
.5130	+1.339	.4067	1.422	.3905	.487	.4574	.188
.5144	1.337	.4178	1.144	.3919	.426	.4588	.193
.5171	1.215	.4192	1.070	.3952	.237	.4643	.244
.5186	1.144	.4219	0.915	.3966	+0.139	.4657	.289
.5204	1.022	.4226	.814	.3995	−0.013	.4669	.290
.5213	0.980	.4247	.730	.4046	.169	.4683	.323
.5222	.908	.4254	.620	.4061	.191	.4697	+0.373
.5241	+0.833	.4275	+0.555	.4124	−0.181		

Table 11c

Photoelectric uv observations of TW Her

J.D.	ΔU	J.D.	ΔU	J.D.	ΔU	J.D.	ΔU
2445546		2445546		2445546		2445546	
.3877	+1.251	.3903	+1.035	.3930	+0.902	.3999	+0.430
.3890	+1.148	.3917	+1.073	.3985	+0.523	.4012	+0.324

Table 11c (cont.)

J.D.	ΔU	J.D.	ΔU	J.D.	ΔU	J.D.	ΔU
2445546		2445546		2445546		2445546	
.4026	+0.210	.4250	-0.028	.4431	+0.260	.4579	+0.379
.4039	+0.145	.4263	-0.002	.4445	.302	.4592	.404
.4122	-0.106	.4277	+0.023	.4458	.304	.4648	.432
.4135	.140	.4327	.106	.4472	.310	.4661	.448
.4149	.108	.4340	.073	.4485	.308	.4674	.501
.4161	.072	.4354	.128	.4538	.276	.4688	.549
.4224	.058	.4367	.139	.4551	.337	.4701	+0.557
.4237	-0.048	.4380	+0.195	.4565	+0.374		

Table 12a

Photographic observations of VZ Her

J.D.	m_{pg}	J.D.	m_{pg}	J.D.	m_{pg}	J.D.	m_{pg}
2433427		2433475		2433836		2434154	
.4037	12.22	.4061	12.19	.4892	11.06	.4653	10.79
.4058	12.10	.4102	11.92	.4921	10.79	.4684	10.77
.4078	12.03	.4123	11.96	.4947	10.81		
.4099	12.07	.4144	11.64	.4976	10.52	2434605	
.4120	12.02	.4165	11.66	.5003	10.24	.3126	10.06
.4141	11.90	.4186	11.39	.5031	10.25	.3154	10.06
.4169	11.71	.4206	11.08	.5060	10.04	.3182	9.98
.4190	11.69	.4227	10.92	.5086	9.97	.3209	10.04
.4210	11.44	.4248	10.92	.5115	10.06	.3237	10.05
.4231	11.17	.4304	10.39	.5142	9.98	.3265	10.08
.4252	11.22	.4324	10.34	.5170	10.06	.3293	10.02
.4273	11.01	.4345	10.23	.5198	10.17	.3320	10.04
.4294	10.84	.4408	10.09	.5281	10.14	.3376	10.18
.4328	10.57	.4429	10.07	.5336	10.23	.3487	10.29
.4349	10.65	.4449	10.06	.5392	10.42	.3515	10.32
.4405	10.28	.4470	10.02	.5421	10.51	.3543	10.35
.4426	10.16	.4512	10.10	.5448	10.55	.3584	10.47
.4467	10.03	.4533	10.27	.5475	10.52	.3626	10.57
.4488	10.13	.4554	10.34			.3653	10.56
.4508	10.27	.4575	10.24	2434154		.3682	10.64
.4530	10.16	.4595	10.24	.4246	10.34	.3709	10.64
.4572	10.42	.4616	10.32	.4288	10.26	.3737	10.60
.4613	10.45	.4637	10.45	.4309	10.26	.3793	10.65
.4634	10.46	.4658	10.38	.4329	10.33	.3848	10.78
.4655	10.53	.4679	10.43	.4350	10.45	.3876	10.73
.4696	10.51	.4699	10.59	.4392	10.44	.3904	10.77
.4717	10.57	.4720	10.48	.4413	10.40	.3932	10.74
.4759	10.70	.4741	10.62	.4434	10.47	.3959	10.87
		.4762	10.63	.4454	10.56	.3987	10.86
2433475		.4783	10.64	.4475	10.52		
.3852	12.23	.4804	10.63	.4496	10.56	2435339	
.3894	12.20			.4538	10.69	.3197	11.20
.3956	12.24	2433836		.4559	10.67	.3218	11.11
.3977	12.29	.4810	11.84	.4580	10.65	.3260	11.01
.3998	12.29	.4836	11.55	.4600	10.75	.3281	10.59
.4040	12.12	.4865	11.57	.4621	10.67	.3302	10.48

Table 12a (cont.)

J.D.	m_{pg}	J.D.	m_{pg}	J.D.	m_{pg}	J.D.	m_{pg}
2435339		2435339		2435991		2435991	
.3322	10.34	.3542	10.20	.4415	11.73	.4651	10.16
.3343	10.24			.4443	11.59	.4776	10.10
.3364	10.01	2435991		.4470	11.42	.4804	10.08
.3385	10.01	.4276	12.19	.4498	11.26	.4845	10.27
.3406	10.05	.4304	12.14	.4526	10.72	.4915	10.36
.3447	9.94	.4359	11.96	.4554	10.59	.4943	10.46
.3468	9.97	.4387	11.98	.4595	10.44	.4970	10.40
.3500	10.05						

Table 12b

Photoelectric yellow observations of VZ Her

J.D.	ΔV	J.D.	ΔV	J.D.	ΔV	J.D.	ΔV
2436363		2436364		2436399		2436420	
.4645	+0.951	.4026	+0.499	.4501	+0.939	.3468	-0.244
.4674	0.982	.4075	.288	.4558	.929	.3521	.219
.4733	1.054	.4104	.182	.4586	.927	.3565	.189
.4762	1.040	.4137	+0.054	.4613	.925	.3596	.177
.4798	1.061	.4169	-0.059	.4666	.921	.3657	-0.135
.4849	1.055	.4190	.147	.4693	.918		
.4878	1.063	.4211	.173	.4721	.905	2436728	
.4935	1.083	.4233	.207	.4777	.922	.5196	+1.077
.4995	1.075	.4255	.222	.4804	.942	.5214	1.061
.5025	1.049	.4277	.212	.4832	.955	.5274	1.075
.5056	0.988	.4319	.196	.4888	.963	.5293	1.073
.5112	.944	.4342	.155	.4916	.963	.5335	1.055
.5146	.851	.4364	.132	.4943	.973	.5376	1.015
.5176	.721	.4386	.148	.4999	.961	.5429	0.883
.5234	.457	.4408	-0.141	.5027	.960	.5448	+0.880
.5265	.322			.5047	.978		
.5295	+0.198	2436398		.5106	.933	2436758	
.5357	-0.060	.3856	+0.138	.5131	+0.937	.4408	+0.999
.5386	.130	.3897	.198			.4453	1.058
.5418	.167	.3982	.261	2436405		.4475	1.052
.5480	.222	.4028	.254	.3474	+0.948	.4517	1.072
.5510	-0.202	.4061	.279	.3532	.492	.4537	1.043
		.4117	.333	.3557	.323	.4633	1.073
2436364		.4143	.346	.3584	+0.144	.4656	1.063
.3584	+1.067	.4171	.385	.3613	-0.022	.4708	1.049
.3637	1.058	.4260	.445	.3657	.112	.4736	1.046
.3697	1.033	.4288	.440	.3687	.170	.4764	1.026
.3724	1.069	.4343	.484	.3784	.207	.4819	0.923
.3753	1.033	.4370	.497	.3916	.110	.4847	.881
.3801	1.053	.4458	.556	.3968	.052	.4875	.843
.3827	1.021	.4489	.561	.4024	.016	.4930	.573
.3855	0.985	.4517	+0.560	.4079	-0.014	.4945	.523
.3890	.965					.4959	.475
.3938	.870	2436399		2436420		.4992	.298
.3967	.741	.4441	+0.953	.3280	+0.295	.5006	.205
.3998	+0.633	.4469	+0.945	.3346	+0.029	.5022	+0.138

Table 12b (cont.)

J.D.	ΔV	J.D.	ΔV	J.D.	ΔV	J.D.	ΔV
2436758		2436807		2436808		2440418	
.5056	+0.008	.3575	+0.946	.3895	+0.507	.5406	-0.137
.5070	-0.010	-3581	.936	.3910	.546	.5434	.123
.5084	.057	.3613	.871	.3956	.585	.5448	-0.122
.5119	.154	.3620	.845	.3971	.582		
.5133	.166	.3627	.802	.4004	.612	2440419	
.5154	.169	.3635	.798	.4020	.633	.3732	+0.828
.5188	.191	.3643	.763	.4036	.621	.3753	.716
.5209	.197	.3662	.720	.4069	+0.645	.3795	.606
.5260	.167	.3670	.692			.3816	.480
.5281	.146	.3678	.681	2440418		.3857	.230
.5302	.155	.3687	.668	.4733	+1.082	.3878	+0.152
.5354	.119	.3694	.649	.4747	1.067	.3920	-0.003
.5382	.084	.3714	.579	.4774	1.061	.3941	.081
.5409	.072	.3721	.526	.4788	1.056	.3982	.173
.5465	-0.020	.3728	.464	.4816	1.053	.4003	.207
		.3735	.438	.4830	1.023	.4045	.200
2436760		.3743	.376	.4856	0.977	.4066	.191
.4624	+0.748	.3760	.290	.4865	.951	.4107	.181
.4645	.772	.3768	.244	.4883	.928	.4128	.176
.4690	.802	.3776	.253	.4892	.904	.4170	.166
.4711	.779	.3784	.198	.4913	.839	.4191	.158
.4732	.811	.3807	.060	.4923	.812	.4232	.152
.4773	.813	.3816	.047	.4941	.758	.4253	-0.127
.4854	.862	.3824	+0.036	.4950	.723		
.4882	.902	.3831	-0.019	.4969	.668	2443721	
.4910	.905	.3839	.031	.4978	.647	.3833	+1.008
.4924	.908	.3848	.066	.4997	.539	.3842	1.040
.4938	.913	.3868	.111	.5006	.440	.3861	1.009
.4975	.901	.3875	.135	.5024	.329	.3870	1.046
.5009	.898	.3883	.134	.5033	.315	.3898	0.990
.5030	.927	.3891	.155	.5052	.224	.3916	.992
.5176	.947	.3898	.168	.5062	.160	.3926	.962
.5197	.956	.3918	.191	.5080	.111	.3944	.915
.5259	.939	.3926	.183	.5089	.101	.3953	.913
.5280	.920	.3935	.191	.5108	+0.019	.3972	.917
.5343	.915	.3943	.191	.5117	-0.076	.3981	.877
.5405	.933	.3952	.175	.5135	.112	.4000	.789
.5426	+0.949	.3972	.206	.5145	.138	.4009	.748
		.3980	.188	.5163	.154	.4027	.740
2436807		.3990	.202	.5173	.184	.4037	.672
.3423	+1.069	.3999	.190	.5191	.198	.4055	.596
.3443	1.068	.4041	.204	.5200	.202	.4064	.581
.3451	1.068	.4080	.171	.5219	.227	.4092	.452
.3459	1.060	.4123	-0.137	.5228	.228	.4111	.322
.3467	1.060			.5247	.233	.4120	.258
.3475	1.040	2436808		.5256	.224	.4139	.185
.3509	1.061	.3431	+0.219	.5274	.223	.4148	.167
.3517	1.053	.3466	.216	.5284	.214	.4166	.110
.3524	1.025	.3723	.393	.5309	.184	.4176	+0.063
.3532	1.043	.3814	.445	.5323	.185	.4194	-0.033
.3554	0.961	.3830	.471	.5351	.172	.4222	.137
.3561	.963	.3846	.487	.5365	.168	.4231	.154
.3568	+0.956	.3879	+0.489	.5392	-0.138	.4250	-0.202

Table 12b (cont.)

J.D.	ΔV	J.D.	ΔV	J.D.	ΔV	J.D.	ΔV
2443721		2443721		2443721		2443721	
.4259	-0.208	.4314	-0.230	.4368	-0.244	.4423	-0.160
.4277	.209	.4333	.251	.4382	.219	.4451	.147
.4287	.222	.4342	-0.241	.4409	-0.169	.4465	-0.133
.4305	-0.223						

Table 12c

Photoelectric blue observations of VZ Her

J.D.	ΔB	J.D.	ΔB	J.D.	ΔB	J.D.	ΔB
2436363		2436364		2436399		2436728	
.4628	+0.855	.4200	-0.590	.4791	+0.882	.5267	+0.916
.4660	.865	.4222	.620	.4818	.878	.5284	.904
.4720	.921	.4266	.653	.4874	.876	.5325	.897
.4747	.938	.4308	.619	.4902	.865	.5344	.898
.4778	.944	.4332	.609	.4929	.860	.5365	.871
.4834	.961	.4353	.606	.4985	.830	.5416	.767
.4863	.940	.4375	.610	.5013	.839	.5439	.731
.4920	.946	.4396	.598	.5037	.821	.5462	+0.590
.4979	.964	.4420	-0.552	.5096	.787		
.5010	.955			.5117	.779	2436758	
.5041	.893	2436398		.5145	+0.783	.4389	+0.880
.5097	.778	.3839	-0.196			.4442	.906
.5128	.686	.3879	.162	2436405		.4465	.946
.5161	.592	.3912	.086	.3488	+0.593	.4516	.962
.5219	.253	.3978	.056	.3545	.134	.4548	.952
.5249	+0.096	.4010	-0.011	.3571	+0.007	.4598	.965
.5280	-0.039	.4045	+0.025	.3598	-0.136	.4621	.965
.5341	.371	.4103	.062	.3628	.338	.4644	.953
.5371	.500	.4157	.113	.3672	.548	.4694	.922
.5403	.602	.4214	.134	.3695	.591	.4722	.915
.5464	.624	.4246	.151	.3759	.625	.4750	.901
.5496	-0.582	.4273	.188	.3863	.573	.4805	.824
		.4329	.227	.3930	.505	.4833	.801
2436364		.4356	.239	.4038	.382	.4861	.744
.3570	+0.946	.4385	.274	.4093	-0.336	.4938	.365
.3624	.954	.4444	.305			.4952	.308
.3682	.974	.4475	.335	2436420		.4985	+0.079
.3711	.984	.4503	+0.348	.3292	-0.006	.4999	-0.012
.3787	.940			.3456	.622	.5013	.095
.3814	.909	2436399		.3480	.615	.5050	.270
.3841	.880	.4427	+0.870	.3505	.609	.5063	.370
.3869	.832	.4455	.866	.3549	.572	.5077	.408
.3924	.719	.4485	.878	.3581	.554	.5112	.515
.3952	.638	.4544	.857	.3612	.554	.5126	.579
.3983	.476	.4572	.857	.3672	-0.522	.5140	.584
.4012	.339	.4600	.848			.5181	.611
.4061	+0.066	.4652	.856	2436728		.5195	.618
.4089	-0.083	.4679	.836	.5186	+0.953	.5209	.605
.4119	.232	.4707	.832	.5205	.939	.5250	.595
.4153	-0.443	.4763	+0.857	.5249	+0.938	.5271	-0.571

Table 12c (cont.)

J.D.	ΔB	J.D.	ΔB	J.D.	ΔB	J.D.	ΔB
2436758		2436808		2440418		2443721	
.5291	-0.551	.3903	+0.344	.5196	-0.637	.3865	+0.879
.5340	.518	.3935	.356	.5214	.655	.3884	.921
.5368	.482	.3964	.374	.5223	.650	.3893	.903
.5396	.477	.3997	.377	.5242	.667	.3912	.857
.5451	-0.414	.4012	.383	.5251	.664	.3921	.838
		.4028	.398	.5270	.668	.3939	.827
2436760		.4063	+0.420	.5279	.652	.3949	.824
.4614	+0.641			.5302	.655	.3967	.778
.4634	.641	2440418		.5316	.641	.3977	.740
.4680	.679	.4728	+0.915	.5344	.623	.3995	.675
.4700	.677	.4740	.902	.5358	.624	.4004	.655
.4721	.687	.4767	.893	.5385	.612	.4023	.513
.4763	.738	.4781	.912	.5399	.583	.4032	.501
.4875	.761	.4809	.884	.5427	.567	.4051	.389
.4903	.764	.4823	.888	.5441	-0.542	.4060	.377
.4917	.766	.4851	.840			.4078	.316
.4931	.770	.4860	.761	2440419		.4088	.224
.4965	.768	.4878	.726	.3725	+0.648	.4106	.095
.4999	.775	.4887	.682	.3746	.567	.4115	+0.083
.5020	.779	.4909	.654	.3788	.394	.4134	-0.026
.5187	.846	.4918	.645	.3809	.218	.4143	.097
.5228	.874	.4937	.586	.3850	+0.002	.4162	.188
.5249	.867	.4946	.536	.3871	-0.111	.4171	.243
.5270	.869	.4964	.463	.3913	.346	.4189	.324
.5312	.870	.4973	.400	.3934	.465	.4199	.364
.5332	.855	.4992	.299	.3975	.601	.4217	.428
.5353	.848	.5001	.232	.3996	.656	.4227	.486
.5394	.831	.5020	.124	.4038	.676	.4245	.585
.5415	.815	.5029	+0.076	.4059	.682	.4273	.644
.5436	+0.821	.5048	-0.018	.4100	.676	.4282	.633
		.5057	.056	.4121	.657	.4301	.605
2436808		.5075	.138	.4163	.617	.4310	.618
.3422	-0.099	.5084	.220	.4184	.609	.4328	.611
.3456	+0.061	.5103	.336	.4225	.564	.4338	.615
.3736	.214	.5112	.381	.4246	-0.517	.4375	.590
.3756	.232	.5131	.472			.4402	.586
.3805	.265	.5140	.519	2443721		.4416	.568
.3822	.273	.5158	.581	.3828	+0.912	.4444	.530
.3839	.275	.5167	.617	.3838	.891	.4458	-0.519
.3872	+0.296	.5187	-0.632	.3856	+0.897		

Table 12d

Photoelectric uv observations of VZ Her

J.D.	ΔU	J.D.	ΔU	J.D.	ΔU	J.D.	ΔU
2440419		2440419		2440419		2440419	
.3718	+0.543	.3864	-0.173	.4031	-0.669	.4156	-0.671
.3759	.527	.3906	.317	.4052	.671	.4177	.630
.3781	.384	.3927	.380	.4093	.656	.4218	.504
.3802	+0.214	.3968	.631	.4114	-0.697	.4239	-0.501
.3843	-0.017	.3989	-0.655				

Table 13a

Photographic observations of AV Peg

J.D.	m_{pg}	J.D.	m_{pg}	J.D.	m_{pg}	J.D.	m_{pg}
2433884		2434600		2435343		2435393	
.5414	10.89	.4768	11.10	.3941	9.73	.3878	10.13
.5441	10.67	.4796	11.00	.4024	9.63	.3941	10.31
.5462	10.36	.4823	10.94	.4079	9.65	.3961	10.29
.5482	10.41	.4851	10.84	.4135	9.69	.3982	10.28
.5524	10.21	.4879	10.50	.4163	9.72	.4107	10.45
.5546	10.13	.4907	10.63	.4191	9.85	.4128	10.52
.5566	10.02	.4935	10.27	.4218	9.92	.4170	10.46
.5587	10.10	.4962	10.20	.4246	9.86	.4189	10.54
.5607	10.05	.4990	10.10	.4274	9.95		
.5629	9.84	.5018	9.95	.4302	9.96	2435395	
.5670	9.85	.5046	10.07	.4329	10.15	.2895	10.79
.5711	9.91	.5073	9.81	.4357	10.16	.2916	10.68
.5733	9.89	.5101	9.86	.4385	10.13	.2937	10.44
.5753	10.06	.5129	9.75	.4413	10.23	.2957	10.37
.5775	10.00	.5157	9.86			.2978	10.35
.5795	10.15	.5185	9.80	2435393		.2999	10.15
.5817	10.21	.5240	9.94	.3378	10.48	.3041	9.92
.5837	10.11	.5268	10.02	.3390	10.50	.3062	9.86
.5858	10.22	.5296	10.00	.3420	10.42	.3082	9.78
		.5323	9.90	.3441	10.27	.3103	9.67
2434598		.5351	9.98	.3461	10.26	.3124	9.73
.5461	10.29	.5379	10.07	.3503	9.96	.3166	9.85
.5489	10.09	.5407	10.16	.3524	10.07	.3187	9.87
.5517	9.91	.5435	10.30	.3545	10.03	.3207	9.84
.5572	9.84			.3566	9.73	.3228	9.85
.5600	9.73	2435343		.3586	9.76	.3249	10.03
.5628	9.74	.3538	11.18	.3607	9.81	.3270	10.02
.5656	9.65	.3566	11.22	.3628	9.74	.3291	10.13
.5684	9.83	.3593	10.90	.3649	9.85	.3312	10.19
.5711	9.71	.3621	10.93	.3670	9.79	.3353	10.18
.5739	9.95	.3649	10.60	.3691	9.93	.3374	10.12
.5795	9.89	.3732	10.42	.3711	9.87	.3395	10.19
.5822	10.07	.3760	10.32	.3753	9.95	.3416	10.37
.5850	10.11	.3788	10.17	.3795	9.98	.3437	10.36
		.3885	9.79	.3836	10.07	.3499	10.45
2434600		.3913	9.69	.3857	10.11	.3582	10.65
.4740	11.25						

Table 13b

Photoelectric observations of AV Peg in integrated light

J.D.	Δm	J.D.	Δm	J.D.	Δm	J.D.	Δm
2435069		2435069		2435069		2435069	
.3133	+1.356	.3208	+1.077	.3272	+0.880	.3332	+0.661
.3143	.342	.3219	.068	.3282	.866	.3341	.636
.3152	.307	.3228	.061	.3291	.843	.3351	.609
.3162	.276	.3236	1.026	.3299	.790	.3361	.564
.3176	+1.215	.3242	+0.984	.3305	+0.772	.3368	+0.535

Table 13b (cont.)

J.D.	Δm	J.D.	Δm	J.D.	Δm	J.D.	Δm
2435069		2435069		2435069		2435069	
.3399	+0.442	.3498	+0.401	.3581	+0.395	.3679	+0.468
.3409	.422	.3505	.389	.3614	.451	.3687	.476
.3419	.419	.3513	.381	.3623	.442	.3693	.501
.3430	.401	.3545	.363	.3630	.435	.3700	.506
.3467	.398	.3552	.362	.3638	.452	.3708	.503
.3474	.394	.3559	.375	.3646	.452	.3716	.515
.3481	.382	.3566	.382	.3653	+0.464	.3724	+0.525
.3491	+0.394	.3573	+0.388				

Table 13c

Photoelectric yellow observations of AV Peg

J.D.	ΔV	J.D.	ΔV	J.D.	ΔV	J.D.	ΔV
2436795		2436804		2436804		2436804	
.5057	+0.498	.4983	+0.504	.5281	+0.170	.5460	-0.296
.5077	.530	.5013	.480	.5285	.155	.5464	.333
.5117	.532	.5029	.478	.5288	.152	.5469	.332
.5135	.529	.5043	.480	.5292	.128	.5473	.345
.5154	.524	.5078	.503	.5295	.120	.5497	.385
.5191	.497	.5085	.472	.5299	.137	.5500	.397
.5223	.515	.5091	.498	.5302	.113	.5504	.397
.5230	.520	.5098	.469	.5306	.102	.5506	.403
.5397	.438	.5105	.467	.5309	.078	.5510	.398
.5442	.317	.5129	.418	.5311	.098	.5515	.417
.5463	.265	.5135	.412	.5328	.070	.5518	.413
.5484	.224	.5142	.412	.5331	.031	.5524	.425
.5532	+0.046	.5149	.384	.5335	.012	.5530	.431
.5560	-0.005	.5156	-378	.5338	.013	.5532	.444
.5588	.076	.5163	.386	.5341	.002	.5551	.427
.5640	.198	.5170	.369	.5345	+0.004	.5554	.437
.5661	.248	.5190	.397	.5348	-0.006	.5558	.448
.5682	.308	.5194	.381	.5352	.009	.5561	.448
.5734	.436	.5198	.364	.5355	.043	.5565	.458
.5761	.465	.5201	.369	.5358	.061	.5568	.442
.5789	.476	.5205	.362	.5372	.093	.5572	.453
.5845	.462	.5208	.370	.5375	.106	.5575	.456
.5883	.492	.5212	.315	.5379	.115	.5579	.471
.5907	-0.479	.5215	.360	.5382	.127	.5581	.468
		.5219	.337	.5387	.107	.5600	.458
2436804		.5221	.329	.5390	.139	.5608	.469
.4754	+0.532	.5234	.303	.5393	.133	.5615	.486
.4804	.492	.5237	.293	.5397	.166	.5622	.495
.4832	.488	.5241	.251	.5400	.154	.5629	.518
.4846	.527	.5244	.248	.5403	.156	.5635	.508
.4860	.487	.5248	.241	.5420	.191	.5642	.495
.4892	.487	.5251	.242	.5424	.203	.5675	.488
.4906	.512	.5255	.236	.5427	.194	.5691	.503
.4920	.510	.5258	.230	.5443	.245	.5705	.491
.4955	.488	.5262	.223	.5450	.244	.5748	.462
.4969	+0.501	.5264	+0.227	.5455	-0.280	.5770	-0.443

Table 13c (cont.)

J.D.	ΔV	J.D.	ΔV	J.D.	ΔV	J.D.	ΔV
2436804		2436814		2441589		2443722	
.5800	-0.439	.3882	-0.145	.3606	-0.293	.3388	+0.420
.5816	.421	.3903	.137	.3620	.353	.3399	.384
.5830	.430	.3956	.104	.3634	.374	.3723	.388
.5846	.393	.3986	.063	.3662	.401	.3461	.367
.5888	.371	.4028	.097	.3676	.436	.3473	.340
.5904	.361	.4049	.082	.3690	.451	.3498	.255
.5925	.314	.4091	-0.047	.3710	.489	.3511	.248
.5953	.326	.4132	+0.005	.3724	.498	.3536	.190
.5971	.312	.4153	.010	.3738	.485	.3548	+0.153
.5985	-0.228	.4174	.006	.3766	.475	.3609	-0.073
		.4216	.028	.3780	.474	.3619	.091
2436805		.4236	.021	.3794	.471	.3644	.104
.5125	+0.252	.4257	.048	.3822	.459	.3656	.149
.5170	.250	.4316	.084	.3836	.451	.3682	.213
.5194	.235	.4337	.084	.3850	.447	.3695	.238
.5215	.264	.4358	.081	.3877	.436	.3728	.335
.5264	.243	.4400	.091	.3891	.419	.3753	.394
.5284	.250	.4420	.119	.3905	-0.403	.3790	.443
.5337	.264	.4441	.121			.3800	.432
.5357	.300	.4483	.123	2441963		.3824	.429
.5378	.297	.4504	.149	.3145	+0.335	.3834	.445
.5420	.309	.4525	.149	.3159	.276	.3857	.434
.5441	.286	.4566	.152	.3194	.174	.3868	.458
.5462	.255	.4587	.162	.3235	.128	.3893	-0.445
.5503	.277	.4608	.155	.3245	.157		
.5524	.280	.4660	.167	.3273	.059	2443765	
.5545	.287	.4688	.174	.3287	+0.035	.2886	+0.383
.5607	.305	.4716	.173	.3308	-0.030	.2913	.316
.5628	.327	.4771	.183	.3322	.052	.2927	.219
.5670	.354	.4799	.211	.3350	.121	.2955	.169
.5691	.359	.4827	.218	.3364	.161	.2969	.102
.5712	.350	.4870	.219	.3391	.241	.2997	+0.027
.5753	.371	.4883	.224	.3401	.313	.3011	-0.050
.5774	.370	.4903	.230	.3426	.335	.3038	.171
.5795	.363	.4945	+0.209	.3440	.377	.3052	.191
.5837	.370			.3467	.464	.3080	.239
.5857	.396	2440506		.3481	.495	.3094	.274
.5878	.396	.4451	+0.215	.3506	.487	.3122	.314
.5923	.372	.4465	.153	.3520	.498	.3136	.369
.5951	.354	.4493	+0.037	.3544	.507	.3163	.425
.5979	+0.365	.4507	-0.002	.3558	.493	.3177	.467
		.4674	.464	.3585	.506	.3205	.485
2436814		.4688	.479	.3599	.461	.3219	.519
.3639	-0.247	.4715	.478	.3627	.456	.3247	.535
.3695	.234	.4757	.522	.3641	.435	.3261	.531
.3710	.219	.4771	.482	.3669	.398	.3288	.503
.3738	.217	.4799	.473	.3683	.395	.3302	.488
.3751	.203	.4813	.475	.3710	.379	.3330	.469
.3765	.191	.4840	.492	.3720	.386	.3344	.431
.3793	.160	.4854	.472	.3745	.372	.3372	.441
.3807	.163	.4882	.447	.3759	-0.345	.3386	-0.403
.3821	.170	.4896	-0.444				
.3861	-0.152			2443722		2444133	

Table 13c (cont.)

J.D.	ΔV	J.D.	ΔV	J.D.	ΔV	J.D.	ΔV
2444133		2445230		2445566		2445622	
.4199	+0.245	.3744	+0.238	.4802	+0.416	.3041	+0.396
.4211	.198	.3757	+0.192	.4815	.357	.3055	.384
.4242	+0.067	.3818	-0.065	.4829	.342	.3068	.359
.4284	-0.036	.3831	.127	.4901	.230	.3082	.324
.4300	.098	.3845	.130	.4914	.194	.3095	.296
.4331	.193	.3859	.167	.4928	.126	.3151	.137
.4347	.233	.3873	.174	.4941	.095	.3164	.106
.4375	.290	.3928	.287	.4954	+0.053	.3178	.058
.4390	.353	.3942	.319	.5031	-0.204	.3191	+0.009
.4418	.437	.3956	.368	.5044	.233	.3205	-0.013
.4437	.471	.3969	.394	.5058	.254	.3265	.185
.4465	.489	.3983	.417	.5071	.279	.3279	.227
.4482	.502	.4044	.457	.5085	.341	.3292	.272
.4515	.479	.4057	.482	.5144	.481	.3305	.315
.4531	.488	.4071	.502	.5157	.492	.3318	.353
.4563	.476	.4085	.485	.5171	.510	.3388	.474
.4577	.479	.4099	-0.498	.5184	.520	.3402	.490
.4608	.460			.5240	.529	.3415	.489
.4623	.453	2445566		.5291	.468	.3428	.492
.4655	.402	.4530	+0.536	.5304	.454	.3442	.497
.4668	-0.400	.4543	.543	.5317	.439	.3499	.521
		.4557	.565	.5331	.430	.3512	.488
2445230		.4571	.543	.5344	.417	.3526	.473
.3577	+0.473	.4645	.527	.5418	.392	.3539	.469
.3590	.478	.4658	.508	.5431	.358	.3553	.447
.3604	.459	.4672	.544	.5445	.373	.3611	.408
.3632	.423	.4685	.498	.5458	.384	.3625	.415
.3702	.334	.4698	.534	.5472	-0.361	.3639	.392
.3716	.293	.4775	.457			.3652	.390
.3730	+0.259	.4789	+0.436	2445622		.3666	-0.372

Table 13d

Photoelectric blue observations of AV Peg

J.D.	ΔB	J.D.	ΔB	J.D.	ΔB	J.D.	ΔB
2436795		2436795		2436804		2436804	
.5046	+0.753	.5574	+0.049	.4797	+0.759	.5698	-0.528
.5067	.787	.5629	-0.151	.4825	.803	.5733	.509
.5108	.773	.5650	.214	.4839	.760	.5747	.498
.5126	.777	.5671	.294	.4853	.798	.5763	.459
.5145	.767	.5720	.474	.4885	.783	.5793	.440
.5182	.773	.5748	.513	.4899	.807	.5807	.424
.5202	.778	.5775	.540	.4913	.777	.5823	.412
.5211	.748	.5831	.533	.4948	.803	.5837	.408
.5386	.622	.5873	.532	.4962	.776	.5881	.341
.5432	.541	.5893	-0.517	.4976	.752	.5897	.326
.5452	.470			.5022	.752	.5916	.303
.5473	.443	2436804		.5036	+0.733	.5946	.273
.5518	.216	.4747	+0.757	.5668	-0.518	.5962	.253
.5546	+0.138	.4784	+0.760	.5682	-0.508	.5978	-0.243

Table 13d (cont.)

J.D.	ΔB	J.D.	ΔB	J.D.	ΔB	J.D.	ΔB
2436805		2436814		2441589		2443722	
.5114	+0.458	.4327	+0.264	.3815	-0.540	.3638	-0.066
.5159	.460	.4348	.250	.3829	.531	.3650	.057
.5180	.486	.4389	.286	.3843	.526	.3675	.144
.5205	.464	.4410	.288	.3870	.508	.3688	.207
.5253	.500	.4431	.312	.3884	.494	.3712	.331
.5274	.518	.4473	.303	.3898	-0.481	.3723	.352
.5326	.482	.4493	.319			.3748	.431
.5347	.509	.4514	.358	2441963		.3759	.455
.5409	.520	.4556	.362	.3138	+0.566	.3785	.512
.5430	.539	.4577	.373	.3152	.535	.3795	.535
.5451	.526	.4598	.351	.3187	.413	.3819	.543
.5493	.563	.4646	.385	.3228	.339	.3830	.578
.5514	.543	.4674	.387	.3242	.315	.3852	.551
.5534	.552	.4702	.387	.3266	.232	.3863	.551
.5576	.565	.4757	.420	.3280	.156	.3888	.524
.5597	.579	.4785	.419	.3301	.028	.3899	-0.519
.5618	.592	.4813	.418	.3315	+0.011		
.5659	.586	.4861	.445	.3343	-0.118	2443765	
.5680	.608	.4877	.453	.3357	.160	.2906	+0.547
.5701	.579	.4893	.456	.3384	.252	.2920	.480
.5743	.594	.4934	+0.444	.3394	.297	.2948	.383
.5764	.615			.3419	.370	.2962	.310
.5784	.604	2440506		.3433	.408	.2990	.132
.5826	.597	.4444	+0.386	.3460	.491	.3004	+0.052
.5847	.616	.4458	.266	.3474	.498	.3031	-0.017
.5868	.626	.4486	.172	.3499	.524	.3045	.068
.5909	.600	.4500	+0.082	.3513	.553	.3073	.119
.5965	.652	.4667	-0.461	.3537	.553	.3087	.175
.6010	+0.660	.4681	.487	.3551	.567	.3115	.237
		.4708	.523	.3578	.534	.3129	.285
2436814		.4722	.520	.3592	.536	.3156	.385
.3622	-0.228	.4750	.565	.3620	.508	.3170	.440
.3681	.192	.4764	.558	.3634	.517	.3198	.514
.3703	.155	.4792	.552	.3662	.466	.3212	.541
.3731	.144	.4806	.558	.3676	.445	.3240	.569
.3745	.145	.4833	.544	.3703	.415	.3254	.595
.3758	.131	.4847	.514	.3717	.405	.3281	.567
.3786	.091	.4875	.480	.3738	.403	.3295	.561
.3851	.063	.4889	-0.455	.3752	-0.395	.3323	.530
.3872	.063					.3337	.522
.3893	.031	2441589		2443722		.3365	.517
.3934	-0.024	.3599	-0.274	.3393	+0.582	.3379	-0.505
.3955	+0.019	.3613	.341	.3418	.564		
.3976	.034	.3627	.385	.3430	.567	2444133	
.4018	.016	.3655	.463	.3454	.516	.4194	+0.359
.4059	.038	.3669	.490	.3467	.508	.4204	.303
.4122	.106	.3683	.499	.3492	.424	.4235	.196
.4143	.126	.3703	.539	.3506	.430	.4248	.129
.4164	.133	.3717	.544	.3529	.315	.4277	+0.042
.4205	.158	.3731	.559	.3542	.322	.4293	-0.016
.4226	.187	.3759	.545	.3569	.176	.4324	.125
.4247	.211	.3773	.545	.3581	+0.151	.4339	.182
.4306	+0.256	.3787	-0.541	.3614	-0.010	.4369	-0.259

Table 13d (cont.)

J.D.	ΔB	J.D.	ΔB	J.D.	ΔB	J.D.	ΔB
2444133		2445230		2445566		2445622	
.4383	-0.352	.3932	-0.297	.4932	+0.252	.3073	+0.554
.4410	.422	.3946	.350	.4945	.184	.3086	.522
.4425	.471	.3960	.420	.4959	+0.137	.3099	.477
.4457	.518	.3974	.457	.5035	-0.203	.3155	.276
.4474	.533	.3988	.492	.5049	.231	.3169	.212
.4506	.530	.4048	.527	.5062	.236	.3182	.140
.4523	.534	.4062	.573	.5076	.291	.3196	.103
.4554	.522	.4076	.557	.5089	.366	.3209	+0.047
.4569	.517	.4090	.576	.5148	.508	.3270	-0.179
.4600	.499	.4104	-0.564	.5161	.550	.3283	.239
.4616	.495			.5175	.577	.3296	.288
.4645	.463	2445566		.5189	.577	.3310	.327
.4662	-0.448	.4535	+0.909	.5245	.599	.3323	.381
		.4548	.890	.5262	.555	.3393	.548
2445230		.4562	.852	.5295	.527	.3406	.553
.3581	+0.749	.4575	.874	.5308	.522	.3419	.566
.3594	.733	.4649	.838	.5322	.506	.3433	.570
.3609	.720	.4662	.842	.5335	.490	.3446	.571
.3636	.706	.4676	.824	.5349	.492	.3503	.557
.3707	.530	.4690	.823	.5422	.415	.3517	.534
.3720	.485	.4703	.782	.5436	.419	.3530	.534
.3734	.441	.4780	.700	.5449	.421	.3544	.515
.3748	.426	.4793	.687	.5463	.395	.3557	.507
.3762	+0.362	.4806	.622	.5476	-0.407	.3616	.479
.3822	-0.002	.4820	.589			.3630	.462
.3836	.049	.4833	.546	2445622		.3643	.456
.3850	.076	.4905	.347	.3046	+0.634	.3657	.450
.3864	.136	.4918	+0.300	.3059	+0.595	.3670	-0.431
.3877	-0.143						

Table 13e

Photoelectric uv observations of AV Peg

J.D.	ΔU	J.D.	ΔU	J.D.	ΔU	J.D.	ΔU
2445566		2445566		2445566		2445566	
.4539	+0.931	.4963	+0.098	.5340	-0.393	.3173	+0.193
.4566	.908	.5040	-0.211	.5353	.407	.3187	.128
.4579	.910	.5053	.195	.5427	.302	.3200	.090
.4654	.849	.5066	.213	.5440	.332	.3213	+0.033
.4667	.826	.5080	.287	.5454	.277	.3274	-0.137
.4681	.825	.5094	.354	.5467	.296	.3287	.203
.4694	.832	.5153	.452	.5480	-0.255	.3301	.254
.4708	.809	.5166	.481			.3314	.289
.4797	.671	.5180	.462	2445622		.3328	.344
.4824	.621	.5193	.489	.3050	+0.621	.3397	.474
.4837	.536	.5249	.529	.3063	.595	.3410	.466
.4910	.387	.5267	.493	.3077	.535	.3424	.487
.4923	.317	.5299	.454	.3090	.547	.3437	.480
.4936	.225	.5313	.432	.3104	.470	.3451	.460
.4950	+0.175	.5326	-0.389	.3160	+0.243	.3508	-0.439

Table 13e (cont.)

J.D.	ΔU	J.D.	ΔU	J.D.	ΔU	J.D.	ΔU
2445622		2445622		2445622		2445622	
.3521	-0.422	.3562	-0.417	.3634	-0.354	.3661	-0.323
.3535	.413	.3621	-0.369	.3647	-0.340	.3674	-0.302
.3548	-0.415						

Table 14a

Photoelectric observations of TU UMa in integrated light

J.D.	Δm	J.D.	Δm	J.D.	Δm	J.D.	Δm
2435925		2435934		2435934		2435963	
.4287	+0.614	.3028	+1.334	.3707	+0.246	.3918	+0.162
.4303	.609	.3039	1.290	.3730	.248		
.4315	.566	.3096	1.307	.3810	.177	2435992	
.4334	.563	.3106	1.307	.3831	.186	.3509	+0.663
.4356	.516	.3116	1.309	.3854	.188	.3523	.633
.4376	.482	.3130	1.294	.3881	.165	.3536	.619
.4394	.434	.3141	1.338	.3956	.181	.3550	.588
.4410	.397	.3180	1.292	.3985	.203	.3562	.562
.4488	.258	.3192	1.269	.3999	.237	.3601	.443
.4504	.203	.3203	1.263	.4118	.282	.3613	.449
.4520	.204	.3220	1.266	.4136	.295	.3626	.395
.4537	.193	.3232	1.245	.4151	.271	.3641	.395
.4602	.146	.3274	1.160	.4167	.283	.3655	.391
.4625	.129	.3289	1.113	.4181	.307	.3669	.333
.4646	.132	.3300	1.089	.4286	.387	.3708	.281
.4667	.137	.3312	1.053	.4298	+0.413	.3721	.278
.4692	.166	.3326	1.020			.3734	.288
.4761	.226	.3382	0.906	2435963		.3752	.259
.5201	.451	.3399	.843	.3638	+0.359	.3799	.243
.5228	.507	.3414	.818	.3648	.331	.3811	.238
.5258	.495	.3428	.787	.3666	.345	.3824	.232
.5284	+0.494	.3445	.719	.3679	.310	.3835	.256
		.3513	.604	.3693	.319	.3847	.246
2435934		.3534	.580	.3731	.221	.3888	.258
.2916	+1.340	.3547	.564	.3742	.195	.3898	.279
.2941	1.282	.3572	.528	.3755	.182	.3911	.251
.2952	1.294	.3588	.495	.3785	.163	.3923	.275
.2963	1.293	.3637	.403	.3819	.168	.3938	.290
.3007	1.301	.3657	.324	.3833	.152	.3982	.296
.3017	+1.309	.3684	+0.282	.3872	+0.166	.3994	+0.296

Table 14b

Photoelectric yellow observations of TU UMa

J.D.	ΔV	J.D.	ΔV	J.D.	ΔV	J.D.	ΔV
2436230		2436230		2436230		2436230	
.4353	+1.365	.4608	+0.890	.4684	+0.763	.4736	+0.682
.4475	+1.205	.4634	+0.833	.4709	+0.702	.4795	+0.639

Table 14b (cont.)

J.D.	ΔV	J.D.	ΔV	J.D.	ΔV	J.D.	ΔV
2436230		2436231		2436267		2436288	
.4820	+0.566	.6314	+0.378	.5525	+1.135	.4838	+0.512
.4846	.526	.6421	.421	.5566	1.130	.4877	.437
.4909	.396	.6476	.438	.5731	1.137	.4943	.395
.4938	.376	.6570	.489	.5779	1.129	.4968	.406
.4967	.362	.6602	.510	.5821	1.169	.4998	.372
.4990	.365	.6630	.536	.5855	1.160	.5028	.379
.5047	.358	.6709	.552	.5954	1.175	.5099	.376
.5075	.346	.6742	.579	.5995	1.179	.5136	+0.380
.5100	.343	.6771	.581	.6037	1.187		
.5158	.391	.6837	.595	.6075	1.214	2436604	
.5186	.393	.6863	+0.617	.6186	1.173	.6110	+1.309
.5214	.419			.6222	1.180	.6138	1.317
.5318	.446	2436264		.6258	1.189	.6163	1.309
.5362	.487	.3965	+1.342	.6453	1.202	.6218	1.295
.5416	.511	.4001	1.313	.6488	+1.190	.6246	1.266
.5488	.540	.4031	1.323			.6274	1.281
.5524	.566	.4104	1.334	2436272		.6329	1.246
.5561	.576	.4140	1.328	.2944	+0.725	.6357	1.205
.5640	.610	.4181	1.340	.2971	.722	.6385	1.181
.5679	.609	.4342	1.370	.3042	.598	.6437	1.074
.5716	.651	.4368	1.393	.3071	.508	.6458	1.028
.5798	.655	.4397	1.358	.3138	.462	.6478	0.951
.5848	.687	.4458	1.371	.3166	+0.410	.6531	.806
.5887	.699	.4490	1.336			.6551	.763
.6021	.780	.4521	1.351	2436278		.6572	.721
.6062	.755	.4622	1.227	.4004	+1.301	.6614	.709
.6254	.821	.4654	1.210	.4057	1.161	.6635	.686
.6287	.802	.4688	1.131	.4119	1.109	.6656	.653
.6375	.825	.4715	1.038	.4147	0.982	.6701	.555
.6411	.853	.4743	0.998	.4175	.967	.6721	.549
.6445	.868	.4785	.839	.4251	.798	.6746	.511
.6515	.915	.4816	.795	.4293	.726	.6794	.427
.6545	.903	.4884	.729	.4362	.589	.6819	.411
.6572	.904	.4946	.655	.4425	.474	.6840	.386
.6640	.915	.4976	.574	.4480	.423	.6885	.351
.6672	.901	.5122	.523	.4508	.382	.6906	.335
.6702	.920	.5045	.467	.4543	.366	.6926	.333
.6780	.943	.5078	.412	.4657	.364	.6965	.335
.6810	.957	.5114	.366	.4688	.383	.6985	.343
.6840	+0.980	.5147	.366	.4723	.388	.7006	+0.332
		.5184	.352	.4765	.386		
2436231		.5219	.338	.4796	+0.395	2436647	
.5743	+0.925	.5254	.342			.3990	+1.152
.5771	.841	.5291	.365	2436288		.4029	1.142
.5802	.777	.5323	+0.405	.4377	+1.322	.4044	1.128
.5886	.638			.4401	1.271	.4092	1.173
.5917	.640	2436267		.4437	1.208	.4111	1.129
.5954	.589	.5207	+0.993	.4472	1.116	.4149	1.144
.6049	.438	.5286	1.067	.4593	0.891	.4168	1.175
.6095	.360	.5329	1.070	.4658	.786	.4184	1.159
.6215	.346	.5369	1.090	.4690	.740	.4224	1.164
.6251	.346	.5447	1.103	.4724	.676	.4241	1.180
.6284	+0.350	.5482	+1.121	.4811	+0.551	.4259	+1.173

Table 14b (cont.)

J.D.	ΔV	J.D.	ΔV	J.D.	ΔV	J.D.	ΔV
2436647		2443848		2443954		2443954	
.4296	+1.145	.5656	+1.294	.5697	+0.889	.6318	+0.418
.4346	1.167	.5721	1.314	.5710	.852	.6332	.417
.4386	1.147	.5736	1.340	.5738	.773		
.4413	1.159	.5790	1.349	.5753	.744	2445471	
.4434	1.142	.5807	1.349	.5783	.704	.3890	+1.216
.4481	1.168	.5847	1.328	.5797	.719	.3903	1.189
.4503	1.154	.5967	1.212	.5825	.711	.3917	1.152
.4522	1.160	.5986	1.226	.5839	.693	.3976	1.048
.4565	1.154	.6022	1.162	.5863	.613	.4016	0.961
.4601	1.157	.6038	1.147	.5876	.605	.4029	.931
.4641	1.123	.6071	1.114	.5901	.564	.4043	.882
.4656	1.161	.6087	1.086	.5915	.567	.4056	.852
.4675	1.176	.6148	0.905	.5940	.532	.4069	.822
.4717	1.147	.6160	.898	.5959	.462	.4170	.673
.4734	1.147	.6191	.853	.6002	.405	.4183	.675
.4753	1.126	.6203	.774	.6016	.424	.4209	.631
.4842	1.147	.6235	.695	.6047	.386	.4245	.549
.4861	1.147	.6308	.598	.6061	.381	.4259	.521
.4883	1.130	.6318	+0.593	.6091	.353	.4272	.513
.4948	1.140			.6135	.336	.4286	.481
.4970	1.182	2443954		.6153	.343	.4397	.335
.4990	1.168	.5583	+1.144	.6184	.353	.4416	.329
.5045	1.181	.5599	1.132	.6198	.345	.4647	.324
.5065	1.208	.5623	1.124	.6225	.359	.4687	.360
.5084	1.197	.5634	1.076	.6240	.364	.4716	.377
.5222	1.248	.5659	0.997	.6271	.364	.4729	.387
.5260	+1.271	.5672	+0.980	.6285	+0.366	.4743	+0.417

Table 14c

Photoelectric blue observations of TU UMa

J.D.	ΔB	J.D.	ΔB	J.D.	ΔB	J.D.	ΔB
2436230		2436230		2436230		2436231	
.4448	+1.127	.5088	+0.018	.5996	+0.502	.5729	+0.772
.4492	1.018	.5146	.036	.6045	.516	.5757	.661
.4567	.801	.5169	.049	.6240	.573	.5787	.556
.4597	.714	.5200	.061	.6272	.587	.5870	.435
.4621	.618	.5301	.099	.6305	.613	.5910	.382
.4670	.505	.5340	.140	.6391	.651	.5934	.342
.4695	.451	.5397	.185	.6427	.677	.6023	.152
.4723	.439	.5471	.212	.6460	.695	.6061	.087
.4781	.354	.5508	.243	.6527	.707	.6096	+0.037
.4808	.286	.5544	.255	.6559	.726	.6172	−0.011
.4834	.235	.5617	.323	.6586	.726	.6200	+0.003
.4896	.109	.5657	.328	.6655	.735	.6232	.006
.4924	.048	.5696	.349	.6687	.748	.6267	.019
.4953	.027	.5780	.374	.6720	.767	.6293	.053
.4980	.027	.5828	.410	.6797	.790	.6407	.104
.5032	.009	.5870	.444	.6825	.806	.6434	.129
.5061	+0.002	.5950	+0.484	.6853	+0.819	.6462	+0.148

Table 14c (cont.)

J.D.	ΔB	J.D.	ΔB	J.D.	ΔB	J.D.	ΔB
2436231		2435267		2436288		2436647	
.6557	+0.205	.5589	+0.979	.4578	+0.658	.4139	+1.020
.6587	.210	.5750	1.040	.4646	.522	.4157	1.052
.6615	.228	.5804	1.047	.4673	.464	.4178	1.048
.6694	.252	.5836	1.034	.4706	.430	.4216	1.025
.6726	.272	.5876	1.054	.4796	.277	.4232	1.040
.6757	.280	.5972	1.079	.4824	.203	.4249	1.012
.6821	.322	.6016	1.064	.4854	.128	.4289	1.045
.6849	+0.323	.6060	1.082	.4892	.090	.4305	1.028
		.6089	1.077	.4956	.050	.4334	1.045
2436264		.6166	1.087	.4982	.057	.4377	1.036
.3983	+1.122	.6204	1.068	.5011	.049	.4404	1.062
.4014	1.153	.6238	1.053	.5053	.037	.4423	1.023
.4049	1.133	.6356	1.063	.5115	.055	.4472	1.023
.4156	1.185	.6395	1.063	.5150	+0.064	.4495	1.038
.4191	1.196	.6417	1.060			.4513	1.032
.4356	1.226	.6469	+1.079	2436604		.4556	1.031
.4382	1.234			.6100	+1.186	.4573	1.030
.4410	1.209	2436272		.6124	1.187	.4592	1.012
.4474	1.197	.2925	+0.441	.6149	1.170	.4632	1.023
.4504	1.208	.2957	.414	.6204	1.164	.4649	1.024
.4538	1.180	.3025	.277	.6232	1.158	.4666	1.005
.4609	1.094	.3058	.222	.6260	1.128	.4705	1.001
.4638	1.031	.3120	.128	.6315	1.096	.4725	1.024
.4673	0.974	.3151	+0.104	.6343	1.067	.4745	1.037
.4702	.897			.6371	1.035	.4833	1.031
.4729	.830	2436278		.6426	0.937	.4852	1.024
.4757	.693	.3991	+1.182	.6447	.876	.4872	1.040
.4798	.546	.4015	1.095	.6468	.796	.4924	1.030
.4830	.479	.4043	1.041	.6520	.618	.4960	1.034
.4867	.439	.4105	0.928	.6541	.549	.4981	1.061
.4902	.433	.4133	.844	.6562	.487	.5031	1.069
.4960	.332	.4227	.600	.6603	.430	.5055	1.079
.4994	.260	.4251	.521	.6624	.413	.5075	1.071
.5027	.199	.4279	.477	.6645	.408	.5212	1.129
.5062	.134	.4348	.394	.6690	.325	.5231	1.110
.5095	.088	.4376	.328	.6711	.290	.5249	+1.106
.5129	.039	.4411	.291	.6732	.248		
.5164	.015	.4466	.168	.6784	.145	2443848	
.5202	.004	.4494	.145	.6808	.099	.5650	+1.136
.5237	.010	.4522	.109	.6829	.045	.5712	1.144
.5272	.025	.4640	.034	.6874	.031	.5729	1.172
.5308	.047	.4675	.068	.6895	.002	.5779	1.164
.5342	+0.078	.4702	.084	.6916	+0.006	.5799	1.170
		.4744	.093	.6956	-0.006	.5838	1.142
2436267		.4779	+0.096	.6975	-0.003	.5855	1.137
.5186	+0.868			.6996	+0.019	.5893	1.108
.5228	.883	2436288				.5911	1.097
.5266	.886	.4364	+1.186	2436647		.5959	1.067
.5308	.932	.4388	1.135	.4022	+1.029	.5978	1.056
.5385	.957	.4425	1.062	.4036	1.015	.6015	1.003
.5465	.965	.4449	0.979	.4069	1.025	.6031	0.965
.5550	.969	.4526	.817	.4084	1.041	.6062	.941
.5548	+0.966	.4551	+0.750	.4103	+1.001	.6080	+0.885

Table 14c (cont.)

J.D.	ΔB	J.D.	ΔB	J.D.	ΔB	J.D.	ΔB
2443848		2443954		2443954		2445471	
.6139	+0.702	.5730	+0.552	.6098	-0.012	.4020	+0.698
.6154	.659	.5747	.504	.6129	.035	.4033	.670
.6182	.612	.5776	.444	.6146	.033	.4047	.640
.6196	.530	.5790	.431	.6175	.027	.4060	.580
.6226	.466	.5818	.436	.6192	.017	.4074	.531
.6161	.429	.5832	.432	.6219	-0.003	.4174	.393
.6309	+0.409	.5857	.361	.6232	+0.006	.4188	.376
		.5869	.344	.6262	.011	.4250	.216
2443954		.5894	.295	.6279	.016	.4263	.179
.5578	+0.999	.5908	.269	.6307	.038	.4277	+0.154
.5592	.980	.5933	.230	.6325	+0.045	.4420	-0.076
.5616	.919	.5954	.206			.4651	+0.005
.5628	.887	.5997	.074	2445471		.4691	-0.012
.5653	.816	.6009	.055	.3894	+1.041	.4720	+0.031
.5665	.780	.6039	.023	.3908	1.021	.4734	0.018
.5691	.708	.6054	+0.008	.3921	0.989	.4747	+0.043
.5703	+0.657	.6084	-0.004	.3980	+0.837		

Table 14d

Photoelectric uv observations of TU UMa

J.D.	ΔU	J.D.	ΔU	J.D.	ΔU	J.D.	ΔU
2445471		2445471		2445471		2445471	
.3889	+1.027	.4051	+0.484	.4254	+0.223	.4656	-0.046
.3912	0.988	.4065	.451	.4268	.180	.4724	+0.041
.3925	.954	.4078	.413	.4281	+0.162	.4738	.050
.4024	.580	.4179	.353	.4425	-0.054	.4752	+0.069
.4038	+0.552	.4192	+0.348				