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ROTATIONAL VELOCITIES AND SPECTRAL TYPES FOR A SAMPLE OF BINARY SYSTEMS

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Rotational velocities and MK spectral types are determined for the primaries and secondaries of 59 visual binaries and for 88 spectroscopic and eclipsing binaries.

Key words: binary systems – rotational velocities

1. INTRODUCTION

As part of a study on the rotation in binary systems we decided to increase the number of visual and spectroscopic systems with known rotational velocities. The aim of this paper is to present the new observational results that will be discussed statistically in a forthcoming paper.

2. THE OBSERVATIONS

The observational program included visual systems selected from the Wallenquist (1954) and the Wierzbinski (1968) Δm catalogues. The systems included lie south of $+20°$ declination; they have separations of the components larger than 5″, magnitudes of both components brighter than 9^m and spectral types of the primaries earlier than F2. The spectroscopic and eclipsing binaries were chosen from Batten's (1967) catalogue among those which are to the south of $+20°$ declination, have spectral types earlier than F2 and magnitudes brighter than 9^m.

The spectrograms were obtained with the 91 cm and 152 cm telescopes of the Cerro Tololo Inter-American Observatory. Both were equipped with Cassegrain spectrographs with $F/1.2$ Schmidt type cameras giving dispersions of aproximately 40 Å mm^{-1}. The spectra, widened to 0.6 mm, were photographed on unbaked Kodak II a–O plates. The slits of the spectrographs were set so that the projected widths on the plates were 15μ. This width corresponds to 1″–1″.5 on the sky. The plates were developed with Kodak D–19 and fixed with Kodak F–5. Nearly 400 spectrograms were taken of both components of 59 visual systems, 88 spectroscopic and eclipsing binaries and 100 MK and $V \sin i$ standards.

The MK standards were taken from Landi, Jaschek and Jaschek (1973) and the $V \sin i$ standards were taken from the lists of Slettebak (1954), Slettebak and Howard (1955), and Slettebak (1955).

3. ROTATIONAL VELOCITIES AND SPECTRAL TYPES

The rotational velocities were determined by the usual method of construction of calibration diagrams between the half-width of the selected spectral line and the $V \sin i$ value, for a number of standard stars in the same spectral range as the program stars. The lines used to measure $V \sin i$ were He I λ 4471 for

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spectral types earlier than B8 and Mg II λ 4481 for spectral types equal to or later than B8. The stars were divided into five spectral ranges for the dwarfs (B0–B3; B5–B7; B8–A2; A3–A7; A8–F2); four for the giants (B0–B6; B5–B7; B8–A2; A3–A7); and two for the supergiants (B0–B9; A0–A9). This subdivision is far from ideal but is the best compromise considering the number of standards and the intensity of the lines used. The halfwidths of the lines were measured on density tracings obtained with the Hilger and Watts microphotometer of the La Plata Observatory. The results were checked on intensity tracings by means of calibration plates obtained for some spectrograms and the two methods are in good agreement. An average of ten standard stars was used for each calibration curve and the dispersion of standard points around the mean lines oscillated between ± 15 and ± 20 km s^{-1}. In this way a value of $V \sin i$ was obtained; another one was derived by visual intercomparison of the program stars with the standard stars with known $V \sin i$ values and the same spectral types. Then the two values were averaged and this was the final $V \sin i$ adopted.

The visual values of $V \sin i$ and the graphical ones never differed by more than 20%, and in the greatest number of cases the difference was 15%. This result gives some idea about the precision of the $V \sin i$ values finally adopted, and it is estimated that this oscillates between 10% and 15%.

The spectral types were assigned by visual intercomparison of the program stars with the MK standards. This was done with an spectrocomparator available at the La Plata Observatory and without knowledge of which system was being classified. As the K line (Ca II λ 3933) falls outside the range of the spectrograms used here, the classification of the A stars was difficult, especially in the range A0–A3. The criteria studied by Landi, Jaschek and Jaschek (1973) were used to classify the stars, and the effect of the rotational velocity on the appearance of the spectra at the present dispersion was accounted for using standards with different $V \sin i$ values.

In summary, it can be said that the given spectral types are on the MK system, but their precision is not the same as it would have been if the prescriptions of the system's originators had been followed, especially with regard to the dispersion.

The results of the observations are given in tables 1 and 2 for the visual binaries and the spectroscopic and eclipsing binaries, respectively.

With the purpose of having compiled in one place all the observational material which will be used in a forthcoming statistical paper, we present here also the material found in the literature.

Binaries of classes IV and V in Batten's (1967) catalogue whose $V \sin i$ values are contained in the catalogue of Bernacca and Perinotto (1970, 1971) were selected. Other main sequence systems discovered by Kodaira (1971) and Abt *et al.* (1970, 1971, 1972a, 1972b) as well as the systems with composite spectra studied by Markowitz (1969), were included. Among the visual systems only the pairs studied by Slettebak (1963) and a few studied by Meisel (1968) were included. In tables 3 and 4 are listed the visual systems and the spectroscopic and eclipsing systems found in the literature, respectively.

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Table 1 Spectral types and rotational velocities of the observed visual systems

HD/CPD/ADS	Sp. Type (P)	Sp. Type (S)	V sin i (P) km.sec^{-1}	V sin i (S) km.sec^{-1}
HD 2884/5	B9V	A2V	175	50
-55°241	B6V+B9V	F7V	100;75	95:
996	A7IV	F7V	300	
1148	B9V	A8V	180	55
1238	A3V	F5:V	210	55
-52°285/4	B8V-IV	G2V::	275	
1924	Am	A7V	55	90
1954	B9.5V	A3V	85	180:
-40°771	A4III	A1V	60:	100
-40°1027	A3V	A0:IV:	290:	155
-32°1479	A5IV	Am	170	80
-38°1297	B9:V:	A1:V	240	≤ 45
-34°1626	A3V	F7V	165	90
3317	Am	F8V	70:	
3355	A0V	A1IV	≤ 45	≤ 45
3597	B8V	B9V	375	350
3623	B8V	A1IV::	60	60:
3823	B8Ia	B8II	≤ 45	≤ 45
3883	B9V	A1V	305	≤ 45
3910	B2V-IV	Ap λ4200	≤ 45	70
3962	B1V	B3V	320	340
3978	B8V	A5IV	130	135
4131	B7III	B7IV	60	300
4134	O9.5II	B2.5V	140	75
-42°1975	A8III	F5V	185	90
4188	O9.5V	B0.5V	165	≤ 45
HD 112092/1	B2IV	B4V	70	250
9247	A0V	Am	120	80
9338	Ap Mn	A7V	≤ 45	180
-15°3966/5	A6III	F3V	100:	55:
HD 134481/2	B9V	A3IV	220	200
HD 142629/30	A3V	B9V	80	200
9913	B1V	B2V	100	80
9951	B2V	B9Vp Si	200	70:
10635	A2V	A8IV	≤ 45	140
10750	A0V	A0V	85	120
10966	B5Ib	B1V	≤ 45	120:
10991	O7V	B1V	≤ 40	155:
11056	A3IV	A8p (βCrB ty)	200:	≤ 45
-75°1409	A0V	A0V	75:	85:
-52°11213	A2V	A0V	70	≤ 45
HD 176270	B8V-IV	B9V	≤ 45	185
HD 181454	B9V	A5V	80	140
12728	F1IV	F2III	60	105
13087	B6V	B8V	350	300
13379	A1V-IV	A2V	165	145
-63°4566	A0IV	A1III	100	200:
13702	A2III	A2IV	90	60
13902	A2V	A8V	270	150
13946	B7V	Am	100	70
15147	A1V	F2V	90	≤ 45
-53°10037	A5V	A7V	210	
15493	Am	F2V	60	100
15627	A4V	A7V	135	150
-73°2253/2	A1V	A1V	≤ 45	80
HD 213398	A0V	G2:	50	
HD 220392/1	A4III	A3III	165	140
16979	F0IV	F2III	75	105
17090	A2V	F2V	≤ 45	50

Symbols

(P) primary
(S) secondary
: poorly determined

Table 2 Spectral types and rotational velocities of the observed spectroscopic binaries

HD	Sp. Type	V sin i km.sec^{-1}	HD	Sp. Type	V sin i km.sec^{-1}	HD	Sp. Type	V sin i km.sec^{-1}
1061	F0V	90	113791	B2V	110	196544	A2V:	55
6882	B6V+B0:V	100;75	114911	B8V	290	198391	A1V	50
14688	A2V	50	116658	B2V+B2V	100;60	198743	Am	50
20320	Am	70	120307	B2IV	100	204188	Am	80
21985	A1:V:	≤ 45	120955	B5IV-V	< 45	205767	A7V	170
22203	B8V+B8V	55;45	123515	B9IV	< 45	206546	Am	70
23466	B3V	145	125337	Am	< 45	207098	Am	80
25204	B3V+A	80	134687	B3IV	≤ 45	209625	Am	< 45
25267	Ap	≤ 45	134759	Ap	50	222098	A1V	50
27376	B8Vp	≤ 45	140008	B5IV	90	224113	B6V:	300
27628	Am	50	140873	B8IV	125			
27749	Am	≤ 45	144426	Am	65			
29140	Am	≤ 45	151890	B1V+B	250			
29376	B3V:	240	156247	B5V+B5V	90;75			
29479	Am	60	159082	B9.5IV	50			
30050	Am:	70	159176	O6V+O6V	125;160			
30211	B5IV	85	159876	δ Scuti Type	60			
30836	B2III	45	161783	B2V+B3V	100;130			
31109	A9IV	170	163181	B0Ia	250			
31237	B2III	80	166937	B8Ia	45			
32964	B9.5V	≤ 45	167647	B3V+A	200:			
35411ab	B1V +B2:	60;45	170465	B6IV	45			
35588	B2V	140	170523	B3III	45			
35715	B2IV	165	171978	A2V	45			
36695	B1V	190	175544	B2V	155			
36822	B0III	50	178125	B8III	50			
37017	B2V	≤ 45	178322	B6V+B5V	< 45;45			
75759	O9IV	45	181182	B8III+K:	95			
76805	B4V	65	182490	A2III-IV	50			
77464	B2V+B2V	60;85	183007	Am	< 45			
78316	B8IIIp	≤ 45	184035	A5IV-III	60			
79351	B2IV	≤ 45	184552	Am	≤ 45			
81188	B2IV	60	185507	B3V+B3V:	130;120			
91636	A1V	≤ 45	185936	B5V	65			
102660	Am	≤ 45	187949	A0V:	100			
104337	B1.5V	100	188728	A1IV	< 45			
104671	Am	45	189103	B3IVp	75			
104841	B2IV	70	191692	B9III	80			
110951	Am	90	193924	B2IV	55			

Table 3 Visual systems, found in the literature, with measured rotational velocities

ADS	Sp. Type	V sin i km.sec^{-1}	ADS	Sp. Type	V sin i km.sec^{-1}	ADS	Sp. Type	V sin i km.sec^{-1}
824 A	B9.5V	300	6255 A	B6V	60	9737 A	B6V	100
B	A1V	250	B	B7V	200	B	B7V	$\leq$ 25
899 A	A0V	250	7093 A	Am	$\leq$ 25	10149 A	A0V	140
B	B9V	250	B	Am	50	B	A5V	80
1507 A	A1V	50	7705 A	Am	$\leq$ 25	10526 A	A0p(Si)	80
B	B9.5V	170	B	Am	$\leq$ 25	B	B9.5V	200
1683 A	B9V	200	7979 A	A0V	180	10628 A	Am	60
B	A1V	300	B	A1V	250	B	Am	$\leq$ 25
2270 A	B7V	200	8347 A	A3V	150	11089 A	A3V	180
B	B9V	200	D	A2p	$\leq$ 25	B	A3V	180
(1731)A	A1V	100	8568 A	A0p	$\leq$ 25	11336 A	A1IV	180:
B	A3V	250	B	Am	$\leq$ 25	B	A5 pec	80
2582 A	A2V	100	8630 A	F0V	$\leq$ 25	11593 A	B3V	130
B	A3V	100	B	F0V	$\leq$ 25	B	B8V	150
2888 A	B0.5V	160	8682 A	A2V shell	250	11635 A	A5V	200
B	B8V	300:	B	A0V;A2V	$\leq$ 25;25	B	A7V	150
(2313)A	B3V	150	8706 A	A0p	25	11639 A	Am	$\leq$ 25
B	A1V	100	B	F0V	25	D	F0IV	250
4068 A	B9V	150	8891 A	A2V	25	11667 A	Am	$\leq$ 25
B	A0V	200	B	Am	50	B	Am	$\leq$ 25
4179 A	08	75	3 Cen A	B5Vp	$\leq$ 25	11853 A	A5V	130
B	B0V	125	B	B9V	150	B	A7V	220
4182 A	B0.5V	$\leq$ 25	9173 A	A7IV	140	11870 A	A0V	100
B	B1V	$\leq$ 25	B	F2V	40	B	A2V	150
4262 A	B7V	200	9258 A	A2V	80	12893 A	B9p	50
B	B0.5V	120	B	A4V	60	B	B9.5V	250
4749 A	A1V	250	9277 A	A0V	100	HD 188211/2 A	A1V	$\leq$ 25
B	A0V	120	B	A0V	80	B	Am	60
4773 A	A2V	120	9 α^2 Libr	A3V	80	13148 A	A3IV	300
B	A5V	120	8 α^1 Libr	F2V	$\leq$ 25	B	A7V	120
6012 A	B8IV	80	9474 A	F0IV	80	15405 A	B7V	120:
B	B9V	250	B	F2IV	$\leq$ 30	B	A1p(Si,Sr)	60:
6175 A	A1V	$\leq$ 25	9701 A	F0IV	80	15434 A	B0.5V	300
B	Am	$\leq$ 25	B	F0IV-V	70	B	B1V	140

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Table 3 *(continued)*

ADS		Sp. Type	V sin i km.sec^{-1}
16095	A	B1(V)e	350
	B	B2V	50
HD 18473	A	A0p(Si)	60
	B	A8V:	90
IQ Per	A	B8Vp:	100:
	B	A0Vnp:	200
23 Ori	A	B1IVn	350
	B	B3Vn	370
HD 45995	A	B3IV:nne	320
	B	B8Ve	220
HD 50123	A	B6Vnpe	300:
	B	B9V:	170
2 Com	A	F0IV:p::	$\leq$ 50
	B	A9V	$\leq$ 50:
h Cen	A	B4IV	$\leq$ 50:
	B	Am	70
HD 149632/1	A	A1Vp:	70
	B	A2V	80:
HD 178001	A	A2V	70:
	B	Am	80:
HD 190864	A	O6	120
	B	B0.5Vp:	60
HD 191566/7	A	B0IVp	140
	B	B1V	140
HD 203374	A	B0.5IVnne	499:
	B	B2V	180
AR Cas	A	B3V	160
	C	A0Vn	230

Table 4 Spectroscopic and eclipsing systems, found in the literature, with measured rotational velocities

HD	Name	V sin i km.sec^{-1}	Sp. Type
1142		$\leq$ 50	G8III;F2V
1486	TV Cas	70	A0V
1952		70;100	F6III;A4V
2421	Boss 82	16	A2Vs
3369	π And	250	B5V
4058	π Cas	55	A5V
4161	YZ Cas	20	A2-3V
4615/6		90;125	G8III;A2V
4727	ν And	80;11	B5V;F8V
4775/6		$\leq$ 50;50	B9.5V;G0III-IV
5621		120;70	A8V;G0II-III
5679	υ Cep	250	B7-8V
7345	ζ Pis B	13	F7V
9352/3		$\leq$ 50;200	KeIb-II; B9V
10516	ψ Per	493	B2e
12111	48 Cas	80	A4V
12534	γ And B	70;70	B9.5V;B9.5V
12881		13	Am
13474/5		85;70	B9V;G0II-III
13974	δ Tri	5	G0V
14262/3		$\leq$ 50;110	A1V;F3III
16739	12 Per	13	F8V
16908		135	B3V
17034	RY Per	280	B4V
17138	RZ Cas	82	A3V
17245/6		$\leq$ 50;80	A1V;G2III
17878/9		$\leq$ 50;50	G5III-A4V
18925/6		$\leq$ 50;50	G5III;A2V
19356ab	β Per	60	B8V
19926/7		$\leq$ 50;120:	KIIIep;A6V
20084		80;50	G0II;F0:V
20365		145	B3V
21278		50	B3V
21912		91	A3V
23089/90		$\leq$ 50;50	B9V;G2II-III
23625		170	B2V
23642		37	A0V
23838		$\leq$ 50;85	G2III;F2:V
23964		16	A0V
24546	A Per	8	F5V
25555/6		160; 50	B9V;GIIII
25833	AG Per	89;71	B4(V);B5(V)
26673/4		$\leq$ 50;100	G5II;A2V

Table 4 (continued)

HD	Name	V sin i km.sec^{-1}	Sp. Type
26961	b^1 Per	75	A2V
27483		12	F6V
27691		8	G0V
28052	71 Tau	225	A8V
28910	ρ Tau	130	A8V
29094/5		≤ 50;≤50	K0II-III;B9V
29763	94 Tau	175	B3V
31278	7 Cam	45	A1V
32537	9 Aur	25	F0V
32630		125	B3V
32990	103 Tau	90	B2V
33959	14 Aur	18	A9V
34318/9		≤ 50;100:	G8III;A0V
34759	ρ Aur	90	B5V
34790		15	A1Vs
36819		115	B3V
36954		180	B3V
37021	θ^1 Ori	162	B1V
37438	125 Tau	60	B2V
39118/9		≤ 50;85	G8III;A1V
39220	TV Cam	25	A2V
39286		230;≤50	B8V;G2IIIe
39357	136 Tau	50	A0V
39698	57 Ori	20	B2V
41753	ν Ori	30	B3V
42560		230	B3V
47579/80		70;110	G5III;A3V
48953/4		≤ 50;80	G5Ia;A5V
50820		130	B3eV;K
52690		≤ 50	M0Ib;A0V
52822/3		≤ 50;≤50	G8III;A1V
57167	R C Ma	98	A9V:
58343		30	B3V
60179	α Gem	13	A1V
66656		10	A0V
PD-60°979		280	B8.5V
PD-60°969		220	B9.5V
PD-60°990		200	B9V
69479/80		≤ 50	G5III;A2V
70442/3		≤50;80:	
74228/9		130;70	A3V:G0III
76370		≤ 50;≤50	G5III;A0V

HD	Name	V sin i km.sec^{-1}	Sp. Type
76644	ι UMa	145	A7V
76943		25	F5V
82610	S Ant	113	A9V
83808/9		≤ 50;≤50	A1V;F6II
86146	19 LMi	3	F5V
94334	ω UMa	15	A1Vs
98230	ξ UMa ftr	10	B0V
98231	ξ UMa btr	8	G0V
98353	55 UMa	60	A2V
102509		≤ 50;110	G4III-IV;A7V
103578	ο Leo	15	A3V
104321	π Vir	70	A5V
107259	η Vir	10	A2V
107700	12 Com	13	A4V
108464/5		60;≤50	A7V;G0III
110854		20	A0V
112014	32 Cam	13;13	A0V;A2V
113158	UY Vir	55	A9V
116656	ζ^2 UMa	13;13	A2V;A2
120315		210	B3V
120901/2		120; 50	A2V;F9II-III
126269/70		80; 50	A2V;G1II-III
132742	δ Lib	78	B9.5V
137052	ε Lib	10	F5V
137391	μ^1 Boo	90	F0V
139006	α Cr B	132	A0V
139319	TW Dra	50	A5
139892	ζ^2 Cr B	100;100	B6V;B6V
143018	π Sco	100	B1V
144217	β Sco	94	B0.5V
144208/9		60;≤50	A2V;F7III
146361	σ^2 Cr B	13;13	F8V;F8V
150265	W UMi	75	A3
151613		55	F2V
153345	AI Dra	99	A1V:
153597	19h Dra	13	F6V
153808	ε Her	90	A0V
156633	u Her	105;88	B2V;B5V
156015		≤ 50	G5III;F2V
157950		50	F5
159870		60;≤60	G5III;A7V
160762		0	B3V

Table 4 *(continued)*

HD	Name	V sin i $km.sec^{-1}$	Sp. Type
160922	ω Dra	13	F5V
161165		240	B9V
161184		240	B8V
161261		350:	Shell
161480		25	B6V
161572		200	B6V
161575		50	B4V
161603		220	B5V
161660		35	B7V
161677		210	B6V
161698		80	B9V
161733		40	B7V
161940		90	A1V
162028		30	B7V
162515		95	B9.5V
162630		40	B9V
162656		40	B9.5V
162679		40	B9V
162724		≤ 50;50	B9V;B9V
162780		295	B9V
164852		220	B3V
168913	108 Her	80	A7V
169689/90		≤ 50;60	G8III;A0V
169753	RZ Scu	250	B0V
170153	χ Dra	8	F7V
170757	RX Her	78;68	B9V;A0V:
175286	50 Dra	15	A1V
175492		50;60	G5III;A2V
175580		≤ 50;≤50	G5III;A0V
180939	RS Vul	90	B5V
181987	Z Vul	195	B5
183912		≤ 50;50:	K3II;B0.5V
184398/9		≤ 50;≤50	K2II-III;A0V
184759/60		≤ 50;≤50	A0V:F8III
187076/7		≤ 50;≤50	M2II;A0V
187321/2		≤ 50;≤50	B9V;G5II
187811		300	B3V
187949		150;50:	A1V;F4III:
189687		230	B3V
190786	V 477 Cyg	40	A3
191747	18 Vul	100	A3V
192577/8		≤ 50;80	K2II;B4V

HD	Name	V sin i $km.sec^{-1}$	Sp. Type
194359/60		85;90	G0III;A3V
352682	W Del	30	A0e+gG5
196088/9		≤ 50;≤50	B9.5V;F4III
196093/4		≤ 50;≤50	K2Ib;B3V
196753/4		≤ 50;80	K0II-III;A3V
198846	Y Cyg	145;143	B0V:;B0V:
199454	S Equ	52	B8V
200031		≤ 50;≤50	G5III; A5V
202447/8		≤ 50;≤50	G2II-III;A4V
202710		≤ 50; 75:	K0III-A7V
203338/9		≤ 50;50	M1Ibep;B2pe
203454		12	F8V
203467		150	B3V
204403		135	B3V
205114/5		≤ 50;≤50	G2II;B9V
206155	EE Peg	30	A4V:
206644	77 Cyg	50	A0V
206672	π^1 Cyg	120	B3V
206821	EK Cyg	< 20	A0V
207650	14 Peg	25	A1Vs
207956	AW Peg	120	A3V:
208057		150	B3V
208095		120	B7V
207218		100;≤50	G0:III;A2V
208253		≤ 50;≤50	A2V:G5III
209147	CM Lac	55	A2
209961		160	B2V
213310/1		≤ 50;90:	M0II;B8V
214240		60	B3V
214558		≤ 50;≤50	G2III;A4V
214652		115	B2V
215182		≤ 50;50:	G8II;F0V
215318/9		70;120	GIII-III;A2V
216014	AH Cep	185;172	B0V;B1V
218407		160	B2V
218634		≤ 50;90:	M4III;A2V
219512		90;80	A7V;F3III
221253	AR Cas	134	B3V
221700	Y Pis	37	A3V
222217	XX Cep	47	A8
223047		≤ 50;≤50	G5Ib;A0V
320861		150	A1V