A&A 437, 375–381 (2005)
DOI: 10.1051/0004-6361:20042003

Astronomy & Astrophysics

Catalogue of the orbital elements, masses, and luminosities for short-periodic *RS CVn*-type eclipsing systems*

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Received 13 September 2004 / Accepted 31 January 2005

Abstract. New data on the orbital elements, masses, and luminosities were collected for 31 pre-contact binary systems of short-periodic *RS CVn*-type. We treat the catalogued data statistically in order to accurately define the properties and evolutionary status of each class system. The ages of pre-contact systems were estimated by the isochrone method. Numerous comments and bibliographic references to the catalogue are also included.

Key words. binaries: eclipsing – catalogs – stars: fundamental parameters

1. Introduction

Our catalogue updates the section devoted to *DW*-type eclipsing variable stars in the "Catalogue of the orbital elements, masses, and luminosities of close binary systems" by Svechnikov (1986). According to the classification by Svechnikov (1985) specially developed for close binaries, the *DW* abbreviation means Detached (components far from the contact configuration) eclipsing binaries similar in their physical characteristics to stars of *W UMa*-type and with orbital periods ($P \lesssim 1\overset{d}{.}2$) noticeably greater than those of *W UMa*-type stars ($P \lesssim 0\overset{d}{.}4 \div 0\overset{d}{.}5$). Another designation widely used in the literature for *DW* eclipsing binaries is "*short-periodic*" *RS CVn*-type systems.

The phenomenological class of *RS CVn*-type binaries was defined by Hall (1972) to comprise all known sorts of anomalous objects with various chromospheric activity levels. These may be single stars, as well as binaries, consisting of far evolved components, subgiants, Main-Sequence (*MS*), and pre-*MS* stars, the orbital periods of which vary in a huge range from twelve hours to ten or more years. The large sample of such objects were catalogued and studied by Strassmeier et al. (1989; 1993). It is quite clear that an *RS CVn*-class that is so inhomogeneous in its properties will be difficult to study. On the basis of intensive photometric and spectroscopic analysis of observational data, therefore, it was advisable to separate out the chromospherically active close binary systems with orbital periods less than $1\overset{d}{.}2$ into an independent category of "*short-periodic*" *RS CVn*-type systems (*DW*-stars). Also all binaries presented in the *DW*-catalogue are eclipsing systems whose variability is rigorously established from photometric light curves, whereas more than a half of the systems from Strassmeier's catalogue (1993) are not eclipsing and their variability is determined from the wave migration period. This past decade has offered plentiful observational information about short-periodic *RS CVn*-type stars.

All *DW*-type systems presented in the new version of the catalogue are characterized by well-studied photometric light curves and radial velocity curves (in most cases). Therefore, we can consider absolute and relative elements of spectroscopic and photometric orbits as reliable data, in contrast to other earlier catalogues by Strassmeier et al. (1989, 1993) and Svechnikov & Kuznetsova (1990).

DW-type binaries have always attracted attention due to their solar-like activity and been intensively studied in past years to understand the nature of their activity. The principle observation features of the short-periodic *RS CVn*-type systems are the following:

- obvious *asymmetry* and significant *peculiarities* inherent in photometric light curves of *DW* systems;
- presence of the long-period regular constituent in a changing light known as the *photometric wave*, or *distortion wave*, interpretation of which is based on the hypothesis of a developed structure of photospheric *spots* covering the stellar surface;
- existence of intensive emission lines such as the well-known doublet H and K Ca II, the resonance doublet Mg II, and the line He I λ 10 830 Å in the spectra of components. It serves as evidence of *chromospheric activity* in these systems;

* Appendix is only available in electronic form at http://www.edpsciences.org

– irregular variations in the orbital period linked with the magnetic stellar wind emanating from the star (to explain the orbital jumps, the *surface magnetic fields* may not exceed a few hundred Gauss);
– powerful *radio*-, *IR*- and *X*-ray *flashes*;

The rich observations of this class of binaries deserve careful study and explain why we have compiled a new catalogue of DW-binaries.

A lot of new data concerning the photometric and spectroscopic elements of orbits of eclipsing systems have been gathered since the catalogue by Svechnikov (1986) was published. Modern all-wave observations, the newest instrumental capabilities of which include *CCD* arrays and multicoloured photometers, considerably increase the accuracy of light curve definition for eclipsing variables. Extra-atmospheric observations from satellites have been carried out for some of these systems. A series of pre-contact binaries was registered in the list of program variable stars of the main mission of the *HIPPARCOS* satellite (1989−1996) in order to more precisely define orbital periods, amplitudes, epochs, and variability types for all variable stars.

Using powerful computers to apply the up-to-date methods of light curve simulation and spectra treatment, including the synthesis method of light curve and direct methods of photometric elements estimation, will add to the number of well-studied stars.

High-dispersion spectrograms that exclude blending effects for spectral lines enable us to make reliable estimations of the mass ratio and proper masses for each component. As a result, all the above-mentioned modernizations concerning observations and data require periodic revision of catalogues and especially of the catalogue for pre-contact systems. The new version of this catalogue contains 31 *DW*-type systems, while only seven systems of this class are presented in the previous version of the catalogue by Svechnikov (1986).

During 1986−2003 a series of photometric catalogues of the eclipsing variables was published:

– "sixth catalogue of the orbits of visual double systems" containing information about 1660 orbits;
– the *INCA* catalogue containing 11 434 program double systems in the framework of the *HIPPARCOS* project was supplemented with 3000 newly discovered doubles, among which 917 are eclipsing variables of *EA*, *EB*, and *EW* types (347 newly discovered);
– a photometric catalogue of light curves constructed from 110 points for each of 118 204 variable stars.

Thus taking into account the new observational data, and thanks to the Internet for a rapid information and discussion (for some eclipsing variables the photometric solutions were unmatched with each other), the updated catalogue of pre-contact systems containing information about masses, radii, luminosities, and other characteristics of a star has been compiled. The archive card catalogue of relative and absolute elements of the close binary systems started as far back as the 1961 by Svechnikov has served as a basis of this one.

For systems whose spectroscopic elements are unknown and whose absolute characteristics are impossible to directly compute, the statistical relations such as "mass–spectrum" ($M-Sp$) and "spectrum-effective temperature" ($Sp-T_{\rm eff}$) which were obtained and substantiated in Svechnikov (1985) were employed here to estimate mass and effective temperature of the primary component by its known spectrum. For the satellites the values of mass and effective temperature are found from known photometric solutions based on mass ratio and the surface brightness ratio of components, respectively. As for determining the major semi-axis and absolute radii, the generalized third Kepler's law is used along with simple geometrical proportions that connect relative radii known from photometric solutions with absolute ones, for instance *WZ And*, *RX Ari*, *AE Cas*, *ST Cen*, *AR Dra*, *MT Her*, *CN Lac*, and *UU Lyn*. The percentage of similar binaries is approximately 25%. In rare cases of lacking information on the relative radii of components, the "mass–radius" ($M-R$) relation obtained by Svechnikov (1985) is employed when calculating the absolute radii, at which point relative radii are deduced from inverse geometrical proportions.

2. Description of the catalogue

All stars are listed alphabetically according to Roman constellations:

1. the sequence number is indicated in the first column;
2. the pre-contact system name is given in the second column;
3. orbital period P (changeability of which is marked by the asterisk "⋆"), the spectra, and luminosity classes of the components are in the third column. If the satellite spectrum Sp_2 was derived from the known spectrum class of the primary component Sp_1 and surface brightness ratio J_1/J_2, then it is enclosed in square brackets;
4. mass ratio q (M_2/M_1) and major semi-axis A expressed in units of Sun radius $R_\odot$ are placed into the fourth column. If q is determined from the spectroscopy via radial velocity curves known for both components ("double-lined spectra" case) then its value is underlined by a solid line; its value is underlined by a dashed line when q is found via the mass function derived from the radial velocity curve known for the more massive component only ("single-lined spectrum" case) under the assumption that this component satisfies "mass–luminosity" $M-M_{\rm bol}$ dependence for MS stars (so-called $M-M_{\rm bol}$ method developed in detail by Svechnikov 1969); and if q is photometrically estimated via light curves then its value is not underlined.
5. masses of more massive primary and less massive secondary components M_1 and M_2 expressed in units of Sun mass $M_\odot$ are presented in the fifth column;
6. radii of primary R_1 and secondary R_2 components expressed in units of Sun radius $R_\odot$ are contained in the sixth column;
7. absolute bolometric stellar magnitudes of primary $M_{\rm bol1}$ and secondary $M_{\rm bol2}$ components estimated according to their geometric sizes, spectra, and luminosity classes are given in the seventh column. When calculating $M_{\rm bol1}$

and M_{bol2} the Popper (1980) scale of effective temperatures was used. The preferred temperature scale in all catalogues by Svechnikov is Popper's. In order to maintain uniform treatment of the newly obtained (as a result of revision) data the same scale was used;

8. relative radii of both components r_1 and r_2 (average components radii) expressed in the units of a major semi-axis of the orbit are given in the eighth column;
9. the relative luminosity of the primary component expressed in relative units ($L_1 + L_2 = 1$) and surface brightness ratio J_1/J_2 are in the ninth column, along with the effective wave length λ_{eff} or the wave length close to V-band pass in which these observations were performed;
10. the orbit inclination of picture plane i and weight W, characterizing the quality of the estimation of absolute and photometric elements of the system on a ten-point scale, are included in the tenth column; criteria for weight estimation are discussed in detail by Svechnikov (1969);
11. the key papers, on the basis of which the photometric and spectroscopic data were selected and, if needed, averaged over the different sets of solutions, are presented in the eleventh column.
12. the symbol ":" is used in any case when an element is determined as unreliable.

3. Catalogue of the orbital elements, masses, and luminosities of the pre-contact (*DW*-type) systems (see Table 1)

4. Statistical treatment of the catalogue data and conclusions

The empirical coefficients of such relations as M–R, M–Sp, M–M_{bol}, and Sp–M_{bol} have been obtained for primary and secondary components by summarizing data compiled for pre-contact systems. 31 systems of *DW*-type were involved in this treatment; for a better fitting to the statistical dependences for systems *WZ And* (2) and *UV Leo* (20), we have taken photometric solutions under Number 1 (see Table 1).

The empirical relation generalized for primary and secondary components Sp–M_{bol} (see Appendix, Fig. A.1) may be written in the following form:

$$M_{bol} = (-15.7757 \pm 0.8488) \cdot \lg T_{eff} + (63.5622 \pm 3.1795). \quad (1)$$

For the mass range of both components $-0.51 \leqslant \lg M \leqslant 0.27$ the empirical relation M–R was found (Fig. A.2) in the linear form:

$$\lg M = (+0.7076 \pm 0.1240) \cdot \lg R - (0.0583 \pm 0.0174). \quad (2)$$

The primary and secondary components of *DW*-type systems also satisfy the linear empirical relations M–M_{bol} and M–Sp (see Figs. A.3 and A.4):

$$M_{bol} = (-6.6283 \pm 0.6241) \cdot \lg M + (4.4470 \pm 0.0881) \quad (3)$$

$$\lg M = +(1.7929 \pm 0.1370) \cdot \lg T_{eff} - (6.7195 \pm 0.5131). \quad (4)$$

It should be interesting to test the conclusions in Dryomova & Svechnikov (1999) made after analyzing 153 *DW*-type binaries taken from the "Catalogue of the approximate photometric and absolute elements of the eclipsing variable stars" by Svechnikov & Kuznetsova (1990) and based on new data on the 31 pre-contact systems from the catalogue presented here. As shown in Dryomova & Svechnikov (1999) the dependence of the radius excess (as well as the luminosity excess) upon mass (or mass ratio), constructed for the primary and secondary components of 153 *DW*-type binaries, is almost constant. The faint radius and luminosity excesses reveal themselves only in the range $M_{1,2} > 1\ M_\odot$ and $q > 0.8$. This means the binaries of *DW*-type have only evolved slightly from Zero Age Main Sequence (*ZAMS*) and stay in the initial stage of the Roche lobes filling; i.e. their evolutionary status is close to that of <u>D</u>etached <u>M</u>ain <u>S</u>equence (*DMS*-type) systems, both components of which are *MS*-stars not yet filling their inner Roche lobes and so not interacting with each other. One must emphasize that this abbreviation (*DMS*) adopted according to the classification by Svechnikov (1985) is used in the General Catalogue of the Variable Stars (see Kholopov et al. 1985). The distinction between these two classes is the chromospheric and photospheric activity (which reveal themselves in numerous spots), sharply expressed in the case of *DW*-type binaries and barely noticeable (i.e. a thousand times less by intensity) in the case of *DMS*-systems. Also, eclipsing binaries with orbital periods less then $1^{d}\!.2$ do not occur among *DMS*-class, whereas all *DW*-systems have orbital periods $P \lesssim 1^{d}\!.2$ at the same masses as for the *DMS*-class, as indicated in Svechnikov (1985). The light curves of *DW* eclipsing variables possess significant peculiarities in contrast to *DMS*-systems.

The excess of the radius of *DW*-satellites is defined as the difference between the observed (calculated as $r_2 \cdot A$) value and that found in accordance with the empirical "mass–radius" relation averaged for *MS* stars. The same is true for the definition of luminosity excess with only one difference: the empirical "mass–luminosity" relation for *MS* stars is used. When calculating radius and luminosity excesses we have used new M–M_{bol} and M–R relations obtained by Gorda & Svechnikov (1999) for detached *MS* eclipsing variables with well-known absolute elements. These radius and luminosity excesses indicate that the position of *DW*-binaries is close to Terminal Age Main Sequence (*TAMS*) but is not a midpoint of the *MS*-band as is true for *DMS*-systems.

Actually analysis of the distributions depicted in Figs. A.5 and A.6 verifies the presence of insignificant radius and luminosity excesses in a majority of satellites in *DW*-type systems. The tendency of radius and luminosity excesses to increase as the mass ratio of *DW*-binaries decreases ($q < 0.6$) is noticed. As for the mass ratio range $q > 0.6$, the average statistical scattering in values of radius and luminosity excesses should be noted.

The maximum radius of *DW*-satellites is two and a half times larger than that of *MS*-stars, and the maximum luminosity excess is approximately two and a half magnitudes at $q = 0.25$. These excesses are indeed quite small in comparison with analogous radius and luminosity excesses for the satellites of *W UMa*-type contact systems, which reach a maximum up

Table 1.

N	Name	P / Sp	q / A	M_1 / M_2	R_1 / R_2	M_{bol_1} / M_{bol_2}	r_1 / r_2	L_1 / J_1/J_2	i / W	Ref.
1	RT	$0^{d}.62892942^{\star}$	0.74	1.23	1.25	4.04	0.315	0.886 V	$88^{\circ}.4$	Arevalo et al. (1995)
	And	$F9V + K2.5V$	3.98	0.91	0.90	5.73	0.227	4.05 V	9	Popper (1994)
										Kjurkchieva et al. (2001)
2	WZ And	$0^{d}.695662240^{\star}$	0.79	1.27	1.91	2.80	0.440	0.76 V	$80^{\circ}.8$	Lavrov (1955)
2	WZ And	$F5V + [G6]V$	4.34	1.00	1.43	3.96	0.329	1.77 V	4	Cook (1948)
2	WZ And	$0^{d}.695660340^{\star}$	0.67	2.10	2.31	2.39	0.461	0.81 V	$81^{\circ}.8$	Kyu-Dong (1977)
2	WZ And	$F5V + [G8.5]V$	5.01	1.40	1.72	3.80	0.344	2.37 V	4	
3	BX	$0^{d}.61011355^{\star}$	0.49	1.52	1.78	2.79	0.448	0.94 V	$74^{\circ}.6$	Bell et al. (1990)
	And	$F3V + [K4]V$	3.98	0.75	1.30	5.26	0.326	8.3 V	7	Derman et al. (1993)
										Jassur et al. (2000)
4	DS	$1^{d}.01051872$	0.59	1.58	2.10	2.39	0.365	0.85 V	$84^{\circ}.3$	Schiller & Milone (1988)
	And	$F3IV - V + G0V$	5.76	0.94	1.19	4.15	0.207	1.82 V	7	
5	HS	$0^{d}.71016230^{\star}$	0.64	1.35	1.35	3.88	0.31	0.77 V	68°	Robb et al. (1990)
	Aqr	$F9V + [K2.5]V$	4.36	0.86	1.35	4.84	0.31	3.35 V	4	Marschall et al. (1991)
										Popper (1995)
6	RX	$1^{d}.02962682$	0.27	1.30	1.96	2.52	0.386	0.99 V	$81^{\circ}.9$	Wilson & Rafert (1980)
	Ari	$F2V + [M0]V$	5.08	0.36	1.10	6.28	0.216	31 V	4	Kreiner et al. (2001)
7	CV	$0^{d}.8469935$	0.94	1.02	1.12	4.40	0.236	0.56 V	83°	Popper (1993)
	Boo	$G3 : V + [G6]V$	4.73	0.96	1.05	4.64	0.221	1.11 V	5	Busch (1985)
8	SV	$0^{d}.5930718^{\star}$	0.59	1.47	1.29	3.67	0.328	0.96 V	90°	Patkos & Hempelmann (1994)
	Cam	$F5V + [K4.5]V$	3.94	0.87	0.83	6.30	0.211	9.93 V	9	Pojmanski (1998)
										Frigo et al. (2002)
										Kjurkchieva et al. (2002)
9	WX	$1^{d}.2245888$	0.74	1.31	1.51	3.19	0.238	0.73 V	$82^{\circ}.6$	Lu et al. (1990, 1991)
	Cnc	$F2V + G4V$	6.34	0.97	1.28	4.28	0.202	1.95 V	7	
10	WY	$0^{d}.82937122$	0.51	1.17	1.07	4.54	0.239	0.97 V	$87^{\circ}.8$	Pojmanski (1998)
	Cnc	$G5V + K2V$	4.49	0.60	0.67	6.28	0.150	12.7 V	8	Heckert (2003)
11	VZ	$0^{d}.84246163$	0.78	1.84	1.76	2.68	0.315	0.78 V	80°	Popper (1988)
	CVn	$F2V + [F8]V$	5.57	1.43	1.25	3.98	0.225	1.80 V	8	Shenghong et al. (1994)
12	AE	$0^{d}.7591215$	0.7:	1.0:	1.50	3.93	0.356	0.82 V	$80^{\circ}.4$	Srivastava & Kandpal (1984)
	Cas	$(G6 - 7)V + [K4.5]V$	4.2	0.7:	1.45	5.07	0.345	4.28 V	2	Nelson (2002)
13	ST	$1^{d}.2234184$	0.90	1.13	2.02	2.85	0.325	0.52 V	$83^{\circ}.7$	Milone & Hrivnak (1981)
	Cen	$F9V + F9V$	6.21	1.02	1.97	2.94	0.317	1.03 V	3	
14	RS	$0^{d}.67235579$	1:	1.1	1.2	4.17	0.28	0.53 V	$67^{\circ}.6$	McFarlane & Hilditch (1987)
	Col	$G0V + [G4]V$	4.2	1.1	1.2	4.28	0.28	1.13 V	2	Rucinski (1983)
15	CG	$0^{d}.63114100$	0.84	0.96	0.89	5.36	0.239	0.70 V	$82^{\circ}.4$	Popper (1994)
	Cyg	$G9.5V + K3V$	3.74	0.81	0.84	5.98	0.224	2.09 V	7	Dapergolas et al. (2000)
										Kjurkchieva et al. (2003)
16	AR	$0^{d}.67583743$	0.75:	1.27	1.49	3.34	0.354	0.82 V	$84^{\circ}.5$	Broglia & Conconi (1979)
	Dra	$F5V + [G9]V$	4.22	0.95	1.32	4.62	0.314	3.2 V	3	
17	BZ	$0^{d}.6641703^{\star}$	0.93	1.0	1.1	4.5	0.28	0.63 V	69°	Srivastava & Sinha (1981)
	Eri	$(G0III) + (G2III)$	4.0	0.93	1.0	5.0	0.25	1.4 V	1	Srivastava & Uddin (1986)
										Srivastava (1986)
18	MT	$0^{d}.48771779$	0.58	1.2:	1.0:	4.5	0.303	0.94 V	$77^{\circ}.6$	Budding & Murad (1989)
	Her	$F8V + [K6]V$	3.2	0.7:	0.7:	6.8	0.222	8.4 V	3	
19	CN	$0^{d}.637359955$	0.77	1.07	1.31	4.06	0.34	0.86 V	$78^{\circ}.1$	Nekrasova (1936)
	Lac	$G3V + [K1.5]V$	3.85	0.82	0.81	5.80	0.21	2.37 V	2	Kreiner (2001); CDS
20	UV Leo	$0^{d}.600086414$	0.97	1.13	1.17	4.29	0.301	0.53 V	$83^{\circ}.2$	Botsula (1978); Popper (1993)
20	UV Leo	$G2V + G2V$	3.90	1.09	1.13	4.36	0.290	1.05 V	7–8	Popper (1995); Wunder (1995)
20	UV Leo	$0^{d}.600086675^{\star}$	0.92	1.21	1.10	4.38	0.277	0.47 V	$82^{\circ}.6$	Frederic & Etzel (1996)
20	UV Leo	$GOV + G2V$	3.96	1.11	1.20	4.23	0.303	1.06 V	8	Popper (1997)
										Zwitter et al. (2003)

Table 1. continued.

N	Name	P / Sp	q / A	M_1 / M_2	R_1 / R_2	M_{bol_1} / M_{bol_2}	r_1 / r_2	L_1 / J_1/J_2	i / W	Ref.
21	*UU*	$0^{d}.46846016$	0.41	1.40	1.41	3.35	0.444	0.97 *V*	$88^{\circ}.5$	Yamasaki et al. (1983)
	Lyn	$F3V+[K7]V$	3.18	0.57	0.90	6.44	0.285	16 *V*	6	Yamasaki et al. (1986)
22	*V361*	$0^{d}.30961493^{\star}$	0.69	1.26	1.02	4.34	0.412	0.92 *V*	$85^{\circ}.7$	Hilditch et al. (1997)
	Lyr	$F9V+[K4]V$	2.48	0.87	0.72	6.46	0.289	5.66 *V*	7	
23	*DD*	$0^{d}.56802738^{\star}$	0.45	1.05	1.36	3.45	0.410	0.88 *V*	$76^{\circ}.5$	Shengbang et al. (1996, 1997)
	Mon	$F5V+[K1]V$	3.32	0.47	1.01	5.29	0.304	4.03 *V*	5	Yamasaki et al. (1990)
24	*UV*	$0^{d}.861046566^{\star}$	0.78	0.98	1.15	4.39	0.252	0.85 *V*	$86^{\circ}.3$	Budding et al. (1996)
	Psc	$G5V+K3V$	4.58	0.76	0.89	5.79	0.194	3.36 *V*	9	Popper (1997)
										Heckert (1999)
25	*RS*	$0^{d}.664238549$	0.60	1.36	1.58	2.95	0.381	0.90 *V*	$87^{\circ}.3$	King & Hilditch (1984)
	Sct	$F4V+[K2]V$	4.15	0.82	1.24	4.96	0.300	5.58 *V*	7	Buckley (1984)
										Kreiner et al. (2001)
26	*GR*	$0^{d}.42985060$	0.22	1.42	1.34	3.32	0.464	0.98 *V*	$71^{\circ}.9$	Lazaro et al. (1995)
	Tau	$(F1)V+[K6]V$	2.88	0.31	0.76	6.72	0.264	15.8 *V*	4	Zhang et al. (2002)
27	*GY*	$0^{d}.4460348^{\star}$	0.8:	1.1	1.2	3.65	0.39	0.73 *V*	88°	Lipari & Sistero (1988)
	Tel	$F2V+[G1]V$	3.1	0.9	1.0	4.60	0.32	1.8 *V*	1	Shaw (1994)
28	*XY*	$0^{d}.47899493$	0.61	1.10	1.13	4.42	0.363	0.97 *V*	81°	Pojmanski (1998)
	UMa	$G2V+K5V$	3.11	0.66	0.66	7.36	0.211	12.9 *V*	7	Cameron & Hilditch (1997)
										Hilditch & Bell (1994)
29	*BH*	$0^{d}.81687080$	0.90	1.16	1.22	4.03	0.255	0.63 *V*	$86^{\circ}.5$	Popper (1997)
	Vir	$F8V+G5V$	4.79	1.05	1.12	4.52	0.233	1.42 *V*	7	Arevalo et al. (2002)
30	*CG*	$0^{d}.935298$	0.53	1.43	1.64	3.2	0.314	0.90 *V*	$78^{\circ}.5$	Shen et al. (1990)
	Vir	$F6IV+K5V$	5.22	0.76	1.50	5.0	0.287	7.52 *V*	6	
31	*ER*	$0^{d}.69809409^{\star}$	0.96	1.10	1.11	4.37	0.259	0.55 *V*	$67^{\circ}.3$	Hill et al. (1990)
	Vul	$G0V+G5V$	4.27	1.05	1.08	4.57	0.253	1.17 *V*	8	Olah et al. (1994)
										Zeinali & Edalati (1995
										Garcia-Sanchez et al. (2003)

Table 2. Evaluations of the ages and their errors calculated by the isochrone method in the $M-R$ diagram for primary components of *DW*-type systems. The ages are given in billions of years (Gyr).

Name	t_1	Name	t_1	Name	t_1	Name	t_1
1. *RT And*	4.54 ± 0.74	8. *SV Cam*	3.89 ± 0.59	16. *AR Dra*	5.44 ± 0.10	23. *DD Mon*	8.62 ± 0.46
2. *WZ And*	7.96 ± 0.17	9. *WX Cnc*	4.95 ± 0.18	17. *BZ Eri*	7.41 ± 0.52	24. *UV Psc*	9.15 ± 0.52
	5.14 ± 0.30	10. *WY Cnc*	4.32 ± 2.50	18. *MT Her*	*ZAMS*	25. *RS Sct*	4.72 ± 0.24
3. *BX And*	3.39 ± 0.24	11. *VZ CVn*	2.99 ± 0.54	19. *CN Lac*	7.76 ± 0.40	26. *GR Tau*	0.96 ± 0.15
4. *DS And*	3.52 ± 0.31	12. *AE Cas*	8.48 ± 0.24	20. *UV Leo*	3.65 ± 0.26	27. *GY Tel*	5.20 ± 0.30
5. *HS Aqr*	1.50 ± 0.11	13. *ST Cen*	5.87 ± 0.54		4.88 ± 0.28	28. *XY UMa*	3.82 ± 0.29
6. *RX Ari*	7.76 ± 0.34	14. *RS Col*	5.20 ± 0.30	21. *UU Lyn*	1.08 ± 0.04	29. *BH Vir*	4.62 ± 0.42
7. *CV Boo*	6.87 ± 0.48	15. *CG Cyg*	1.83 ± 0.21	22. *V361 Lyr*	*ZAMS*	30. *CG Vir*	3.98 ± 0.23
						31. *ER Vul*	4 ± 0.38

to $12 \div 15$ times and 9^{m}, respectively, at $q = 0.15$ as compared to *MS* stars according to Svechnikov (1990). This comparison is important because *W UMa*-type contact systems present the next evolutionary stage of pre-contact short-periodic *RS CVn*-type binaries. The resulting radius and luminosity excesses of *DW*-satellites are quite expected in the framework of the formalism of magnetic braking.

This approach explains the evolution of low-mass ($M_1 \lesssim 1.5 \div 2\ M_{\odot}$) *DMS*-binaries, *DW*-stars, and *W UMa*-type contact systems in terms of orbital angular momentum loss (*AML*) and combines them into a common evolutionary chain that in fact has already been confirmed from extensive observational data by Svechnikov & Kuznetsova (1990) and from the relations of statistics and lifetimes obtained by Tutukov et al. (2004).

The magnetic stellar wind in low-mass close binaries is a driving force in the approach of the two components. But considering that the orbital *AML*-timescale is shorter than the nuclear timescale, the mass loss process in the binary may be initiated before the components fill up their Roche lobes. It is very likely that such a process might lead to the appearance of excess in radii and luminosities of *DW*-satellites. As for satellites of *W UMa*-type contact systems, the question of radius and luminosity excesses was treated in detail by Istomin (1986) with the assumption that the luminosity increase of their satellites is due to gravitational energy release originating from the matter flowing from the more massive component.

Analysis of the position of *DW*-systems relative to tracks constructed from evolutionary stellar models by Maeder & Meynet (1988) in the L–$T_{\rm eff}$-diagram (Fig. A.7) showed that the primaries are well positioned within the *MS* band in the Hertzsprung-Russel (*H-R*) diagram and justified their status as slightly evolved stars, whereas the satellites demonstrate luminosity excesses for their masses. The same conclusion can be made from Fig. A.9. The M−R diagram (Fig. A.8) clearly shows that almost all *DW*-primaries are strongly localized between the boundaries of *ZAMS* and *TAMS* also taken from models by Maeder & Meynet (1988); and yet at the same time *DW*-satellites are oversized for their masses. Also the M−Sp-diagram (Fig. A.10) is of interest because of temperature excesses which are so evident for secondary components of *DW*-systems.

The ages and their errors, calculated by the isochrone method in M−R diagram for primary components of *DW*-type systems and taken from the catalogue presented here, are placed in Table 2. The isochrone method is also based on the theoretical stellar evolution models by Maeder & Meynet (1988), taking an overshooting into account along with mass loss of components and developed for Population I stars with (X, Y, Z) = 0.70, 0.28, 0.02. This method was expounded in Dryomova & Svechnikov (2003). The choice of these models with given abundances is explained by the fact that all eclipsing binaries considered here are located in Sun neighbourhood and therefore should have similar chemical composition.

The t_1 ages and their errors are given in Gyr. Pre-contact systems such as *WY Cnc* (10), *VZ CVn* (11), and *AE Cas* (12) lay off the M−R desigh diagram so the $L - T_{\rm eff}$ diagram was applied to estimate the ages of these systems by the isochrone method as well. We obtained a fairly wide spread for an age change; for example, the age of *UV Psc* (24) equals approximately 10 Gyr, while *MT Her* (18) and *V* 361 *Lyr* (22) binaries are located near the *ZAMS*.

This new catalogue of short-periodic *RS CVn*-type systems gives information about elements of spectroscopic and/or photometric orbits such as orbital period, mass ratio, proper masses, orbital inclination, surface brightness ratio, luminosities, absolute and relative radii. We have determined that 18 *DW*-systems correspond to the "double-lined spectra" case, while only three systems (*UU Lyn*, *DD Mon*, *GR Tau*) relate to the "single-lined spectrum" case. In these instances the indicated *DW*-type systems are characterized by well-studied radial velocity curves and photometric light curves. It is evident from their high weights as mentioned in the catalogue. The remaining ten pre-contact eclipsing binaries have no spectroscopic observations so may only be described in photometric solution terms. Nevertheless this catalogue may serve as a reliable data source with just an accent on those five systems whose weights (*W*) do not exceed 2: *AE Cas*, *RS Col*, *BZ Eri*, *CN Lac*, and *GY Tel*. This catalogue is useful for analyzing basic empirical relations such as M−R, M−Sp, M−$M_{\rm bol}$, and Sp−$M_{\rm bol}$ and when studying properties of pre-contact *DW*-class which represents the intermediate stage between the detached *DMS*-class and contact binaries of *W UMa*-type.

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Online Material

Appendix A: Appendix to the catalogue

1. **RT And**. All available photometric and spectroscopic data have been reanalyzed in the same manner. *UBVRIJK* light curves without maculation effects together with the radial velocities of both components were analyzed with the Wilson-Devinney code by Pribulla et al. (2000). The high orbital inclination was confirmed by photoelectric observations of the secondary minimum. A small eccentricity found from the light curve analysis cannot be ruled out. The face-to-face position of the spots on the surface of both components (registered in 1971) indicates the possibility of a mass transfer from the primary to the secondary component through a magnetic bridge connecting both active regions. Analysis of all available light curves suggests a random position of starspots and does not confirm the idea of active longitudinal belts by Arevalo et al. (1995). From the longitudinal spot motion (between 1995 and 1998) it was inferred by Ekmerci et al. (2002) that the migration period of the distortion wave has a value of 6.6 years. This system was included in the main *HIPPARCOS* mission ($r = 75 \pm 6$ pc). Spectroscopic observations in the range 6500−6700 Å and *BVRI* photometry were obtained by Kjurkchieva et al. (2001). Both spectral and photometric data lead to the conclusion that the secondary star is oversized for its mass. Spectral types were designated to both components as averaged over data by Arevalo et al. (1995) and Popper (1994). Preference was given to a photometric solution by Popper (1994) averaged over nine sets of data by Zeilik et al. (1994).
2. **WZ And** is an eclipsing binary without spectroscopic elements. Two photometric solutions are presented according to the visual-photometric observations by Chudovichev (1952) and to the collected and analysed light curves, which were available in the literature before 1977 (see Kyu-Dong 1977). The nature of the variations of the orbital period and its abrupt jumps were theoretically studied in the frame of a mass exchange model as applied to close binary systems by Biermann and Hall (1973). Their calculation yielded a mass flow of $7.42 \times 10^{-6}\ M_{\odot}$ per year from the hotter component to the colder one. At present it is impossible to favour either one of the authors. The spectral type of the primary component has been classified as *F*5 according to Wood (1978).
3. **BX And** is the brighter component of the visual binary *ADS* 1671. The *UBVJK* photometry of this system was thoroughly studied by Bell et al. (1990) and Dermann et al. (1993). The analysis of three *V Algol*-like light curves and infrared light curves in the *J* and *K* pass-bands indicates marginal contact of the binary with a hot spot (20% of the star surface) on the secondary component, which is approximately 1200 K hotter than the surrounding photosphere. It seems likely that variations in the period are due to changes in the mass transfer rate. There is no asymmetry in the profiles of the minima and no displacement in the secondary minimum, while the maxima are equal according to Jassur et al. (2000). The series of spectroscopic observations were carefully processed with the use of cross-correlation functions *CCF*. The relatively narrow wavelength range in this study precludes any attempt to make a spectral classification for the binary under consideration. Comparative analysis of absolute elements (masses, radii, luminosities) shows that the primary component is close to the *TAMS*; but the secondary component is $2 \div 3$ times larger than is expected for its *ZAMS* mass, and it lies upwards and to the right of the *ZAMS* line in the *HR* diagram as was noted by Bell et al. (1990).
4. **DS And** is well covered by photometric and spectroscopic observations by Schiller and Milone (1988). No sign of a period variability is indicated over a 52 yr timespan covering the moments of minimum light. Complete *BVRI* light curves and radial velocity curves extracted from the photographic and Reticon spectra and analyzed with the cross-correlation technique were solved compatibly with the generalized Wilson-Devinney model. The primary component nearly fills its Roche lobe, while the satellite is a slightly evolved solar-type star. The distance modulus ($8^{m}.17$) and

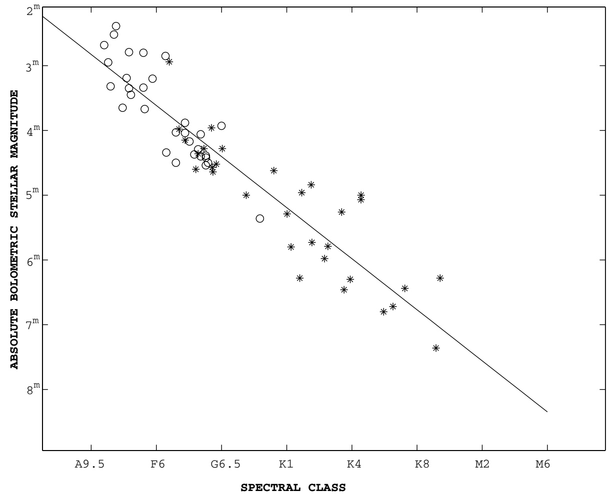

Fig. A.1. The generalized empirical *"spectrum–luminosity"* dependence for the primary (designated as circles) and the secondary (marked by asterisks) components of *DW*-systems

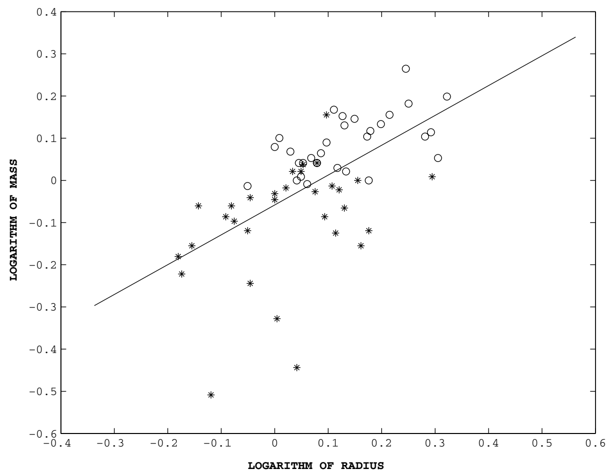

Fig. A.2. The generalized empirical *"mass–radius"* relation for *DW*-systems. The designations are the same.

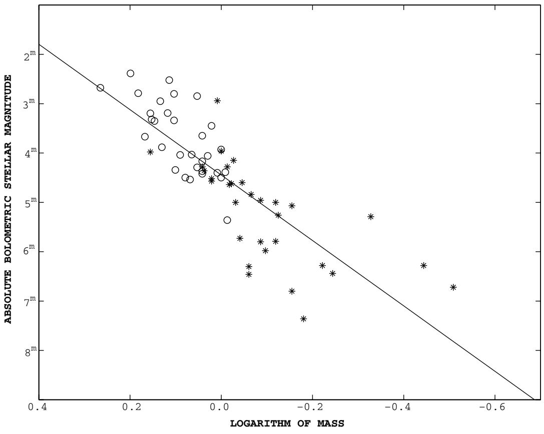

Fig. A.3. The generalized empirical *"mass–luminosity"* relation for *DW*-systems. The designations are the same.

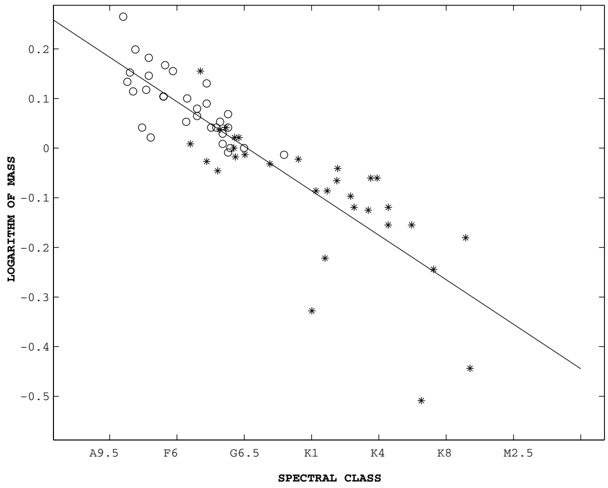

Fig. A.4. The generalized empirical *"mass–spectrum"* relation for the *DW*-systems. The designations are the same.

the measured proper motion confirm that this binary is a member of *NGC* 752 open cluster.

5. **HS Aqr = HD 197010** is an X-ray emitting chromospherically active binary system. A series of the photometric observations including *V*-and *R*-bands was carried out by Robb et al. (1990). But these data are insufficient to accurately compute orbital elements and so approximate values of the relative radii r_1, r_2, mass ratio q, temperatures of hot and cool stars, and orbit inclination i were chosen by the best fit to the model light curve in *R*-band. The large asymmetry in the brightness of the maxima is generally attributed to stellar spots, which may also be the source of the observed X-rays. 32 spectra at 1 Å resolution in the region Mg *B* triplet were obtained and analyzed by Marschall et al. (1991); but it gave no information about the mass ratio of the system, while the spectroscopic observations performed by Popper (1995) allowed calculation of the minimum values of masses $M_1 \cdot \sin^3 i$, $M_2 \cdot \sin^3 i$ and of the mass ratio itself.
6. **RX Ari**. The light curves have been analyzed by Wilson & Rafert (1980) using the differential corrections method. The spectroscopic solution is absent. The spectral type of the primary component has been classified as *F*2 by Kreiner et al. (2001) and its mass estimated with the use of a "mass–spectrum" relation by Popper (1980). The satellite mass was determined using the "mass–luminosity" dependence for MS-stars and the photometric value of mass ratio $q_{\rm ph}$. One may conclude that this system is a MS-binary with an oversized secondary.
7. **CV Boo** was photographically discovered as an eclipsing binary by Busch (1985) and is well covered by spectroscopic observations. The sources for estimating the spectral types are the intensities of NaD-lines; and since the inclination (85°) was chosen arbitrarily by Popper (1993), it was recalculated with the empirical dependence of the main minimum amplitude A_1 upon the orbital inclination derived for near-contact systems by Svechnikov (1985). New photometric observations are needed for more precise definition of the geometric elements such as relative radii of both components r_1, r_2, and inclination i.
8. **SV Cam**. 34 spectra were collected as a result of near *IR* spectroscopic observations and analyzed by applying *CCF*-mapping (Pojmanski 1998). It is important to emphasize that $G2 \div 3\ V$ photometry-based classification, as well as that derived from the average equivalent width of the lines, would not correspond to the stellar masses, if one does not suppose the primary surface is covered with a large amount of dark spots or that curcumstellar matter is present. Such explanation is plausible since some excess in the infrared flux was observed by Cellino et al. (1985). Derived masses of the components would fit the $F5\ V + K0\ V$ classification best. However the model parameters for a circular orbit without spots obtained by the Wilson-Devinney code in Frigo et al. (2002) indicate the lower effective temperature of the satellite that corresponds to a $K4 \div 5\ V$ spectral class. The spectroscopic observations performed by Kjurkchieva et al. (2002) in the range 6500−6700 Å cover the whole orbital period. The absorption profiles of the line H_α and Fe I 6678 Å are doubled out of the eclipses. Three sources of the activity of this system have been found in Kjurkchieva et al. (2001): (i) photospheric spots on the primary component; (ii) enhanced chromospheric emission from the satellite; and (iii) some additional emission originating from circumstellar gas. Relative orbit elements were taken from a more general spot solution of the light curve by Patkos & Hempelmann (1994).
9. **WX Cnc** was found to be a detached binary whose light curve asymmetry is due to a spot lying on the satellite surface, according to Lu et al. (1990). The photoelectric light curves (*V*-, *B*-bands) and the radial velocity curves were solved compatibly using the Wilson-Devinney method in Lu et al. (1991). The radial velocity curves were also computed by the cross-correlation method in Lu et al. (1990).
10. **WY Cnc**. The solution combines the near *IR* spectroscopic observations by Pojmanski (1998) applying *CCF*-mapping and the new optical *BVRI*-photometry data by Heckert (2003), which were modeled using the *ILOT* code (Information Limit Optimization Technique)

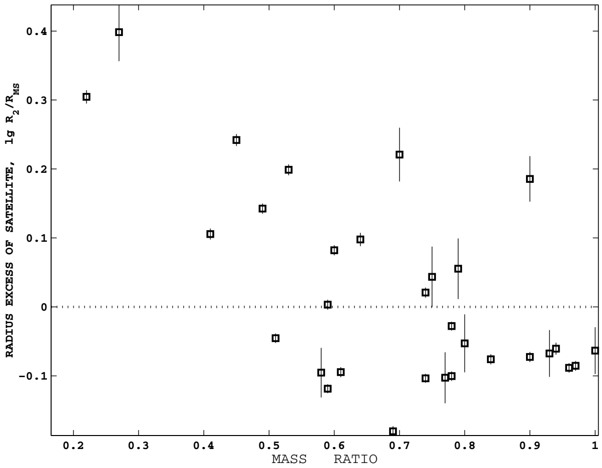

Fig. A.5. The dependence of the radii excesses (designated as squares) and their errors (denoted as bars) upon the mass ratio for *DW*-satellites in comparison with *MS* stars.

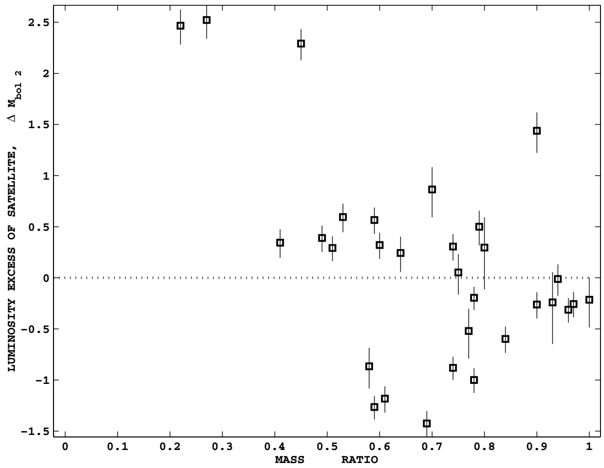

Fig. A.6. The same as Fig. 5a but for the luminosity excesses.

according to Budding & Zeilik (1987) and cleaned from the effects of the distortion wave and spots. Fits for each wavelength were done independently.

11. **VZ CVn** is a well-detached binary. The last photoelectric light curves were observed by Shenghong et al. (1994) in *B*, *V*-bands. These data helped to evaluate the orbital period more exactly. The new light curves showed some pulsation variations near the maxima. The spectral types are based on the colour indices. The orbital solution was found as a combination of the spectrographic observations of this system by Popper (1988) and the photometric analysis by Cester et al. (1977). The physical characteristics of this system place its components well within the Main Sequence band in the *HR*-diagram with the less massive, colder component lying near the *ZAMS* and the more massive star slightly evolved. From analysis of the colour indices one would conclude that the masses are too large for the observed radiative properties. There is no clear evidence for any variation in the period over an interval of 46 yr.
12. **AE Cas**. The photometric elements P, i, r_1, r_2, and L_1 were obtained by employing the Kopal method of Fourier analysis of light curves in *U*, *B*, and *V* filters in Srivastava & Kandpal (1984). The spectroscopic data are absent and the spectra of both components were estimated according to their colour indices. The absolute elements of the system are restored with the use of a "mass–spectrum" relation, third Kepler's law, and the relative radii and luminosities. Information about the period behaviour and its improved value is given by Nelson (2002).
13. **ST Cen** was well covered by *UBV* photometric observations on the basis of which the synthetic light curve solution was obtained by Milone & Hrivnak (1981) using the Wilson-Devinney code. Spectral classifications for both components were derived from the spectroscopy observations. The data on radial velocity curves are absent, and there is no strong evidence for Ca II H and K emission or for light curve variability. The nature of the asymmetry is not clear. Three stable photometric solutions were found for $q = 0.9$, 0.62, and 0.46, but the theoretical light curves predicted with Solution I ($q = 0.9$) showed better fit to the observed normal points. Further photometry and high-resolution spectroscopy are needed for more accurate calculation of the absolute elements of the binary.
14. **RS Col** shows a *W UMa*-like light curve, although its classification by Agerer et al. (1999) as *EW*/*DW* may prove to be erroneous as it is thought. This binary is covered well by *ubvy* observations analyzed by Rucinski (1983) and by $BVRI_c$ photometry observations performed by McFarlane & Hilditch (1987). The photometric solutions have been found by McFarlane & Hilditch (1987) using the *WUNA*3 code by Rucinski. These solutions have proved very insensitive to mass ratio, that tends toward the unity, which is rather unlikely. The absolute elements have been predicted unreliably, so spectroscopic data are needed for more accurate computation of absolute stellar characteristics for given system.
15. **CG Cyg** is the most peculiar system among the short-period chromospherically active binary stars. From the copious data sets on this system it seems that CG Cyg changes its spot structure rather rapidly. Photometric observations were obtained by Heckert (1994), Dapergolas et al. (2000) and Kozhevnikova et al. (2004). But the preference was given to photometric elements averaged by Popper (1994) over 29 sets of photometric data by Zeilik et al. (1994) who analyzed these sets using procedures by Budding & Zeilik (1987) to separate an eclipse, proximity, and spot effects in a light curve. As noted by Dapergolas et al. (2000) the system presents irregularities outside of the eclipses and depths of the minima change as time advances. It is a complex system with changing active regions probably due to photospheric activity. The spectroscopic observations were carried out by Popper (1994) at Lick Observatory with the Hamilton echelle-*CCD* spectrometer with high dispersion (0.4 km s^{-1} per pixel). The latest spectroscopic data around the H_α line were obtained by Kjurkchieva et al. (2003). Masses and mass ratio values of both components are averaged over spectroscopic data presented by

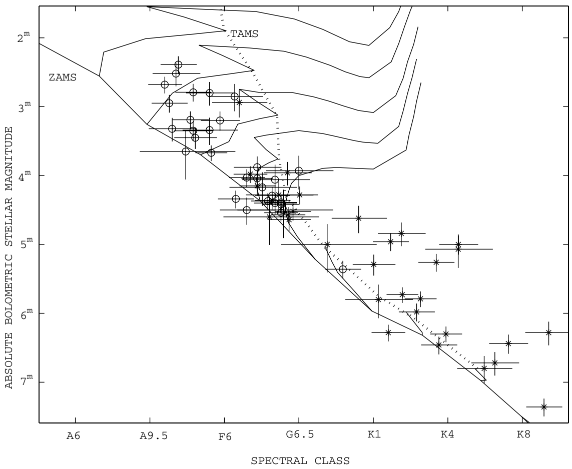

Fig. A.7. The location of the primaries and satellites of *DW*-systems against a background of the evolutionary tracks by Maeder & Meynet (1988) in the "$M_{\rm bol}$–Sp"-diagram. The *MS* band is marked between the *ZAMS* and *TAMS* boundaries designated by solid and dotted lines respectively. Denoted as crosses, the errors of $M_{\rm bol}$ and Sp values for *DW*-components are found from the proportions constructed on the basis of relationship $\sigma \sim W^{-0.5}$ with the assumption of correspondence of the average errors in (M, R) and (L, $T_{\rm eff}$) taken from Andersen (1991) to the weight $W = 5$.

Popper (1994) and Kjurkchieva et al. (2003). The values of mass ratio q found from the photometry and spectroscopy differ from each other very strongly. This binary was included in the Tycho *HIPPARCOS* mission.

16. **AR Dra = BV 226**. Photometric solutions according to Roche geometry were obtained by Broglia & Conconi (1979) on the basis of the numerous B, V photoelectric observations processed using the Wilson-Devinney light curve synthesis method. One should note, however, a small seasonal change in the light curves. The spectroscopic observations and data about mass ratio q are *absent*. The components of this system are well inside the critical inner lobes corresponding to assumed value $q = 0.75$, and the system is most likely a detached one. The presence of a gaseous material around the components or an intrinsic variability of one of the stars are both possible. The spectral classes of the components were assigned by the colour indices.
17. **BZ Eri**. First photoelectric photometry in three *UBV* colours has been analyzed in Srivastava & Sinha (1981). The orbital period variations were registered by Srivastava (1986) from 1976 to 1979 when the period slightly decreased, but from 1979 to 1980 it increased. The changes in depth, humps, and asymmetries in the branches of minima noticed in U, B, V light curves may be interpreted on the basis of the mass transfer between the components according to Srivastava (1986). The secondary minimum, as found by Srivastava & Uddin (1986), is subjected to wave-like distortion that may be connected with a physical change in the system. Current knowledge of this eclipsing binary is not satisfactory, as noted by Srivastava & Uddin (1986), because the spectroscopic and/or scanner observations are not very informative, but the existing photometric data are insufficient for a reliable estimate of the physical and geometrical elements of the orbit.
18. **MT Her** has a β Lyrae-type light variation character according to the first photoelectric observations by Budding and Murad (1982). The ephemeris comes from Pokorny (1973). The photometric elements were computed by modified Roche's model in the *NOPTS* code by Budding & Murad (1989) using observational data in B, V filters. The secondary effective temperature (5500 K), mass ratio (0.6), and ratio of radii (0.75) were chosen as initial approximations to find optimal curve fitting. The spectral type of the primary component in accordance with the colour index is expected to be somewhat later than $F5$-type classification as, for example, with $F8$. This spectral estimate accords better with the derived absolute radius. There is no convincing evidence of a period variation over the last 12 000 orbital revolutions. More complete spectrographic study is needed for accurate definition of the absolute parameters of this binary system.
19. **CN Lac** is a poorly-studied binary in Nekrasova (1936). The photometric elements were obtained on the basis of 187 photographic observations by Wachmann (1935), but spectroscopic data are absent. The system is projected onto the *NGC* 7209 region, but is not a member of the cluster. The estimates of the orbital elements and absolute parameters are rough, so the weight W for this system was assigned as very low.

20. **UV Leo**. The intrinsic variability of the system light linked with the spots on the components surfaces distorts the photometric data whose "*cleaning*" procedure nevertheless does not eliminate the uncertainty in photometric solutions. Therefore two photometric solutions are considered here:

    (a) The first evaluation of absolute stellar parameters is a combination of the photometric analysis by Botsula (1978) with the spectroscopic results obtained by Popper (1993). High-resolution *CCD* spectra and the cross-correlation function obtained by Popper (1993) demonstrate that the hotter primary component is more luminous and larger as opposed to the satellite. It corresponds well to the modern evolutionary theory for coeval stars on the Main Sequence.
    (b) The second solution is based on spectroscopic data obtained with the use of the Hamilton echelle-*CCD* spectrometer by Popper (1997) and the combination of *HP*, *VT*, and *BT* photometry performed within the framework of the Hipparcos/Tycho mission and 8480−8740 Å ground-based spectroscopy, as if mimicking *GAIA* observations in Zwitter et al. (2003). Also the set of $UBV(RI)_{\rm c}$ photometric data by Frederic & Etzel (1996) was used, the analysis of which has showed that the hotter and more massive star is the smaller and less luminous one; whereas for two *MS* stars the opposite relationship is expected if one does not suppose the mass exchange.

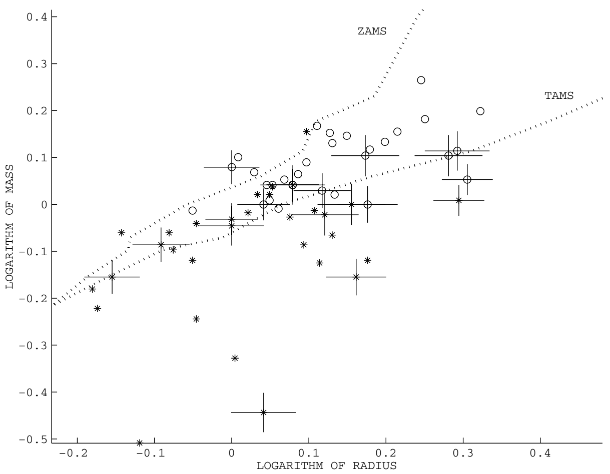

Fig. A.8. The location of the primaries and satellites of *DW*-systems relative to the *ZAMS* and *TAMS* boundaries in the "*M*−*R*" diagram based on the evolutionary tracks by Maeder & Meynet (1988). The designations are the same. If error in the component mass or radius is comparable with the symbol size, its designation is absent on the diagram.

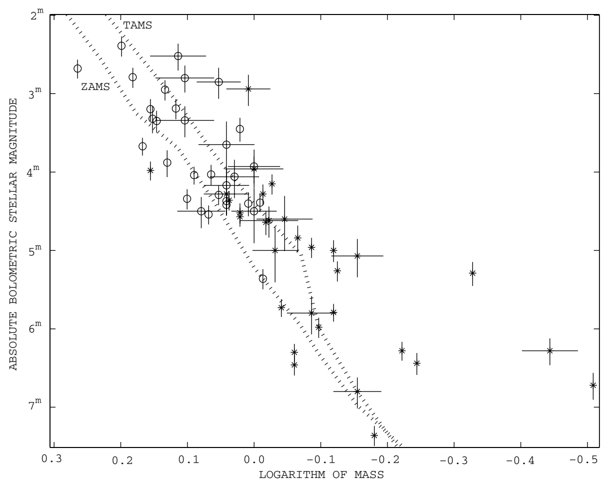

Fig. A.9. The same as Fig. 7 but in "the $M_{\rm bol}-M$" diagram.

21. **UU Lyn** has Main Sequence components that do not make contact but come very close to the corresponding Roche lobes. The period change does not appear according to Yamasaki et al. (1983). The symmetry of the light curve is also noted. Masses, absolute radii, and major semi-axis were derived by Yamasaki et al. (1986) combining results of spectroscopic ("single-lined spectrum") and *B*, *V*-bands photometric observations. There is excellent agreement between the photometric mass ratio deduced from light curve analysis and the spectroscopic one.
22. **V 361 Lyr** is quite well-studied both photometrically and spectroscopically and has been identified as a true pre-contact binary. From analysis of the new differential *V*-band light curves along with *V*- and *R*-band light curves (see Hilditch et al. 1997), which were computed by the synthetic code taking non-Keplerian corrections into account, it follows that the primary component fills its Roche lobe while the secondary component is detached and fills ∼57% of the Roche volume. These data confirm the stable nature of the asymmetric light curve. The eclipse maps have also been built for both components to illustrate the small changes in the cool spot structures for the primary component. The spectroscopic observations carried out simultaneously in the blue and red regions indicate the "double-lined spectra" case. This is a rare binary system that has very small orbital period but is not a contact.
23. **DD Mon** is a single-lined spectroscopic binary, so it is impossible to directly evaluate the mass ratio of components *q*. The absolute and relative orbit elements were found as a combination of photoelectric *B*-, *V*-band observations by Shengbang et al. (1996), Shengbang et al. (1997) and from spectroscopic data including 39 spectrograms in the blue region made by Yamasaki et al. (1990). No emission features have been detected either during eclipses or outside them. All results show that the components of this binary have evolved away from the *ZAMS* and through the mass–transfer process to the present semi-detached state. The variation in the light curve shape may be caused by the system evolution and by activity of the dark spots according to Shengbang et al. (1997). The components are undermassive for their radii and luminosities, which could be explained by their mass loss.
24. **UV Psc**. The high-dispersion spectrograms received with the Hamilton *CCD*-spectrometer and covering 47 spectral regions along with the radial velocity curves of Popper (1997) allowed estimation of both the spectra and masses of components, respectively. 14 light curves obtained by various observers were analyzed by Budding & Zeilik (1987) and Budding et al. (1996), taking the properties of starspots and distortion waves into account. The 14 photometric solutions agree quite well. These data served to initiate the stellar parameters when running the *ILOT* code, which seeks better fit of all parameters for the photometric light curves simultaneously (Heckert 1999).
25. **RS Sct** is a β Lyrae type eclipsing binary that possesses appreciable intrinsic variation in comparison with other eclipsing binaries according to Cook (1992), while the effect of the third light as a factor of such variation is excluded. The absolute and relative orbital elements were obtained as a combination of spectroscopic observations by King & Hilditch (1984) and photometric data by Buckley (1984) taking the lack of coincidence between the values of the photometric ($q \sim 0.77$) and spectroscopic($q \sim 0.6$) mass ratio into account. The orbital parameters $a_1 \cdot \sin i$, $a_2 \cdot \sin i$ and minimum values of masses $M_1 \cdot \sin^3 i$, $M_2 \cdot \sin^3 i$ were calculated from analysis of the radial velocity curves of both components based on the Reticon spectroscopy. As computed by the Wilson-Devinney code the simultaneous solution of *BVR* light curves results in a detached configuration, although Buckley noted that the solution obtained by Wood (1978) with the *WINK*-code indicates a tendency towards a semi-detached model.

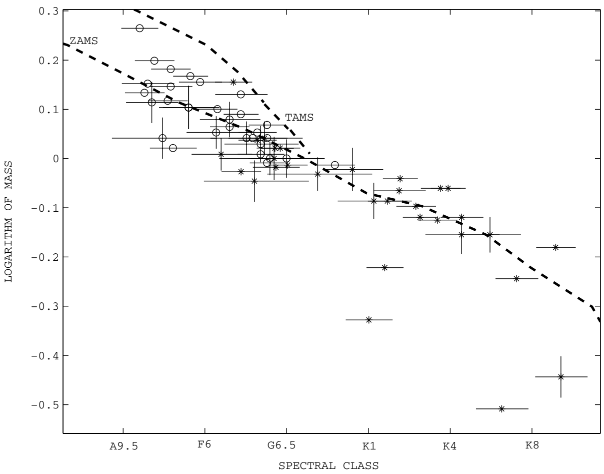

Fig. A.10. The same as Fig. 7 but in the "*M*−*Sp*" diagram.

26. **GR Tau** is a near-contact detached system with both components almost filling their critical Roche lobes, as follows from the photometric solution obtained by the Wilson-Devinney code based on the long-term photoelectric and *CCD* photometry of Zhang et al. (2002) and on visual and infrared light curves by Lazaro et al. (1995). The spectroscopic observations carried out by Yamasaki et al. (1984) correspond to a "single-lined spectrum" case, therefore no spectroscopic mass ratio for the system is known. The direct spectra measurements are not available, and the spectral classification of the components was performed in accordance with the colour indices. More spectroscopic and photometric observations are needed to clarify the spectral classification of the stellar components and the current evolutionary status of the system.

27. **GY Tel** was included in the observational program of southern eclipsing binaries and classified by Lipari & Sistero (1988) as a near-contact short-period system showing *EB*-type light curve. Extremely poor data, such as an orbital period, main and second minima depths, and a primary spectrum assigned by the colour index, were obtained by Shaw (1994) as a result of processing 400 *UBV* photoelectric observations. The rest orbital parameters and absolute elements were reconstructed by relying on approximate statistical dependences of the type "mass–spectrum", "mass–radius", "inclination–main minimum depth", and so on, derived by Svechnikov (1985). It explains such a tiny evaluative weight. The large thermal decoupling of the components should also be noted.

28. **XY UMa** The set of the system geometric parameters was first obtained by Hilditch & Bell (1994) and then evaluated more precisely by the eclipse mapping technique. This algorithm is based on the maximum entropy method to recover the images of the distribution of visual surface brightness for the primary component (Cameron & Hilditch 1997). The reconstructed images derived from *V*, *I*, *R*-photometric light curves show the presence of time-variable star spot activity in the eclipsed region of the primary. Processing of 42 spectra collected and computed by *CCF*-mapping as a result of near *IR* spectroscopic observations reveals the faint satellite at the low signal-to-noise ratio. It allows in fact to derive the absolute elements of an orbit (see Pojmanski 1998).

29. **BH Vir** is an active binary system displaying vast solar-type variability. Photometric visible light curves have been published regularly since 1957 and are now supplemented by the *J* and *K* infrared light curves of Arevalo et al. (2002) from which new geometrical elements were determined with the use of the *ILOT* code developed by Budding & Zeilik (1987). *IR* light curves show equal maxima, especially in *K* filter. The infrared light curve solutions are in good agreement with the calculations by Zeilik et al. (1990) from the *ILOT* analysis of *UBVRI* light curves. The spectra defined with the high-resolution Hamilton spectrometer and absolute elements were obtained by Popper (1997).

30. **CG Vir** is a double-lined eclipsing binary, for which the orbital solutions were found by Shen et al. (1990) from photoelectric (1977, 1982) and spectroscopic observations (1985−86). The yellow light curves were solved by the Russell-Merrill method. The solutions of ten light curves computed by the Wilson-Devinney method assuming the detached model gave smaller residuals than those obtained in the semi-detached model. The system shares a number of properties with *Algol*-type binaries, so it is likely that *CG Vir* might have left the *Algol*-phase not so long ago.

31. **ER Vul**. The orbital solution is compiled on the basis of *UBVRI* photometric data by Olah et al. (1994) and high-resolution spectroscopic observations carried out by Hill (1990). No firm spectroscopic evidence for the existence of extended material around this binary was found by Gunn & Doyle (1997). The well-known irregularities of this binary are interpreted largely in terms of the dark maculae whose major characteristics (size, surface position) are quantified. Very Large Array (*VLA*) continuous monitoring of this system (*X*-band, 3.6 cm) has shown a pattern of variability with the dominant slow hourly timescale variations (about 3 mJy), whereas the contemporaneous Extreme Ultraviolet Explorer (*EUE*) in the 70−140 Å band did not show any significant *EUE* flaring, which could correlate with the radio emission, according to Rucinski (1998). *VLA* multifrequency observations were also carried out and discussed in Garcia-Sanchez et al. (2003).

The binary **TYLeo*** has led to only very unreliable photometric data on the photographic plates of the Zonnenberg survey. This system was also included by Popper (1996) in the spectroscopic program of lower Main Sequence eclipsing binary stars ($P = 1\overset{d}{.}18466$, $Sp_1 = G0\,V$). Assuming *DW* systems class-averaged $\overline{q} = 0.8$ as an initial value for the mass ratio and using the empiric relations of the type "spectrum–mass", "mass–radius", and "main minimum amplitude–orbital inclination", one might restore the elements of the spectroscopic and photometric orbits ($Sp_2 = K0\,V$, $M_1 = 1.1\,M_{\odot}$, $M_2 = 0.9$: $M_{\odot}$, $A = 5.9\,R_{\odot}$, $R_1 = 1.2\,R_{\odot}$, $R_2 = 1\,R_{\odot}$, $M_{\rm bol1} = 4\overset{m}{.}2$, $M_{\rm bol2} = 5\overset{m}{.}2$,

$r_1 = 0.20$, $r_2 = 0.16$, $i = 75°$, $(J_1/J_2)_V = 2$, $(L_1)_V = 0.75$). But as the three spectrograms showed in Popper (1996), there is no evidence for a second component in the spectrum, although the phases are uncertain. In addition, analysis of the modern photometric and spectroscopic observations carried out by Lacy et al. (2002) leads to the conclusion that the above system is *not an eclipsing binary* and that its classification was a mistake by Hoffmeister (1933).