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Spectroscopic Binaries near the North Galactic Pole
Paper 21: Eight Short-Period Binaries

R. F. Griffin & D. W. Beggs *The Observatories, Madingley Road, Cambridge, England CB3 0HA*

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Abstract. Orbits based principally on radial-velocity measurements made with the Haute-Provence Coravel spectrometer are presented for eight binary systems which include some of the faintest HD stars in the Galactic-Pole field. They are HD 103418 (which is double-lined), 105021, 108151, 113169, 113323, 113650, 113714, and 116514. Their periods range from 3.7 to 15.1 days. Very little else is known about any of them.

Key words: radial velocities — spectroscopic binaries — orbits — stars, individual

1. Introduction

With Paper 21 this series may be said to 'come of age'. The treating of several binary systems in one paper now is a departure from the convention previously adopted in the series. Two factors have come together to facilitate such wholesale determination of orbits. One is the discovery, at a very late stage in the survey of radial velocities of late-type *Henry Draper Catalogue* stars (Cannon & Pickering 1919, 1920) in the North Galactic Pole field, of a considerable number of binary systems with very short periods (a few days). They seem to be concentrated amongst the most difficult stars on the programme to observe—several of them are far fainter than the mean cut-off magnitude of the *HD Catalogue* in the relevant part of the sky, and they tend also to be of earlier spectral types than most of the stars on the programme, so they give relatively poor cross-correlation 'dips'. The other factor is the opportunity that one of the authors has enjoyed, in the past few Galactic Pole seasons, to use the Geneva Observatory's splendid Coravel radial-velocity spectrometer (Baranne, Mayor & Poncet 1979) on the 1-metre telescope at Haute-Provence; indeed, this paper ought to be sub-titled "A celebration of Coravel", which would no doubt be in keeping with its festive ordinal number! It is only through the use of Coravel, which has generously been granted by Dr. M. Mayor, that it has been possible to follow the velocity changes of all these short-period binaries, which are at, and often beyond, the bounds of practicality to observe with the Cambridge instrument. Not only can they be routinely observed at Haute-Provence with integration times that do not represent in total an excessive proportion of the night's observing, but the weather at Haute-Provence is sometimes good enough to allow 'instant orbits' to be plotted as one monitors such short-period objects night after night.

Table 1. The eight short-period binary stars.

HD no.	V*	$(B-V)$*	Spectral type		α	2000		δ		
	m	m	HD	DDO*	h	m	s	°	′	″
103418	9.28	0.76	K0	K0 V	11	54	34	23	48	41
105021	9.22	0.54	G5	F9 V	12	5	31	21	0	1
108151	9.68	0.60	G5	G1 V	12	25	18	40	3	26
113169	9.38	0.74	G5	G9 V	13	1	26	31	22	41
113323	10.25	0.55	G	F9 V	13	2.8		12	38	
113650	10.02	0.66	G5	G6 VI	13	5.1		12	40	
113714	10.28	0.68	G5	G4 V	13	5	29	12	49	36
116514	9.30	0.67	G5	G4 V	13	23	36	33	22	27

*These quantities have been kindly supplied by Dr. K. M. Yoss. The spectral type has been inferred from DDO-type photometry.

2. The eight stars

Table 1 gives the basic data for the eight stars. We are much indebted to Dr. K. M. Yoss, with whom we are in collaboration in research on the Galactic Pole field, for allowing us to present his *UBV* magnitudes and preliminary conclusions concerning the spectral types of the objects in advance of his own comprehensive publication. It must be emphasized that the spectral types have been inferred from DDO-style photometry and do not represent the results of actual classifications of spectra. No photoelectric magnitudes have been published previously for any of the stars. The only MK types available for any of them are to be found in a catalogue of Abastumani objective-prism observations (Zaitseva 1973) which lists HD 113169 as G8 V and HD 116514 as G5 IV.

So little else is known about any of the stars that it can all be summarized in this paragraph. A search of the SIMBAD database turned up a total of only four non-catalogue references that mentioned any of the stars. One of them was to Copenhagen-style photometry (Hansen & Radford 1983, an effort organized by R.F.G. when Radford was a graduate student under his supervision), which showed that HD 103418 and 105021 are dwarfs, and another was to the paper by Yoss, Neese & Hartkopf (1987) which records one radial-velocity observation of HD 113169. The remaining two papers — the only ones unconnected with the survey of which the present series of papers is a by-product — are an objective-prism classification of HD 108151 as spectral type G0 (Upgren 1963) and the discovery by Goyal (1958) that HD 113169 has a large proper motion—about 0″.1per annum in each coordinate. The *AGK3* (Heckmann & Dieckvoss 1975) attributes large proper motions—slightly in excess of 0".l per annum in each case — to HD 103418, 108151 and 113169; it shows that HD 105021, 113714 and 116514 have small proper motions, hardly significantly greater than their uncertainties, while the proper motions of HD 113323 and 113650 are still unknown.

3. Radial velocities

HD 103418. The velocity variations were actually discovered at Cambridge in 1984, but it was only during an observing run with the radial-velocity spectrometer at the Dominion Astrophysical Observatory (Fletcher *et al* 1982) early in 1988 that the

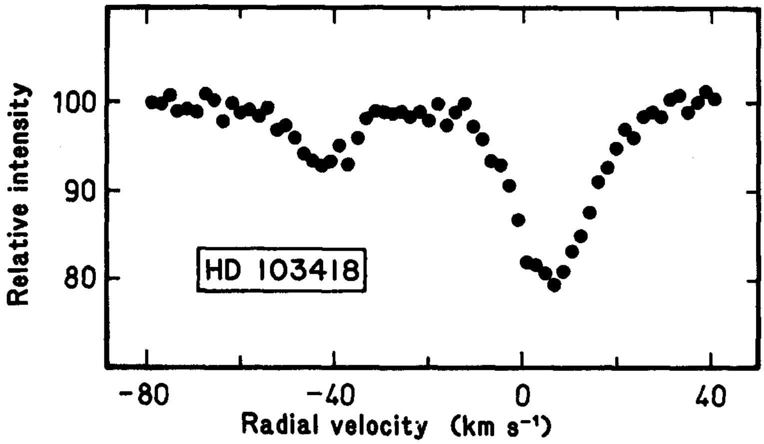


Figure 1. Radial-velocity trace of HD 103418, obtained with the Haute-Provence Coravel on 1991 January 30 and illustrating the very unequal double-lined nature of the object. The number of photon counts per bin in the 'continuum' is about 11,000.

rapidity of the variations was recognized. Shortly afterwards the nature and period of those variations were determined by the 'instant orbit' technique with Coravel. However, it was not until the following observing season that the system was recognized as double-lined, with a very weak secondary 'dip'. Since then the secondary velocity has normally been measured as well as the primary at every observation; owing to the limited scan length of Coravel in relation to the velocity amplitudes, it has usually been necessary to observe the two components in separate traces. In Table 2a below, such consecutive pairs of observations have been placed on the same line, against an averaged time, where the time difference between the observations of the two components does not exceed 7 minutes (0.005 day); the rapidity of the velocity variations (sometimes exceeding 2 km s^{-1} per hour) makes the averaging of longer intervals unwise. Fig. 1 shows one of the few traces that include both the components.

HD 105021. The variability was discovered in 1987 when an isolated Coravel observation disagreed with the only previous Cambridge one. Cambridge measurements later in 1987 demonstrated the rapidity of the variation, whose period and character were determined in the following season with the DAO and Coravel instruments.

HD 108151. The star was first observed in Cambridge; the variability was discovered with Coravel, shown to occur on a short time-scale by the DAO spectrometer, and the orbit was then determined 'instantly' by Coravel in the 1988 observing run.

HD 113169. The discovery and investigation of this binary has been almost wholly attributable to Coravel, an 'instant orbit' being plotted in 1988.

HD 113323. This very faint system has been less well observed than the other seven stars. The observations have nearly all been made with Coravel. The velocity variations were not recognized as rapid until late in the 1989 season; the 1990 season was characterized by poor weather, and it was only in 1991 that the orbit was satisfactorily covered.

HD 113650. Another faint system observed almost exclusively with Coravel; the orbit was determined in 1988.

HD 113714. Another Coravel system, which is entirely beyond the reach of the Cambridge instrument: not only is the star particularly faint but it gives weak dips that are substantially broadened by stellar rotation that must be expected to be synchronous with the orbital period of 3.68 days (the shortest of any of the stars treated in this paper). An 'instant orbit' was drawn from Coravel measurements in 1988.

Table 2a. Photoelectric radial-velocity measurements of HD 103418.

Heliocentric Date		HMJD	Velocity Prim. $km\,s^{-1}$	Velocity Sec. $km\,s^{-1}$	Phase	$(O-C)$ Prim. $km\,s^{-1}$	$(O-C)$ Sec. $km\,s^{-1}$
1974 Mar	3.020*	42109.020	+ 10.4		.605	0.0	
1984 Apr	28.854*	45818.854	+ 35.0		508.695	+ 0.7	
1985 Feb	24.020*	46120.020	+ 18.8		549.942	− 0.8	
1988 Jan	26.493†	47186.493	− 5.5§		696.003		
	31.507†	191.507	+ 32.4		.690	− 0.8	
Feb	1.476†	192.476	+ 46.5		.822	+ 0.1	
Mar	11.019	231.019	− 48.8		702.101	+ 0.4	
	11.957	231.957	− 75.3		.230	0.0	
	12.944	232.944	− 61.2		.365	− 0.1	
	15.904	235.904	+ 45.3		.770	− 0.5	
	16.898	236.898	+ 32.3		.906	+ 0.8	
	22.088*	242.088	+ 13.9		703.617	− 0.1	
	23.077*	243.077	+ 45.1		.753	+ 1.0	
1988 Feb	23.246‡	47580.246	+ 24.2		749.930	+ 0.5	
	24.204‡	581.204	− 33.5		750.062	− 0.1	
	25.303‡	582.303	− 73.8		.212	+ 0.4	
Mar	25.899	610.899	− 58.6	+ 36.6	754.128	− 0.3	− 0.9
	27.011	612.011	− 74.6	+ 56.5	.281	− 0.5	0.0
	27.913	612.913	− 52.2		.405	− 0.7	
	27.922	612.922		+ 27.9	.406		− 0.8
	28.871	613.871	− 14.0§		.536		
	30.014	615.014	+ 34.5	− 74.9	.692	+ 0.8	− 0.6
	30.938	615.938	+ 46.1	− 91.0	.818	− 0.5	− 1.2
Apr	27.869	643.869	+ 21.8	− 59.8	758.644	+ 0.1	− 0.1
	28.841	644.841	+ 45.7		.777	− 0.6	
	28.853	644.853		− 88.0	.779		+ 1.6
	29.932	645.932	+ 24.6	− 63.4	.926	− 0.5	+ 0.1
	30.953	646.953	− 34.8	+ 10.2	759.066	+ 0.6	+ 0.5
May	1.922	647.922	− 72.7	+ 56.7	.199	+ 0.3	+ 1.5
	2.890	648.890	− 66.8	+ 49.2	.332	+ 0.8	+ 0.7
1990 Jan	27.025	47918.025	− 71.9		796.192	+ 0.2	
	31.044	922.044	+ 43.1		.742	+ 0.3	
Feb	12.265‡	934.265	− 48.1	+ 24.8	798.416	+ 0.3	− 0.6
1991 Jan	26.055	48282.055	− 28.0	+ 0.2	846.048	− 0.4	+ 0.1
	27.069	283.069	− 72.0	+ 53.0	.187	− 0.6	− 0.4
	28.085	284.085	− 68.6	+ 49.6	.326	− 0.1	0.0
	29.066	285.066	− 36.1	+ 9.1	.461	− 0.7	− 0.5
	30.042	286.042	+ 6.8	− 41.5	.594	− 0.3	+ 0.4
	31.082	287.082	+ 42.5	− 84.1	.737	+ 0.5	+ 0.3
Feb	3.109	290.109	− 64·5	+ 45·4	847·151	0·0	+ 0·4
	4·082	291·082	− 73.0	+ 56.3	.285	+ 0.7	+ 0.2
	5.222	292.222	− 41.7	+ 16.3	.441	− 0.4	− 0.5

§Blend, not reliably resolvable computationally. Not used in orbital solution.

Table 2b. Photoelectric radial-velocity measurements of HD 105021.

Heliocentric Date			HMJD	Velocity km s^{-1}	Phase	$(O-C)$ km s^{-1}
1973	Feb	22.042*	41735.042	− 29.4	.599	− 0.6
1987	Feb	28.977	46854.977	+ 12.1	340.066	− 0.8
	Mar	25.942*	879.942	− 47.1	341.722	+ 0.3
		29.906*	883.906	− 29.8	.985	− 0.5
	May	7.954*	922.954	− 23.6	344.574	+ 1.2
		8.915*	923.915	− 34.9	.637	− 0.3
	Dec	10.223*	47139.223	− 57.4	358.913	− 0.4
1988	Jan	23.454†	47183.454	− 61.0	361.845	+ 0.2
		26.481†	186.481	+ 3.6	362.046	− 0.9
		27.582†	187.582	+ 26.0	.119	+ 0.8
		31.442†	191.442	+ 4.1	.375	− 0.5
	Feb	1.383†	192.383	− 4.9	.437	− 0.5
	Mar	11.025	231.025	− 20.0	365.000	+ 0.8
		11.965	231.965	+ 11.4	365.062	+ 0.2
		12.947	232.947	+ 26.3	.127	+ 0.3
		13.999	233.999	+ 26.1	.197	+ 0.2
		14.924	234.924	+ 20.7	.258	+ 0.5
		15.908	235.908	+ 11.8	.323	− 0.1
		16.900	236.900	+ 3.0	.389	+ 0.4
		22.096*	242.096	− 48.7	.734	+ 0.4
		23.103*	243.103	− 57.8	.800	0.0
	Apr	1.005*	252.005	+ 2.7	366.391	+ 0.3
	Nov	7.196	472.196	− 26.1	380.990	+ 0.2
1989	Feb	23.249‡	47580.249	+ 27.5	388.154	+ 0.3
		24.211‡	581.211	+ 23.9	.218	− 0.4
		25.311‡	582.311	+ 16.6	.291	+ 0.4
	Mar	12.033*	597.033	+ 18.5	389.267	− 0.6
		18.026*	603.026	− 36.7	.664	+ 2.1
		24.988	609.988	+ 25.6	390.126	− 0.3
		25.904	610.904	+ 26.7	.187	+ 0.2
		27.015	612.015	+ 19.0	.260	− 0.9
		27.932	612.932	+ 11.9	.321	− 0.3
		28.873	613.873	+ 2.7	.384	− 0.7
		30.096	615.096	− 8.4	.465	+ 0.1
		30.949	615.949	− 17.0	.521	− 0.1
	Apr	27.875	643.875	+ 4.8	392.373	− 0.2
		28.918	644.918	− 5.0	.442	+ 0.1
		29.939	645.939	− 15.6	.510	− 0.4
		30.961	646.961	− 25.7	.577	− 0.3
	May	1.911	647.911	− 34.4	.640	+ 0.7
		2.904	648.904	− 45.3	.706	− 0.2
1990	Jan	27.031	47918.031	− 21.2	410.550	+ 0.1
		31.053	922.053	− 59.5	.817	− 0.1
	Feb	12.274‡	934.274	− 33.6	411.627	− 0.5
1991	Jan	26.082	48282.082	− 42.3	434.688	+ 0.1
		27.076	283.076	− 52.2	.754	− 0.2
		28.090	284.090	− 60.1	.821	− 0.4
		29.089	285.089	− 60.6	.887	0.0
		30.049	286.049	− 45.8	.951	− 0.1
		31.090	287.090	− 8.9	435.020	+ 0.3
	Feb	2.154	289.154	+ 26.9	.157	− 0.4
		3.116	290.116	+ 23.8	.220	− 0.3
		4.086	291.086	+ 18.7	.285	+ 1.8
		6.092	293.092	− 1.5	.418	+ 0.1

Table 2c. Photoelectric radial-velocity measurements of HD 108151.

Heliocentric Date		HMJD	Velocity $km\,s^{-1}$	Phase	$(O-C)$ $km\,s^{-1}$
1984 Apr	28.896*	45818.896	46.5	0.771	+0.4
1986 Apr	10.880	46530.880	25.0	92.337	−0.1
1987 Mar	3.918	46857.918	14.8	134.396	−1.3
1988 Jan	26.500†	47186.500	23.0	176.654	−0.6
	31.513†	191.513	31.8	177.299	−0.3
Feb	1.479†	192.479	12.7	.423	−0.5
Mar	11.053	231.053	17.7	182.384	.0
	11.984	231.984	9.3	.504	−0.2
	12.954	232.954	19.5	.629	0.0
	14.002	234.002	44.7	.763	0.0
	14.919	234.919	65.2	.881	−0.6
	16.902	236.902	64.5	183.136	+1.3
	22.103*	242.103	52.3	.805	−0.7
	23.110*	243.110	72.4	.935	+0.7
Nov	7.202	472.202	16.6	213.398	+0.7
1989 Feb	11.070*	47568.070	36.2	225.727	−1.1
Mar	12.052*	597.052	10.3	229.454	−0.5
	18.009*	603.009	48.7	230.220	+0.8
	25.910	610.910	43.6	231.237	−1.1
	27.017	612.017	19.3	.379	+0.9
	27.936	612.936	8.5	.497	−1.0
	28.875	613.875	18.2	.618	+0.2
	30.097	615.097	47.7	.775	+0.7
	30.956	615.956	66.1	.886	−0.3
Apr	27.885	643.885	10.5	235.477	+0.7
	28.925	644.925	17.1	.611	0.0
	29.944	645.944	40.6	.742	+0.2
	30.962	646.962	65.2	.873	+0.6
May	1.929	647.929	73.3	.998	−1.1
	2.905	648.905	65.2	236.123	0.0
1990 Jan	27.033	47918.033	39.3	270.735	+0.4
	31.077	922.077	41.9	271.255	+1.0
1991 Jan	26.087	48282.087	11.5	317.555	+0.1
	27.081	283.081	28.9	.683	+0.3
	28 120	284.120	54.9	.816	−0.2
	29.087	285.087	72.6	.941	+0.4
	30.053	286.053	70.8	318.065	−1.0
	31.094	287.094	52.0	.199	−0.2
Feb	2.205	289.205	10.0	.470	0.0
	3.118	290.118	15.5	.588	+1.2
	4.090	291.090	33.4	.713	−1.0
	6.112	293.112	74.6	.973	+0.7

HD 116514. The star was first observed at Cambridge, but the discovery of its variability was made with Coravel; this is another star whose nature was elucidated by an 'instant orbit' in 1988.

Tables 2a-2h present the journals of radial-velocity observations for the respective stars. Their form is similar to that of the corresponding tables in previous papers in

Table 2d. Photoelectric radial-velocity measurements of HD 113169.

Heliocentric Date		HMJD	Velocity km s^{-1}	Phase	$(O-C)$ km s^{-1}
1986 Apr	11.118	46531.118	−4.9	.735	−0.1
1987 Mar	4.142	46858.142	+7.8	55.787	+0.9
1987 Jan	31.522†	47191.522	+27.9	111.910	−0.9
Mar	11.117	231.117	−34.3	118.575	−1.1
	12.013	232.013	−6.7	.726	0.0
	12.997	232.997	+26.7	.892	+0.3
	14.005	234.005	+31.7	119.061	−0.1
	14.964	234.964	+3.8	.223	−0.9
	16.911	236.911	−34.8	.550	+0.5
	22.145*	242.145	−34.3	120.432	−0.5
1989 Feb	23.266‡	47580.266	−22.9	177.352	−0.2
	24.250‡	581.250	−37.2	.518	−0.3
	25.313‡	582.313	−13.9	.697	−0.8
Mar	25.004	610.004	−24.1	182.358	−0.3
	25.945	610.945	−37.0	.517	−0.1
	27.030	612.030	−12.6	.699	−0.1
	27.953	612.953	+20.3	.855	−0.2
	28.930	613.930	+34.1	183.019	0.0
	30.105	615.105	+6.3	.217	+0.3
	30.986	615.986	−24.7	.365	+0.3
Apr	27.888	643.888	+32.0	188.062	+0.3
	28.998	644.998	−0.2	.249	+1.0
	29.948	645.948	−30.7	.409	+0.7
May	1.038	647.038	−31.2	.593	0.0
	1.940	647.940	−1.9	.745	+0.7
	2.938	648.938	+28.3	.913	−0.8
1990 Jan	27.054	47918.054	+5.9	234.217	−0.2
	31.145	922.145	+29.2	.905	+1.0
Feb	12.355‡	934.355	+33.2	236.961	−0.1
1991 Jan	26.157	48282.157	−36.6	295.511	+0.4
	27.104	283.104	−18.5	.670	0.0
	28.151	284.151	+19.0	.847	0.0
	29.176	285.176	+33.8	296.019	−0.3
	30.077	286.077	+15.1	.171	−0.6
	31.110	287.110	−21.2	.345	+0.2
Feb	3.148	290.148	+21.2	.856	+0.4
	4.112	291.112	+34.5	297.018	+0.4

this series, except that in the present case the 'default' source of each measurement is the Haute-Provence Coravel. Other sources are identified by the following symbols after the dates concerned:

*Cambridge 36-inch reflector (Griffin 1967);

†Dominion Astrophysical Observatory 48-inch reflector (Fletcher *et al.* 1982);

‡Coravel on the 61-inch Danish reflector at ESO, Chile.

Apart from the first observation of HD 103418 and the first of HD 105021, which were made with the Cambridge instrument by G. A. Radford, all the observations at

Table 2e. Photoelectric radial-velocity measurements of HD 113323.

Heliocentric Date		HMJD	Velocity km s^{-1}	Phase	$(O-C)$ km s^{-1}
1986 Apr	10.949	46530.949	−10.6	0.152	+0.1
1987 Mar	4.047	46858.047	−14.1	59.749	−0.1
1989 Mar	26.103	47611.103	−24.5	196.954	+0.4
Apr	30.000	646.000	−0.9	203.312	−0.7
May	1.943	647.943	−8.1	.666	−0.1
	2.943	648.943	−21.4	.848	0.0
1990 Jan	27.147	47918.147	−23.6	252.897	+0.3
	31.147	922.147	−5.6	253.626	−0.2
Feb	12.359‡	934.359	−21.3	255.851	+0.2
	14.384‡	936.384	−5.2	256.220	−0.1
	15.315‡	937.315	+0.6	.389	−0.6
Mar	13.362†	963.362	−12.6	261.135	−0.3
1991 Jan	26.161	48282.161	−4.9	319.220	+0.2
	27.108	283.108	+1.6	.392	+0.3
	28.154	284.154	−2.5	.583	+0.6
	29.179	285.179	−15.7	.769	−0.1
	30.082	286.082	−25.0	.934	−0.1
Feb	3.161	290.161	−8.5	320.677	+0.2
	4.116	291.116	−22.1	.851	−0.6
	5.153	292.153	−21.5	321.040	−0.4
	6.177	293.177	−3.6	.227	+1.0

Table 2f. Photoelectric radial-velocity measurements of HD 113650.

Heliocentric Date		HMJD	Velocity km s^{-1}	Phase	$(O-C)$ km s^{-1}
1986 Apr	10.951	46530.951	−27.5	.477	−0.2
1987 Mar	4.081	46858.081	+7.9	29.846	+0.8
1988 Jan	31.527†	47191.527	−1.1	59.783	−0.2
Mar	11.123	231.123	−17.1	63.338	−0.1
	12.020	232.020	−26.1	.418	−1.4
	12.933	232.933	−27.7	.500	−0.1
	13.944	233.944	−25.2	.591	−1.2
	14.947	234.947	−14.7	.681	0.0
	15.901	235.901	−3.5	.767	−0.3
	16.914	236.914	+8·4	.858	0.0
	22.157*	242.157	−15.0	64.328	+0.9
1989 Feb	23.271‡	47580.271	−13.5	94.684	+0.9
	24.252‡	581.252	−2.2	.772	−0.2
	25.317‡	582.317	+9.2	.868	−0.2
Mar	25.012	610.012	−19.2	97.354	−0.3
	25.949	610.949	−25.7	.438	+0.2
	27.033	612.033	−27.0	.535	0.0
	27.962	612.962	−22.3	.619	−0.6
	28.934	613.934	−12.0	.706	−0.5
	30.108	615.108	+2.3	.811	−0.6
	31.004	616.004	+12.1	.892	+0.4

Table 2f. Continued.

Heliocentric Date		HMJD	Velocity km s^{-1}	Phase	$(O-C)$ km s^{-1}
1989 Apr	27.892	47643.892	−22.9	100.396	+0.1
	29.002	645.002	−26.7	.495	+0.8
1990 Jan	27.083	47918.083	+15.8	125.012	−0.8
	31.149	922.149	−20.6	.377	+0.7
Feb	12.361‡	934.361	−27.6	126.474	−0.3
1991 Jan	26.164	48282.164	−12.5	157.699	−0.1
	27.110	283.110	−0.5	.784	+0.3
	28.155	284.155	+10.3	.878	−0.1
	29.182	285.182	+16.1	.970	−0.1
	30.084	286.084	+15.4	158.051	−0.1
Feb	3.151	290.151	−24.7	.416	−0.1
	4.118	291.118	−26.3	.503	+1.3
	5.155	292.155	−23.7	.596	0.0
	6.180	293.180	−13.1	.688	+0.7
June	12.933*	419.933	+15.9	170.068	+1.2
	13.934*	420.934	+6.6	.158	−0.1

Table 2g. Photoelectric radial-velocity measurements of HD 113714.

Heliocentric Date		HMJD	Velocity km s^{-1}	Phase	$(O-C)$ km s^{-1}
1986 Apr	10.957	46530.957	+28.2	.847	−1.7
1987 Mar	4.103	46858.103	−24.1	89.731	−0.6
1988 Jan	31.539†	47191.539	−47.3	180.323	+0.9
Feb	1.485†	192.485	−80.0	.580	+1.4
Mar	11.129	231.129	+52.9	191.079	−0.5
	12.060	232.060	−50.2	.332	+1.9
	12.178	232.178	−69.8	.365	−5.1
	12.929	232.929	−84.1	.569	−0.2
	12.991	232.991	−81.1	.585	−1.0
	13.104	233.104	−70.9	.616	+0.5
	13.172	233.172	−66.0	.635	−0.9
	13.939	233.939	+31.5	.843	+3.2
	14.168	234.168	+47.9	.905	−1.6
	14.943	234.943	+45.5	192.116	+2.2
	15.177	235.177	+16.4	.179	−2.5
	15.896	235.896	−69.5	.375	−1.2
	16.951	236.951	−55.2	.661	−0.5
1989 Feb	23.274‡	47580.274	+59.4	285.940	+2.0
	23.359‡	580.359	+61.3	.963	+0.6
	24.255‡	581.255	+6.9	286.207	+0.3
	25.308‡	582.308	−87.2	.493	+3.7
Mar	25.953	610.953	−27.1	294.275	−0.8
	27.036	612.036	−83.1	.570	+0.6
	27.967	612.967	+19.1	.823	−0.7
	28.939	613.939	+50.2	295.087	−1.5
	30.112	615.112	−77.7	.405	+0.1
	31.014	616.014	−59.8	.650	−0.7

Table 2g. Continued.

Heliocentric Date		HMJD	Velocity $km\,s^{-1}$	Phase	$(O-C)$ $km\,s^{-1}$
1989 Apr	27.899	47643.899	−3.5	303.227	−0.7
	29.013	645.013	−87.4	.529	+2.2
	29.953	645.953	−0.4	0.785	−2.9
May	1.058	647.058	+52.4	304.085	+0.3
	1.949	647.949	−49.8	.327	0.0
	2.948	648.948	−78.5	.598	−1.8
1990 Jan	27.079	47918.079	−28.3	377.720	+0.3
	31.153	922.153	+21.2	378.827	−0.3
1991 Jan	26.170	48282.170	−64.6	476.641	−1.9
	27.117	283.117	+49.0	.898	+1.4
	28.160	284.160	+18.8	477.182	+0.9
	29.186	285.186	−86.5	.461	+2.1
	30.088	286.088	−33.1	.706	+2.2
	31.119	287.119	+65.8	.986	+3.3
Feb	3.155	290.155	+13.0	478.811	−1.5
	4.121	291.121	+53.3	479.073	−1.5

Table 2h. Photoelectric radial-velocity measurements of HD 116514.

Heliocentric Date		HMJD	Velocity $km\,s^{-1}$	Phase	$(O-C)$ $km\,s^{-1}$
1980 May	14.964*	44373.964	+28.5	0.913	−0.3
1987 Mar	3.012	46857.012	+34.1	418.987	−0.1
1988 Feb	1.520†	47192.520	−40.7	475.476	+0.2
Mar	11.168	231.168	+35.6	481.984	+1.5
	12.048	232.048	+21.7	482.132	−0.3
	13.008	233.008	−14.0	.293	−0.3
	14.007	234.007	−39.7	.462	+0.6
	14.990	234.990	−29.9	.627	0.0
	16.918	236.918	+32.9	.952	+0.3
	22.169*	242.169	+15.5	483.836	−0.4
Apr	13.996*	264.996	−20.2	487.679	−0.4
1989 Feb	24.269‡	47581.269	+30.4	540.931	−0.4
	25.314‡	582.314	+26.6	541.107	+0.5
Mar	18.091*	603.091	−32.9	544.605	+0.5
	25.977	610.977	+30.8	545.933	−0.1
	27.052	612.052	+24.1	546.114	−1.0
	27.971	612.971	−8.4	.268	−0.5
	28.942	613.942	−38.3	.432	−0.4
	30.117	615.117	−30.1	.630	−0.6
Apr	27.904	643.904	−40.6	551.477	+0.3
	29.051	645.051	−21.2	.670	+0.6
	29.956	645.956	+13.1	.822	+0.1
May	1.047	647.047	+34.5	552.006	+0.2
	1.955	647.955	+17.1	.159	+0.1
	2.993	648.993	−21.9	.333	+0.6

Table 2h. Continued.

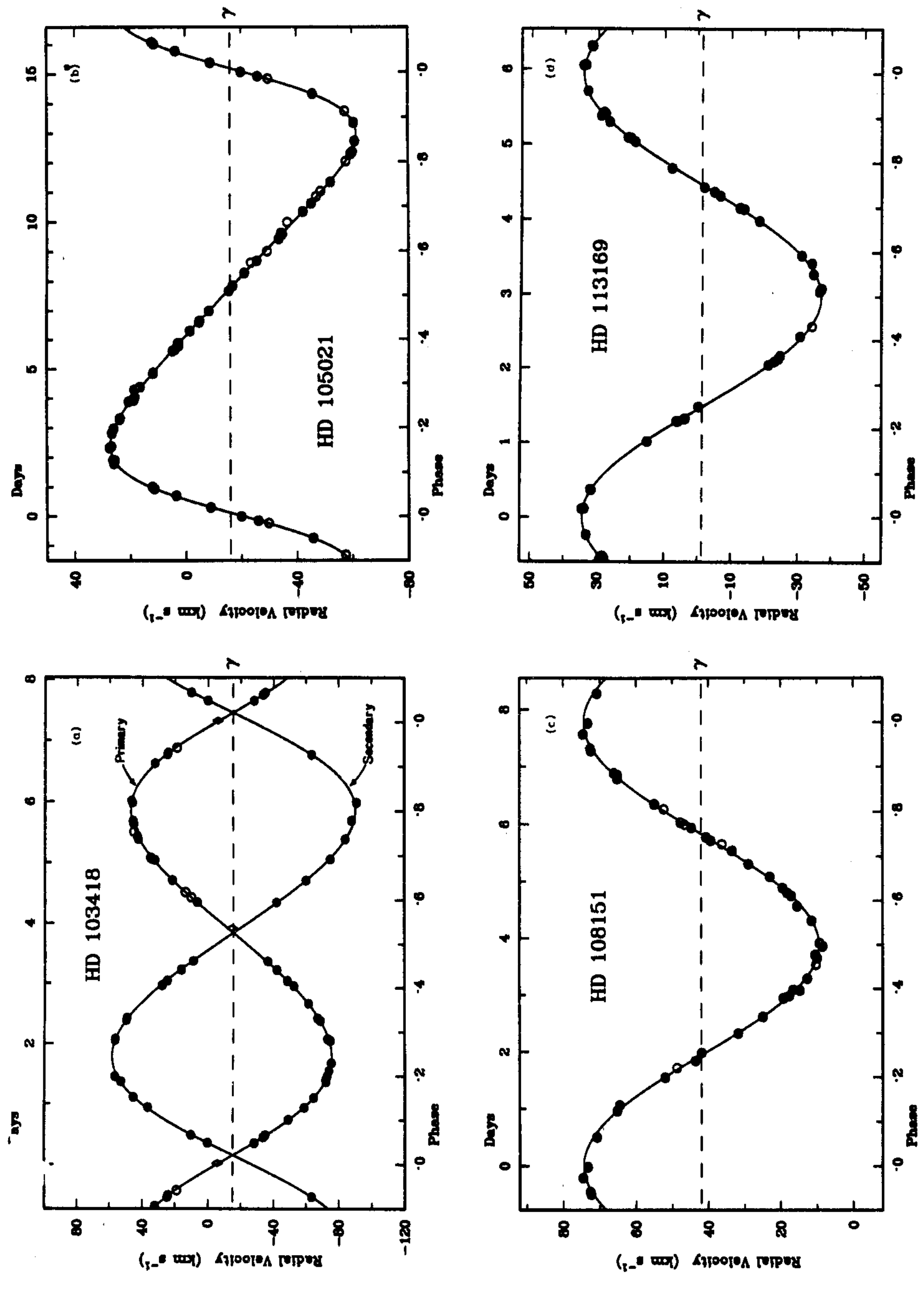
Heliocentric Date		HMJD	Velocity km s^{-1}	Phase	$(O-C)$ km s^{-1}
1990 Jan	27.060	47918.060	−29.6	597.636	−1.3
	31.175	922.175	−21.6	598.329	0.0
Feb	12.384‡	934.384	−32.2	600.385	−0.3
1991 Jan	26.184	48282.184	+31.8	658.944	−0.2
	27.131	283.131	+26.3	659.104	−0.2
	28.179	284.179	−10.9	.280	−0.2
	29.190	285.190	−39.4	.451	+0.1
	30.115	286.115	−32.7	.606	+0.5
Feb	3.186	290.186	−12.9	660.292	+0.4
	4.137	291.137	−39.7	.452	−0.1

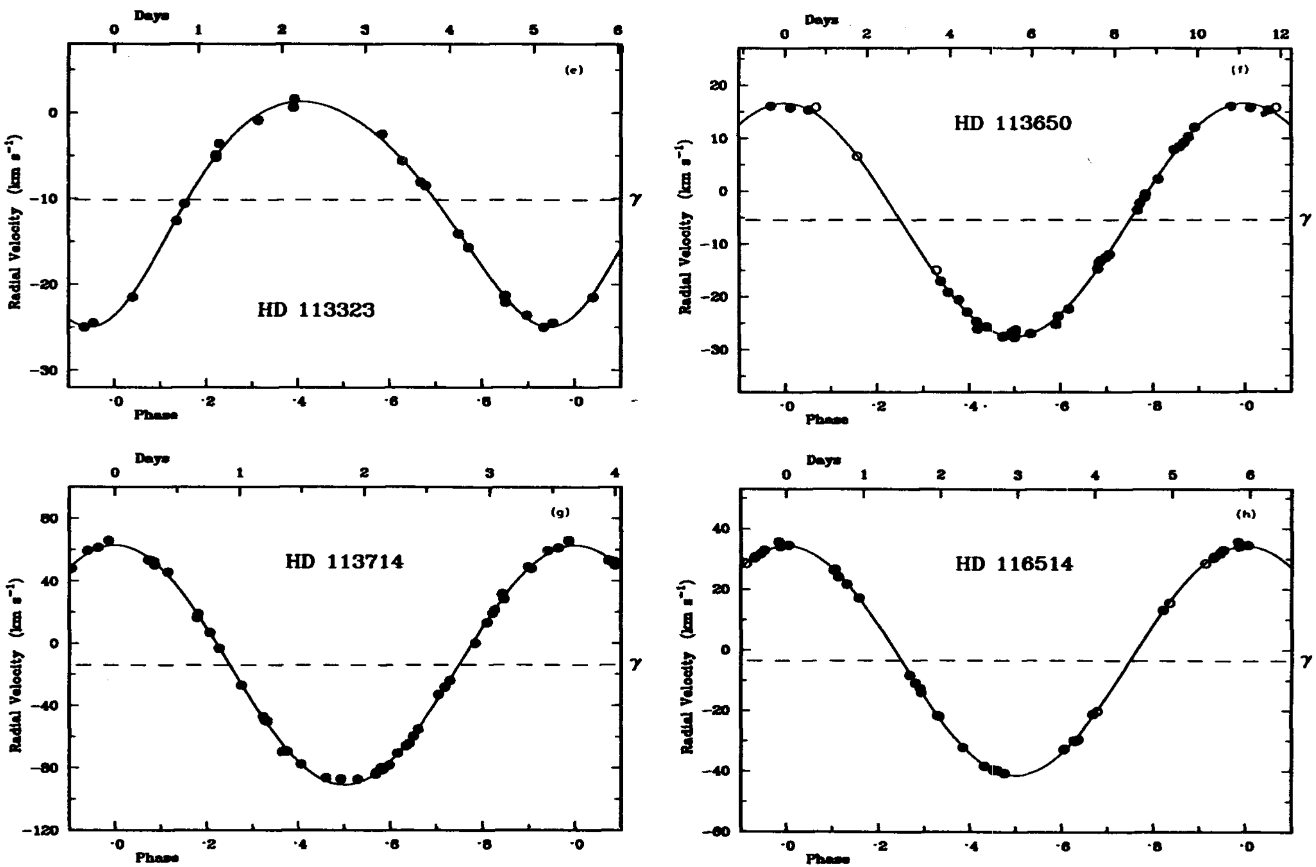
all the telescopes were made by R. F. G.. He has been assisted at the DAO and sometimes at ESO by Dr. R. E. M. Griffin, and at Haute-Provence most often by her but sometimes by one of their sons or by Mr. K. P. Marshall.

Difficulties sometimes arise in combining Coravel radial velocities with those observed with other spectrometers, owing to differences of zero-point. The procedure that has been uniformly followed at all the spectrometers involved in the observations reported here, and at the Palomar one (Griffin & Gunn 1974) which happens not to have supplied any data for the stars of present interest, is to measure all velocities differentially against reference stars (Griffin 1967,1969), of which the only one relevant to North Galactic Pole stars is 41 Com. No difficulty has ever been noticed with lack of homogeneity of the velocities obtained at Cambridge, the Dominion Astrophysical Observatory and Palomar; but Coravel velocities, when standardized on 41 Com in the same way as the others, seem for many stars to be systematically more positive than velocities from the other instruments. However, there is no evidence that that is so for the observations reported here: correction of the Coravel (Haute-Provence and ESO) velocities by + 1.5 km s^{-1} (the average amount needed to bring the Coravel observations, as reduced at Geneva to the 'IAU faint standard' system (Mayor & Maurice 1985) into agreement with the velocities long adopted (Griffin 1969) for the Cambridge reference stars) leads to substantial homogeneity with the available Cambridge and DAO velocities.

4. Orbits

The calculation of the orbits is straightforward apart perhaps from the assignment of appropriate weights to the observations from the different sources. The pool of data from the ensemble of orbits permits a considerably better estimate to be made of the relative reliabilities of the velocities from the four spectrometers involved than could be obtained from a discussion of any one orbit individually. The residuals from an initial trial set of orbits showed (not unexpectedly) that the Cambridge measurements were less accurate than the others, so in a second trial they were weighted one-half. The resulting weighted mean-square residuals from the seven orbital solutions


HD 105021
HD 103418
Primary
Secondary
HD 113169
HD 108151
Days
Phase
Radial Velocity (km s⁻¹)
γ



Figures 2a—2h. The computed orbital radial-velocity curves for the eight stars, with the measured radial velocities plotted. Filled circles represent observations made with integrating spectrometers, *viz.* the Coravels at Haute-Provence and ESO and the DAO spectrometer; open circles represent Cambridge data which have been attributed half-weight in the solutions. Two open diamonds in Fig. 2a (HD 103418) refer to observations rejected owing to blending of the two components.

(HD 113714 being excluded, since its very diffuse dips cause all results to be much more ragged for that object) are as follows:

Spectrometer	Mean-square residual ($km\,s^{-1}$)	No. of measures
Coravel (Haute-Provence)	0.29	218
Coravel (ESO)	0.18	23
Cambridge	0.26	30
Dominion Astrophys. Obs.	0.30	14

We have hardly felt called upon to increase the weighting of the relatively small number of ESO measurements in order to equalize the weighted variances any further.

The orbital elements for the eight stars are set out in Table 3. The quantity given in the column headed "T or T_0" is the epoch T of periastron in the cases of orbits with nonzero eccentricities, and is the epoch T_0 of zero mean longitude as defined by Sterne (1941) and recommended by Batten, Fletcher & McCarthy (1989) for circular orbits. The penultimate column gives the r.m.s. deviation of an observation of unit weight from the velocity computed according to the adopted orbit; the last column shows the number of radial-velocity measurements contributing to the orbital solution. The standard deviations of the various orbital elements are given in the line immediately following the relevant line of elements; only the significant digits of the standard deviation are normally given (and the decimal point where it is adjacent to them), and they are ranged directly beneath the digits to which they correspond in the elements themselves.

The phases and residuals of the individual radial-velocity measurements according to the adopted orbital solutions have been added to the tabulations of those measurements in Tables 2a–2h. The computed velocity curves are shown in Figs 2a–2h. Connoisseurs of this series of papers will notice modest changes in the style of the Figures in comparison with those in the earlier papers. The new ones were drawn automatically by a programme written by D.W.B. whereas all the diagrams in previous papers were drawn by R.F.G.'s own hand.

Five of the eight orbits are shown in Table 3 as having zero eccentricity. Their eccentricities were adopted as being exactly zero after trial solutions had shown them to be below the level of significance. It is appropriate to indicate what level that is for each of the five orbits concerned. Table 4 shows, for each orbit, the values of e and ω obtained from an orbital solution in which the eccentricity was left as a disposable parameter, and also the sums of squares of the residuals from the solutions with e free and with e set to 0. The last two data may be used in conjuction with the tests proposed by Bassett (1978) or equivalently (Lucy 1989) by Lucy & Sweeney

Table 4. Eccentric solutions for the five orbits adopted as circular.

Star	Eccentricity	ω(degrees)	Sum of squares e free	Sum of squares $e=0$	no. of obs.
HD 108151	0.002 ± 0.005	128 ± 146	17.26	17.34	42
HD 113169	0.004 ± 0.004	252 ± 47	9.56	10.00	37
HD 113650	0.003 ± 0.008	191 ± 141	11.56	11.62	37
HD 113714	0.012 ± 0.006	350 ± 22	119.30	134.02	43
HD 116514	0.005 ± 0.004	341 ± 38	8.11	8.74	35

Table 3. Orbital elements for the eight stars.

Star	P days	T or T_0 HMJD	γ km s^{-1}	K km s^{-1}	e	ω deg	$a \sin i$ Gm	$f(m)$ $M_\odot$	σ km s^{-1}	n
HD 103418	7.301537	47573.453	−15.05	61.26	0.090	81.7	6.13	0.1722	0.5	38
	20	23	.08	.11	2	1.2	1	10		
(secondary)				74.32			7.43	0.3074	0.7	21
				.18			2	20		
HD 105021	15.08227	47457.266	−16.03	44.41	0.325	265.6	8.71	0.1160	0.5	54
	13	17	.08	.13	3	.5	3	11		
HD 108151	7.77561	47601.295	+41.94	32.48	0	—	3.472	0.0276	0.6	42
	9	6	.11	.16			17	4		
HD 113169	5.94023	47655.397	−1.35	35.74	0	—	2.919	0.0281	0.5	37
	4	3	.09	.13			11	3		
HD 113323	5.48853	47913.22	−10.16	13.12	0.142	206	0.981	0.00125	0.4	21
	9	7	.11	.16	12	5	12	5		
HD 113650	11.1385	47706.316	−5.46	22.10	0	—	3.384	0.0125	0.6	37
	3	13	.12	.15			24	3		
HD 113714	3.68061	47576.814	−14.1	76.9	0	—	3.890	0.174	1.8	43
	3	3	.3	.4			21	3		
HD 116514	5.93926	47563.863	−3.53	37.82	0	—	3.089	0.0334	0.5	35
	4	4	.10	.12			10	3		

(1971) to determine the statistical significance—none, in these cases — of the departure of the relevant orbit from exact circularity. Of course the longitude of periastron is indeterminate in a circular orbit, a fact which accounts for the absurd standard errors of that quantity in Table 4; the standard error is actually about $\varepsilon\,(e)/e$ radians in each case.

5. Discussion

This section begins with a few notes on some of the individual orbits. There follows a brief discussion on the nature of HD 103418 in the light of the discovery that it is double-lined. The lack of observable secondaries in the other seven systems is noted. There is little more that can be said about those seven systems in the almost complete absence of other information about them. There is, however, some more general interest in the eccentricities of binary-star orbits in the period range covered by the present sample; the radial-velocity traces also carry some interesting information on rotation rates. Those two topics are accordingly discussed in subsequent paragraphs.

5.1 *Notes on Certain Orbits*

HD 103418. The secondary dip has an equivalent width only 27 per cent of that of the primary. The observational errors of the primary and secondary velocities are less disparate than the dip areas, because longer integration times were naturally used in an effort to get good velocities for the weak secondary. A weighting of 0.5 for the secondary velocities has been adopted, and brings the weighted variances of the velocities of the two components into practical equality: the r.m.s. residuals of the primary velocities are 0.49 km s^{-1} and those of the secondary are 0.70 km s^{-1}.

HD 113323. The number of observations is smaller than in other orbits in this paper and in this series of papers generally, but the measurements are well distributed in phase and their r.m.s. residual is only 0.40 km s^{-1}.

HD 113650. There is an uncomfortably large gap in the phase coverage, but there is little uncertainty involved in bridging it, particularly since the orbit proves to be circular.

HD 116514. The data points are noticeably bunched on the orbital velocity curve in Fig. 2h. The bunching arises from the fact that most of the velocities for this object (as for the others) were measured at nightly intervals in just four observing runs, and it happened in this case that the same set of phases recurred in all four runs. The same thing must be true of HD 113169, whose period differs by less than a thousandth of a day from that of HD 116514 (indeed, it will take about a century for the relative phases to slip by one cycle), but owing to minor differences in the time distribution of the observations the effect is less apparent in the case of HD 113169.

5.2 *The HD 103418 System*

The only one of the eight binaries which can be discussed as a double star is HD 103418, since that is the only one with both components visible in the spectrum. We have seen that the ratio of the dip areas on radial-velocity traces is about 1:0.27. We can make use of Fig. 21 of Baranne, Mayor & Poncet (1979), in conjunction with the table on p. 206 of Allen (1973) giving the run of colour index with stellar absolute magnitude, to estimate the magnitude difference between the components in the wavelength region, roughly corresponding to the photometric *B* band, in which Coravel operates. The orbital elements give the mass ratio of the components as 1.21:1, with very small uncertainty; we can interpret the mass ratio in terms of a spectral-type difference from the table on p. 209 of Allen (1973). Furthermore, we know (Table 1) the integrated ($B - V$) colour. The three observational data are tolerably well fitted by the model set out in Table 5, consisting of main-sequence stars of types G5 and K1. The mass ratio would prefer the types to be a little closer together, whereas the dip ratio would prefer them distinctly further apart, but the discrepancies correspond at most to a few tenths of a magnitude in the values of M_V and are not serious. The combined type might be expected to be rather earlier than the K0 given in the *Henry Draper Catalogue* (Cannon & Pickering 1919) and also suggested in Table 1 above on the basis of narrow-band photometry. However, the difference from an integrated type of, say, G7 is not significant in the case of the *HD Catalogue* and may be explicable in the narrow-band case in terms of unrecognized duplicity.

A significant comparison can be made between the masses shown in Table 5 for the stars in the model and the actual minimum masses, $m \sin^3 i = 1.023 \pm 0.008$ and $0.843 \pm 0.006\ M_\odot$, demanded by the orbital parameters for the primary and secondary respectively. The comparison leads to the surprising conclusion that $\sin^3 i \sim 1.10$. Since that is manifestly impossible, we are bound to conclude that there is an error in the model; it no doubt stems from the underestimate of masses in the relevant table in Allen (1973), and similar evidence has been noted repeatedly in the past (Griffin 1990 and references therein). Nevertheless, it is quite evident that $\sin^3 i$ must be very close to the maximum acceptable value of unity, and therefore the HD 103418 system must be seen so nearly edge-on that eclipses are a real possibility. A number of photometric observers has been invited to watch for eclipses at the known times of conjunction; Mr R. Fried has made such a watch at the privately operated Braeside Observatory near Flagstaff, Arizona, and has reported that no eclipse was seen. Since the sum of the radii of the model stars is about a tenth of their projected separation $(a_1 + a_2) \sin i$, the orbital inclination must differ from 90° by about a tenth of a radian or more, implying that the actual masses must be greater by at least 1.5 per cent than the minimum values required by the orbital parameters.

5.3 *The Secondary Stars in the Other Systems*

A number of clues exists to help in the detection of the secondary stars in spectroscopic binary systems. One of them is the presence of distortions in the orbital velocity curve in the vicinity of the γ-velocity (*e.g.* Griffin 1978) owing to 'dragging' of the primary towards the systemic velocity by blending with the unrecognized secondary. Inspection of the curves in Fig. 2 shows no such effect except possibly in the case of HD 113714, which however only appears to show the effect at *one* conjunction. Another source of hope and inspiration is the mass functions. Although it is possible for a binary to be double-lined despite an arbitrarily small mass function if the orbital inclination is

Table 5. Model for HD 103418.

Spectral type		M_V m	$(B-V)$ m	M_B m	Mass $M_\odot$	Mass ratio
Model	G5 V	5.1	0.70	5.80	0.93	1.23
	K1 V	6.18	0.95	7.13	0.76	
	G5V + K1V	4.76	0.76	5.52		
HD 103418 (observed)			0.76			1.21

The intrinsic areas of the dips for colours 0m.70 amd $0^{\mathrm{m}}.95$ are expected to be 5.0 and 6.0 km s^{-1} respectively; weighted by the relative *B* luminosity of 1:0.29 they should be in the ratio 1:0.35, to be compared with the observed ratio 1:0.27.

small enough, statistically it is the systems with the largest mass functions that are most likely to be double-lined, simply because the mass function involves the cube of the secondary mass. The mass functions of five of the seven stars other than HD 103418 are not encouraging, ranging from 0.0012 $M_\odot$ (HD 113323) to 0.033 $M_\odot$ (HD 116514). The other two systems are much more promising candidates for observable duplicity: HD 105021 has a mass function of 0.116$M_\odot$, while HD 113714 has one of 0.174 $M_\odot$ —slightly greater even than that of HD 103418. Efforts have been made with Coravel to detect the secondaries in those systems (as well as in some of the others). On HD 105021 a trace of the relevant region of velocity space was accumulated up to 10,000 counts per bin, similar to the exposure of HD 103418 exhibited in Fig. 1; on HD 113714, which is a magnitude fainter, an exposure of 6,000 counts per bin was obtained. No evidence of a secondary dip was seen in either case.

Even though the secondary stars are not observable with the radial-velocity spectrometer, they must nevertheless exist, and if the inclinations of the orbits are high enough there will be eclipses. Again, those systems that have large mass functions are the ones most likely to eclipse, since not only m_2 but $\sin^3 i$ has to be large to give a large mass function — and that is quite aside from arguments based on rotational velocities. HD 113714 is perhaps the most likely of the single-lined binaries to show eclipses; in a circular orbit the geometry of eclipses is the same at both conjunctions, and the photometrically deeper eclipse is the one in which the secondary star (whose surface brightness is expected to be lower than that of its companion) transits in front of the primary. The ephemeris for those eclipses is given by $T_0 + (n + 1/4)P$, where n is any integer and T_0 and P are given in Table 3. Such an ephemeris is true for any system whose orbit is circular, but does not hold in general for eccentric orbits.

5.4 *Orbital Eccentricities*

It is to be expected that binaries with sufficiently short periods will have had their orbits circularized by tidal effects. There has been a good deal of controversy recently (summarized briefly by Mazeh *et al.* (1990)) concerning the actual period below which orbits ought to be circular and whether that period ought to vary with stellar age; observationally the critical period has been found to lie, for different groups of stars, between about 4 and 14 days, so it is very much in the range occupied by the stars of interest here. Those eight stars do not by any means support the proposal of Zahn & Bouchet (1989) that there is one unique period below which orbits should be circular: here, the second-shortest orbit is eccentric and the second-longest is not.

5.5 *Rotational Velocities and their Possible Uses*

The 'dips' in radial-velocity traces have widths as well as positions: the widths tell us something about the rotational velocities while the positions give us the radial velocities. In most cases — including those of the stars treated here, in all probability — other sources of line broadening are negligible in comparison with the broadening caused by stellar rotation. On that basis, the widths of the best-fit gaussians to all traces are routinely expressed in terms of v sin i (the projected equatorial rotational velocities), as a by-product of the radial-velocity reductions, according to the recipe given by Benz & Mayor (1981). The solar value of the macro turbulence is assumed to be appropriate to all the stars. The mean values of v sin i from all the traces of each of the stars studied in this paper are given in Table 6. The formal standard errors of the v sin i values follow from the calculated precisions of the dip widths from which they are derived; they are likely to be optimistic assessments of the true uncertainties, especially where they are below 1 kms^{-1}.

The v sin i values can usefully be interpreted only in the context of assumptions concerning one or more relevant quantities such as the rotational period P, the stellar radius R, and/or the orbital inclination i, which are all interrelated by the simple equation $P(v \sin i) = 2\pi R \sin i$, each side of which represents the projected circumference of the star. If the radius R can be taken as known, the quotient $P/\sin i$ follows. If, on the other hand, the rotation period is assumed, the product $R \sin i$ follows. If both P and R are assumed, then v sin i can be used to find the inclination.

The components of short-period binary systems in circular orbits normally rotate in synchronism with the orbital revolution — a fact that is readily understood theoretically, since the time-scales involved in 'capturing' the axial rotation are much shorter than those involved in circularizing the orbit (*e.g.* Zahn 1977). Even in eccentric orbits the rotation is often captured, but since the tidal interaction between the components varies very rapidly with their separation it is captured at an angular velocity that nearly corresponds to the orbital angular velocity at periastron — the phenomenon of 'pseudo-synchronization' that has been quantitatively described by Hut (1981). The rotation periods of stars which possess detectable azimuthal inhomogeneities can be determined directly by photometric methods. If the inhomogeneities are sufficiently pronounced ('starspots'), as they often are in the cases of short-period binaries, rotational modulation is readily seen in ordinary broad-band photometry. The type star for that class of photometric variability among late-type main-sequence stars is BY Dra; surprise has been expressed by some commentators, *e.g.* Eggleton (1985), that its rotational and orbital periods are unequal, but in fact (Hall 1986) its rotation is pseudo-synchronized to its eccentric orbit in very nearly the ratio prescribed by Hut (*op. cit.*). Less active systems may show little or no detectable variability in the integrated light of broad bands of the spectrum, but many of them nevertheless reveal their rotational periods when systematically observed spectroscopically in the light of the H and K lines of Ca II (Vaughan *et al.* 1981),

Table 6. Observed projected rotational velocities and inferred stellar radii.

Star	$v \sin i$ $\mathrm{km\,s^{-1}}$	Putative P_{rot} days	Putative $R \sin i$ $R_\odot$	Radius from putative MK type $R_\odot$
HD 103418 A	6.8 ± 0.5	(6.9)	0.92	0.93
HD 105021	6.0 ± 0.6	(9.6)	1.14	1.08
HD 108151	7.5 ± 0.6	7.8	1.16	1.02
HD 113169	7.3 ± 0.5	5.9	0.85	0.87
HD 113323	6.3 ± 1.1	(4.9)	0.61	1.08
HD 113650	1.2 ± 1.3	11.1	0.3:	:
HD 113714	21.5 ± 0.7	3.7	1.56	0.96
HD 116514	11.4 ± 0.4	5.9	1.33	0.96

The five columns list the following data:
(1) The identification of the star;
(2) The mean value of $v \sin i$, derived from Coravel radial-velocity traces;
(3) The expected period of axial rotation, on the assumption that rotation is synchronized with the orbital revolution in the cases of circular orbits or pseudo-synchronized (values in brackets) (cf. Hut 1981) in the cases of nonzero eccentricity;
(4) The projected stellar radius computed from the product of the quantities in columns (2) and (3);
(5) The stellar radius which, according to Allen (1973), corresponds to the spectral type estimated in Table 1 from DDO-type photometry or, in the case of HD 103418, the type proposed in the model in Table 5.

where one is probably detecting regions of enhanced surface activity corresponding to plage regions on the Sun.

In view of their short orbital periods, it is quite likely that careful photometric monitoring will show that at least some of the stars studied in this paper exhibit variability which will enable their rotation periods to be determined directly. Pending such monitoring, we use the projected rotational velocities given in Table 6 to determine the values of $R \sin i$ on the basis that the rotations are synchronized or pseudo-synchronized to the orbital periods. The expected rotational periods and the corresponding projected stellar radii are added to Table 6, as are the radii expected according to the table on p. 209 of Allen (1973) applied to the spectral types proposed in Table 1 above or, in the case of HD 103418, the type (G5) proposed in the model in Table 5. The projected radius of HD 103418 is seen to be similar to the expected radius, in apparent confirmation of the conclusion that that system is seen at an inclination close to 90°. It appears that HD 108151 is also seen at a high inclination, in which case its small mass function has to be understood in terms of a small mass for the secondary star — it would need to be ~ 0.4 $M_\odot$ if i ~ 90°. HD 105021 is another system which we tentatively conclude to be seen nearly edge-on; the secondary mass needs to be approximately 0.75 $M_\odot$. The last two stars on the list have seemingly anomalous values of the projected radii, being too large for their spectral types. The rotational velocities of both stars are large enough to make substantial contributions to the observed line-widths, and are therefore rather sensitively determined by the measured widths of the cross-correlation functions and cannot be far from the truth. The alternative escape hypotheses must be that either the stars are rotating faster than synchronously or else they are actually larger than main-sequence stars of their presumed types are supposed to be. The former hypothesis is particularly unattractive in the case of HD 113714, whose orbital period is so short that asynchronous rotation would be a major surprise; the large mass function, too, bespeaks a quite massive companion which would be quick to compel rotational synchronism. We are obliged to conclude that HD 113714 is somewhat evolved, in the same way (though not necessarily to the same extent) as Procyon, which has a radius of 2.1 $R_\odot$ (Steffen 1985) although the F5 V type to which it is analogous should have a radius of only 1.2 $R_\odot$ (Allen 1973). HD 116514 presents a possibly milder case of such evolution above the main sequence. These must of course be tentative conclusions that will be open to refinement and perhaps correction once the interest of observers is aroused in these stars — as it is to be hoped that it will be by this paper. Nevertheless it is reassuring to see some support for the idea that HD 116514 is oversize in the Abastumani classification of that star (Zaitseva 1973) as being of luminosity class IV rather than V.

If we were disposed to press on with this discussion to its logical conclusion, we could try to use each 'observed' value of $R \sin i$ together with the expected value of R (both given in Table 6) to derive $\sin i$, which could then be substituted in the expression for the mass function to give the secondary mass on the basis of a primary mass assumed from the spectral type. However, it seems best to refrain from doing that: the compounding of a number of assumptions (albeit ones that are individually reasonable) with rotational velocities whose accuracy is not unlimited, and then cubing the result for use in the mass function, threatens to transgress the tenuous boundary between scientific inference and idle speculation!

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