

LIGHT CURVE SOLUTIONS OF ECLIPSING BINARIES IN THE SMALL MAGELLANIC CLOUD. II.

V. IVANOV and D. KJURKCHIEVA

Department of Physics, Shumen University, 9700 Shumen, Bulgaria

E-mail: viva_nov@abv.bg

E-mail: d.kjurkchieva@shu-bg.net

Abstract. We present the results from modeling of the light curves of 50 eclipsing stars in the Small Magellanic Cloud (SMC) obtained in the framework of the project OGLE. We established that the components of the target binaries were hot stars with big relative radii and low densities.

1. INTRODUCTION

The study of eclipsing binaries is very important for the modern astrophysics because these stars are one of the most useful sources of information about the stellar parameters. The investigation of eclipsing binaries in large and homogenous sample gives a possibility to improve the empirical statistical relations between the stellar parameters. The microlensing project OGLE (Udalski et al. 1998) monitored millions of stars in the Magellanic Clouds during the last years. The huge photometric database is available also for investigations of detected variable stars.

We study the eclipsing binaries in SMC in order to get their global parameters by simultaneous fitting of the data in the three colors. This paper presents the results from the light curve solutions of 50 eclipsing stars with circular orbits. We chose to model such binaries which have enough B and V points into the eclipses (in opposite case the light curve solution is undetermined).

2. RESULTS

Our modeling procedure (see detailed description in Kjurkchieva and Ivanov 2006) consists of following stages: (a) Preliminary light curve solution on the basis of several known empirical relations (Flower 1996, Zaritsky et al. 2002, Graczyk 2003); (b) Fast initial light curve solution by the code Binary Maker 3 (Bradstreet and Steelman 2004); (c) Final simultaneous multicolor solution using the code DC (Wilson and Van Hamme 2003) that gives the values of the varied parameters and their errors; (d) Calculation the global stellar parameters using the known distance $DM=18.9^m$ to the binaries (i.e. to the SMC) and the local reddening according to Zaritsky et al. (2002).

Table 1 presents the values of the parameters obtained by our light curve solutions and Fig. 1 illustrates fits for contact (C), semidetached (SD) and detached (D)

Table 1: Parameters of the target eclipsing binaries

No	$type$	P	V	T_i	q	i	r_i	L_i	R_i	M_i	ϱ_i
21	C	0.27	15.86	5400 5100	0.76	64.1	0.413 0.365	1065 695	37.40 33.04	5.17 6.63	0.0001 0.0002
47	D	1.23	19.09	11500 6200	0.95	89.3	0.268 0.276	111 9	2.67 2.74	2.79 1.50	0.1482 0.0731
124	C	11.8	16.63	9300 6100	0.48	80.6	0.477 0.352	675 127	10.04 7.40	4.57 4.62	0.0045 0.0114
179	C	3.87	14.79	22900 15300	0.74	47.9	0.410 0.357	21820 3336	9.41 8.20	11.80 8.49	0.0142 0.0155
188	SD2	0.76	16.79	15200 13200	0.73	72.6	0.375 0.351	1270 603	5.16 4.83	5.43 6.46	0.0398 0.0577
198	D	2.13	17.80	18600 16400	0.65	81.2	0.206 0.217	711 476	2.58 2.71	4.63 6.18	0.2721 0.3128
216	D	4.46	18.39	11800 6600	0.31	78.1	0.179 0.284	191 43	3.31 5.25	3.23 3.33	0.0893 0.0231
219	D	0.90	17.00	15000 10500	0.53	70.6	0.298 0.235	1402 165	5.56 4.39	5.58 4.93	0.0325 0.0587
226	D	4.16	17.33	11500 9100	0.38	78.5	0.167 0.297	242 263	3.93 7.02	3.45 5.48	0.0570 0.0159
234	D	2.71	17.36	12200 12900	1.10	72.6	0.254 0.264	337 471	4.12 4.27	3.78 6.17	0.0542 0.0796
236	D	1.30	17.54	12700 9600	0.71	67.2	0.253 0.337	380 180	4.04 5.38	3.91 5.03	0.0594 0.0324
240	D	1.74	16.08	18500 16900	0.98	74.1	0.306 0.302	3280 2220	5.59 5.51	7.03 8.01	0.0404 0.0482
244	D	0.85	16.49	14300 12700	0.88	82.3	0.372 0.342	1434 701	6.19 5.68	5.61 6.64	0.0238 0.0364
246	D	1.33	18.11	12300 9100	0.64	73.6	0.238 0.335	194 94	3.08 4.33	3.25 4.26	0.1121 0.0528
290	C	4.26	15.15	20300 17400	0.99	32.2	0.391 0.390	10611 5825	8.35 8.32	9.69 9.15	0.0167 0.0160
302	D	1.41	16.27	16200 14200	0.86	59.3	0.308 0.309	2288 1309	6.09 6.11	6.37 7.38	0.0283 0.0326
303	D	5.01	17.57	11700 6100	1.00	88.5	0.232 0.234	492 30	5.42 5.46	4.19 2.91	0.0265 0.0179
304	D	0.64	17.72	9300 8000	0.42	69.1	0.352 0.289	218 81	5.70 4.69	3.35 4.08	0.0182 0.0398
308	D	6.08	16.34	17600 16800	0.48	84.6	0.089 0.083	2457 1769	5.35 4.98	6.50 7.74	0.0427 0.0628
313	D	1.32	15.56	26300 27700	1.29	57.2	0.310 0.337	9348 13737	4.67 5.08	9.36 10.17	0.0922 0.0778
335	D	1.34	18.16	11000 11200	1.14	73.6	0.305 0.313	134 154	3.20 3.27	2.94 4.84	0.0902 0.1387
337	D	0.84	18.17	12700 9500	0.70	65.5	0.388 0.322	321 55	3.71 3.08	3.73 3.63	0.0731 0.1244
339	D	0.90	19.18	8500 8200	0.72	84.8	0.305 0.269	41 28	2.95 2.60	2.12 2.81	0.0833 0.1603
344	D	70.1	18.97	5800 5500	1.00	88.7	0.082 0.080	56 44	7.42 7.24	2.31 3.36	0.0057 0.0089
348	D	1.15	16.67	13600 11000	0.88	60.6	0.371 0.356	1167 395	6.17 5.93	5.30 5.96	0.0227 0.0288
355	D	2.62	16.49	8300 9200	1.09	66.9	0.261 0.246	361 492	9.21 8.70	3.85 6.22	0.0049 0.0095
361	D	103	18.67	10500 10700	1.03	85.2	0.318 0.321	78 87	2.67 2.70	2.53 4.17	0.1330 0.2131

Table 1: Continuation

No	$type$	P	V	T_i	q	i	r_i	L_i	R_i	M_i	ϱ_i
368	D	1.01	17.67	11200	1.12	67.0	0.358	152	3.28	3.04	0.0864
				14600			0.355	514	3.25	6.27	0.1839
405	C	2.52	15.62	16300	0.93	38.3	0.402	3910	7.87	7.38	0.0152
				14800			0.389	2368	7.62	8.09	0.0184
419	D	1.11	19.23	7800	1.00	83.3	0.267	34	3.19	2.02	0.0622
				7700			0.262	31	3.14	2.95	0.0958
426	D	0.96	17.13	13300	0.59	73.5	0.272	709	5.03	4.63	0.0366
				12100			0.251	389	4.65	5.94	0.0596
436	D	1.64	19.11	10100	0.95	78.4	0.318	52	2.36	2.27	0.1738
				10100			0.313	50	2.32	3.52	0.2816
438	D	0.80	17.96	9800	0.94	79.0	0.289	128	3.93	2.90	0.0479
				9700			0.292	124	3.97	4.59	0.0737
452	D	2.98	17.16	11800	0.94	68.9	0.307	458	5.14	4.11	0.0304
				11500			0.293	368	4.90	5.88	0.0502
460	D	0.69	19.33	35100	0.92	83.4	0.364	734	0.73	4.67	11.833
				34100			0.336	553	0.68	6.36	20.417
465	SD2	1.74	17.56	13800	0.51	70.1	0.265	589	4.26	4.40	0.0573
				8800			0.327	112	5.25	4.47	0.0310
470	SD2	0.62	18.68	10600	1.00	75.1	0.370	99	2.96	2.70	0.1051
				8800			0.378	44	3.02	3.36	0.1222
484	C	0.54	17.47	14400	0.96	52.1	0.397	581	3.89	4.39	0.0751
				13700			0.390	452	3.82	6.12	0.1106
556	D	0.87	18.20	13200	0.95	80.6	0.242	189	2.64	3.23	0.1766
				13200			0.267	231	2.92	5.33	0.2160
569	D	0.88	18.37	12000	0.79	77.5	0.344	189	3.19	3.23	0.0997
				9500			0.348	64	3.24	3.81	0.1129
571	SD2	4.73	16.93	13100	0.47	77.0	0.327	1233	6.84	5.38	0.0169
				6300			0.314	52	6.58	3.55	0.0125
572	D	9.84	19.32	8100	0.94	71.9	0.337	31	2.83	1.97	0.0874
				8000			0.361	34	3.03	3.06	0.1104
574	C	18.7	18.89	5200	0.78	45.6	0.422	98	12.23	2.70	0.0015
				4200			0.378	46	10.98	3.41	0.0026
594	SD2	0.55	19.15	8700	1.02	78.9	0.377	34	2.59	2.03	0.1173
				9100			0.377	42	2.59	3.30	0.1916
596	C	1.24	16.37	27300	0.88	29.4	0.402	8840	4.22	9.22	0.1236
				21400			0.380	2976	3.98	8.36	0.1330
599	D	2.30	17.21	14800	0.55	61.6	0.342	842	4.43	4.85	0.0562
				12700			0.313	358	4.06	5.85	0.0878
605	D	1.12	18.24	11900	0.92	71.9	0.321	155	2.94	3.06	0.1207
				11500			0.320	131	2.93	4.66	0.1852
619	D	1.57	17.28	16100	0.97	80.7	0.232	814	3.68	4.81	0.0970
				15600			0.241	771	3.83	6.76	0.1212
621	C	2.15	15.19	13600	0.89	30.4	0.401	4487	12.10	7.66	0.0043
				11100			0.381	1443	11.49	7.50	0.0050
626	D	1.30	16.15	19400	0.97	65.7	0.291	3332	5.13	7.06	0.0527
				19400			0.284	3160	4.99	8.43	0.0680

binary. The first four columns of Table 1 show respectively the star catalogue number (<http://ogle.astrouw.edu.pl>), type of the obtained configuration (Sd2 means semidetached binary which secondary star fills-in its Roche lobe); orbital period P (in days); out-of-eclipse magnitude in V color. The next four columns present the values of the fitted parameters: temperatures of the components T_i ; photometric mass ratio q ; orbital inclination i ; mean relative stellar radii r_i . The last four columns show the

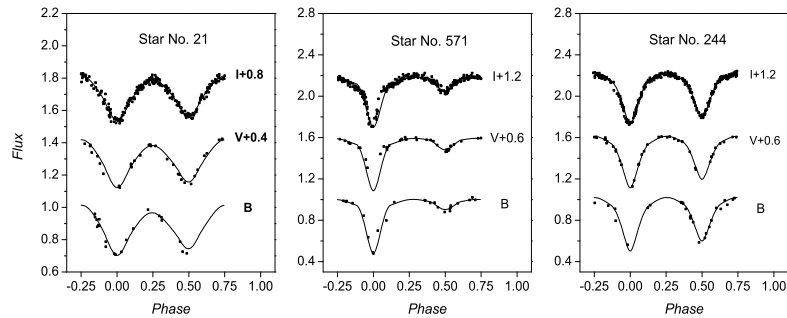


Figure 1: Illustration of 3-color light curve solutions for contac, semidetached and detached star.

global parameters of the stellar components (in solar units): luminosities L_i ; radii R_i ; masses M_i and densities ρ_i .

The statistical analysis of the obtained parameters of the 50 target binaries in SMC leads to the following conclusions:

(1) Around half of the stars have temperatures between 10000 K and 15000 K. This result is in correspondence with the colors reported by Udalski et al. (1998) as well as with the fact that the spectra of the irregular galaxies (as SMC) are similar to the spectra of hot star.

(2) The stellar components are with relative big radii (between 0.2 and 0.45) and low densities.

(3) It is interesting that all semidetached binaries are SD2 configurations.

Acknowledgments

The research was supported partly by funds of projects DO 02-362 and DO 02-85 of Bulgarian Science Foundation.

References

- Bradstreet, D., Steelman, D.: 2004, Binary Maker 3, User Manual.
 Flower, P.: 1996, *ApJ*, **469**, 355.
 Graczyk, D.: 2003, *MNRAS*, **342**, 447.
<http://ogle.astrouw.edu.pl/>, OGLE II, SMC, Catalogue of eclipsing Binaries.
 Kjurkchieva, D., Ivanov, V.: 2006, *Bulg. Astr. J.*, **8**, 57.
 Udalski, A., Szymanski, M., Kubiak, M.: 1998, *Acta Astron.*, **48**, 147.
 Wilson, R., Van Hamme, W.: 2003, Preprint "Computing Binary Star Observables".
 Zaritsky, D. et al.: 2002, *AJ*, **123**, 855.