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Spectroscopic Binaries near the North Galactic Pole Paper 24: HD 106104, 109281, 109463 and 110743

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Abstract. The four stars treated in this paper have been under observation with photoelectric radial-velocity spectrometers for many years. They have proved to be binaries with periods of 30, 1828, 1514 and 822 days respectively; the orbits are of modest eccentricity apart from that of HD 110743 which is indistinguishable from a circle. The mass functions are small, and no companion has been observed for any of the stars. HD 110743, a K dwarf, is much the nearest of the four, and its orbit is of short enough period for the photocentric motion to have been recognized by *Hipparcos*. An eleventh-magnitude star rather more than $1'$ away from HD 106104 is shown to be a genuine physical companion, with practically identical radial velocity, proper motion and distance modulus, although the projected separation is about 13,000 AU.

Key words. Radial velocities—spectroscopic binaries—orbits—stars, individual—HD 106104—HD 109281—HD 109463—HD 110743.

1. Introduction

A fairly recent publication (Yoss & Griffin 1997) in this *Journal* described a comprehensive photometric and radial-velocity survey of the late-type stars that are in the North Galactic Cap ($b > 75°$) and feature in the *Henry Draper Catalogue*. It was noted in that survey that no fewer than 125 of the 903 stars that were measured had been identified as spectroscopic binaries. The present author, in some cases with collaborators, had already published orbits for 33 of them and has subsequently provided one more (Griffin 2000), and three have been published by others. (One of those three (Jasniewicz, Duquennoy & Acker 1987) has since been implicitly withdrawn.) There remains, therefore, a formidable collection of the best part of a hundred loose ends needing to be tied up. The present paper represents a modest start upon that task, which is not made any easier by the fact that all of the stars reside within the same small area of sky and so in a sense compete for the same observing time. Many of them also have long periods, so the work could not be hurried beyond a certain point, no matter how much observing time might be available.

The four stars treated in this paper do not share any particular property apart from inclusion in the Galactic-Pole survey: they have been selected for publication because they are among the best observed of the binaries whose orbits remain to be determined. HD 106104, 109281 and 109463 are all in the constellation Coma Berenices, while

HD 110743 is at a higher declination and is in the south-western part of Canes Venatici. HD 109463 is sufficiently close to the Coma Cluster to have received a Trumpler (1938) designation, no. 189. It is also the brightest ($7^{m}.7$) and latest (K5) of the stars and gives very fine radial-velocity traces. At the other extreme, HD 106104 is remarkably faint ($10^{m}.3$) for an HD star; probably for that reason its HD number is overlooked in a catalogue (Hill 1982) specifically compiled to give cross-identifications of A- and F-type stars in the North-Galactic-Pole region, as well as in a photometric catalogue by Knude (1993). HD 106104 is also particularly early ($\sim$ F8) in type – much earlier than the ostensible limit of G5 imposed in the selection of late types from the *Henry Draper Catalogue* – and consequently is more troublesome to to observe. The other two stars are of intermediate character.

Table 1 recapitulates salient data from the survey paper (Yoss & Griffin 1997) about the four stars. It includes a fifth star, a visual companion (albeit a distant one, about 76″ away in position angle 114°) to HD 106104; the object was included in the Galactic-Pole survey (Yoss & Griffin 1997) purely out of inquisitiveness because of its proximity to a star that was validly selected for the programme. The 'mk' spectral types in Table 1 were inferred from DDO-type photometry (McClure 1976, and see the survey paper cited above) and are not actual spectral classifications although they form a good substitute. Equally, the values for M_V, the implied z distances (which are for practical purposes equal to the line-of-sight distances to the stars, in view of the very high Galactic latitudes), and [Fe/H] are all derived from the DDO photometry.

Table 1. Properties of the stars discussed (Yoss & Griffin 1997).

HD	V m	B–V m	Type HD	Type 'mk'	M_V m	z pc	[Fe/H]
106104	10.34	0.53	G5	F9 V	+4.2	164	—
109281	8.68	1.01	K0	K0 III	+1.4	285	+0.02
109463	7.69	1.41	K2	K5 III–IV	+1.6	165	−0.02
110743	8.76	0.83	K0	K1 V	+6.1	34	+0.04
106104 B	11.27	0.62	—	G3 V	+4.9	182	—

Some additional photoelectric photometry in the V and B bands (but none in U) is available for the stars and is listed in Table 2; published spectral types are given in Table 3. There is a difference of opinion regarding the type of HD 110743, but it is readily resolved: the giant type proposed by Upgren (1962) was obviously wrong from the outset, because it implied a distance at which the star's large proper motion of about 0″.38 per annum, which has been known since the nineteenth century (Porter 1895), would correspond to an unacceptable transverse velocity in the range 500–1000 km s^{-1}.

Rather surprisingly in view of the faintness of HD 106104 in particular, all four stars feature in the *Hipparcos* (1997) catalogue; their parallaxes and the corresponding distances, distance moduli and absolute magnitudes are set out in Table 4. The uncertainties of small parallaxes are reflected very asymmetrically in the derived distance estimates, so distances corresponding to $\pi \pm \sigma$ are given in brackets after the central

Table 2. Additional photoelectric magnitudes.

Star	V m	B−V m	Reference
HD 106104	10.352	—	Knude (1993)
	10.34	0.56:	Hipparcos (1997)
HD 109281	8.67	1.03	Ljunggren (1965)
	8.67	1.03	Hartkopf & Yoss (1982)
	8.71	—	Hansen & Radford (1983)
	8.68	—	Hipparcos (1997)
HD 109463	7.70	1.39	Häggkvist & Oja (1973)
	7.81	—	Hartkopf & Yoss (1982)
	7.69	—	Hipparcos (1997)
HD 110743	8.79	0.83	Ljunggren (1965)

Table 3. Additional spectral types.

Star	Type	Reference
HD 106104	g:F8	Schwassmann & van Rhijn (1951)
	F8	Hill (1982)
HD 109281	gG8	Malmquist (1960)
	K0 III	Upgren (1962)
	G9 II–III*	Hartkopf & Yoss (1982)
HD 109463	K5 III–IV*	Yoss (1977)
	K5 III–IV*	Hartkopf & Yoss (1982)
HD 110743	dK0	Malmquist (1960)
	G8 III	Upgren (1962)
	K1	Bidelman (1985) [*vice* Kuiper]

*From DDO photometry, not spectra

Table 4. *Hipparcos* parallaxes and derived distances and absolute magnitudes

Star	Parallax ms of arc	Distance pc	Dist. modulus m	M_V m
HD 106104	5.82 ± 1.73	172 (132–245)	6.17 ± 0.7	+4.2 ± 0.7
HD 109281	0.44 ± 1.14	(> 630)	>9.0	<−0.3
HD 109463	2.58 ± 0.97	390 (290–620)	7.94 ± 0.9	−0.2 ± 0.9
HD 110743	22.90 ± 1.65	44 (41–47)	3.20 ± 0.16	+5.59 ± 0.16

values; the asymmetries of the distance moduli are less serious and are glossed over in a representative uncertainty value.

2. Radial velocities

The first photoelectric radial-velocity measurements of the three brighter stars were made nearly (in one case more than) thirty years ago; HD 106104 was not observed until 1982. Because the stars were part of a large survey programme and the initial purpose was to obtain just two observations of each object, there was a deliberate delay in obtaining a second observation, and several years elapsed before velocity variability was established and the objects transferred to the spectroscopic-binary programme for systematic surveillance. Thus systematic observation has lasted only for intervals ranging from 12 to 22 years, but as even the longest orbital period is 5 years all the stars have been seen round several cycles and their orbits are very well established. The longest period belongs to HD 109281 and is so precisely an integral number of years (1828 ± 3 days, while 5 years is 1826 $\frac{1}{4}$ days) that the observing seasons correspond to exactly the same set of orbital phases cycle after cycle, causing the data to be unavoidably bunched in phase; the damage to the orbit determination is, however, more cosmetic than real, unlike the situation that can arise with periods that are very close to 1 or 2 years.

Radial-velocity spectrometers that have contributed measurements for this paper include the original instrument at Cambridge (Griffin 1967), the one made by Dr. J. E. Gunn and the writer for the Hale 200-inch telescope (Griffin & Gunn 1974), the Geneva Observatory's *Coravel*s (Baranne *et al.* 1979) at Haute-Provence and ESO, the instrument (Fletcher *et al.* 1982) at the Dominion Astrophysical Observatory's 48-inch coudé reflector at Victoria, and most recently a *Coravel*-like instrument at Cambridge. The numbers of observations made with the respective instruments are noted in Table 5.

Table 5. Usage of the various photoelectric radial-velocity spectrometers.

Spectrometer	HD: 106104	106104 B	109281	109463	110743	Totals
Cambridge (old)	2	—	55	28	47	132
Palomar	—	—	2	1	1	4
Haute-Provence	50	11	28	32	27	148
ESO	3	—	2	2	2	9
DAO	4	—	4	2	7	17
Cambridge (new)	5	2	11	11	8	37
Totals	64	13	102	76	92	347

Very few radial velocities have been published previously for any of the four stars. For HD 106104 there is none. HD 109281 was observed three times with the Kottamia 74-inch telescope by Woolley *et al.* (1981), who used a prismatic Cassegrain spectrograph which gave a reciprocal dispersion of 66 Å mm^{-1} at Hγ; Sandage & Fouts (1987) listed one velocity (+71.6 km s^{-1}), measured with a reticon detector at the Mount Wilson 100-inch coudé spectrograph, but they gave no date so it is not possible to include their observation in the discussion here. Heard (1956) reported a mean of four radial velocities obtained for HD 109463 with the David Dunlap 74-inch reflector at 66 Å mm^{-1}, but the observations were not given individually and did not suggest to Heard that the velocity was variable. Two measurements (only two days apart) were obtained of the star by Chériguene (1971), who used the coudé spectrograph of the Haute-Provence 193-cm telescope at a reciprocal dispersion of 25 Å mm^{-1}. Finally, HD 110743 is the subject of one observation published by Yoss, Neese & Hartkopf (1987), who noted that it was obtained with 'IRS', which they described by way of explanation as 'KPNO 0.9-m IRS'. All available radial velocities, already published or newly presented here, are listed in Tables 6(a)–(d).

It is a troublesome fact, but one that has to be faced, that radial velocities stemming from different sources are apt to exhibit different zero-points. *Coravel* measurements have been particularly troublesome in that regard, since their zero-point has seemed to possess a dependence on stellar colour (*e.g.* Scarfe, Batten & Fletcher 1990). That has recently been admitted, and a new reduction procedure and zero-point has been adopted (Udry, Mayor & Queloz 1999). The data in the Tables 6 are intended to be on the Cambridge zero-point used in the previous papers in this series; to that end, observations made at Cambridge, Palomar and Victoria have been standardized with respect to the Cambridge reference stars (Griffin 1969) — meaning in this case 41 Com alone, since that star is conveniently at hand in the Galactic-Pole field. All Haute-Provence and ESO *Coravel* observations are stored in a data base in Geneva, whence those needed for this paper were kindly retrieved by Dr. S. Udry. They are on the new zero-point and seem in the case of each star to need an adjustment of $+0.8$ km s^{-1} (which has already been applied to the velocities as given in Tables 6) to make them homogeneous with the other data. That is an agreeable finding, because it has long been considered (Griffin & Herbig 1981) that that is the offset usually needed to bring measurements that are on the 'IAU' zero-point into harmony with those on the Cambridge basis. For that reason, the same offset has been applied to the few published observations that feature in the tables.

The homogeneity of the observations made with the new Cambridge *Coravel* is possibly not above reproach: they agree all right in the case of the two red giants (HD 109281 and 109463), but for the two bluer stars they would agree more comfortably if altered by -0.3 km s^{-1}. Not enough experience has yet been gained with the instrument for there to be any certainty about any colour dependence of the zero-point; for present purposes the empirical correction of -0.3 km s^{-1} has been made to the relevant observations of HD 106104 and 110743, and of the visual companion of HD 106104, but no change has been made to those of HD 109281 or 109463.

3. Orbits

To obtain the best orbits it is necessary not only to coordinate the zero-points of different data sources but also to assign appropriate weights.

Preliminary orbits showed very clearly that *none* of the radial velocities gleaned from the literature stands comparison with those measured with the photoelectric spectrometers, so they have all been rejected from the orbital solutions although they are retained in the Tables 6 and plotted in the orbit diagrams in those cases where they fall within the boundaries of the plots.

It has been found in many previous analyses, as it has in this one, that radial velocities measured with the original spectrometer in Cambridge, upon which the photoelectric

Table 6a. Radial-velocity observations of HD 106104.

Date	MJD	Velocity km s^{-1}	Phase	(O – C) km s^{-1}
1982 Mar. 8.00*	45036.00	+12.8	0.501	−3.4
1984 Apr. 23.90*	45813.90	+18.9	26.488	+3.2
1988 Jan. 31.51†	47191.51	+15.7	72.511	−0.8
1989 Mar. 26.03	47611.03	+16.3	86.526	−0.8
May 1.88	647.88	+18.9	87.757	+1.3
1990 Jan. 27.11	47918.11	+14.8	96.785	−1.5
Feb. 12.29‡	934.29	+6.5	97.325	−0.2
14.36‡	936.36	+11.6	.394	+0.5
15.31‡	937.31	+13.2	.426	+0.4
1991 Jan. 28.11	48284.11	−8.7	109.012	−0.3
29.10	285.10	−9.8	.045	+0.4
30.05	286.05	−10.4	.077	+0.1
Feb. 3.17	290.17	−2.2	.214	−0.2
4.09	291.09	+0.2	.245	−0.4
5.09	292.09	+3.7	.278	+0.5
6.08	293.08	+6.0	.311	+0.3
Dec. 17.15	607.15	+14.7	119.804	−0.4
19.16	609.16	+9.5	.871	+0.4
19.21	609.21	+6.7	.872	−2.2
1992 Jan. 14.12	48635.12	+19.1	120.738	+0.8
15.08	636.08	+16.7	.770	−0.4
16.09	637.09	+15.1	.804	0.0
17.12	638.12	+12.7	.838	+0.3
18.12	639.12	+9.2	.872	+0.2
19.17	640.17	+4.9	.907	+0.3
20.15	641.15	+2.0	.939	+1.9
21.15	642.15	−4.3	.973	0.0
Feb. 26.49†	678.49	−3.5	122.187	+0.7
27.40†	679.40	−2.0	.217	−0.3
28.33†	680.33	+0.1	.248	−0.8
Apr. 21.97	733.97	−10.1	124.040	0.0
22.91	734.91	−10.6	.072	0.0
23.90	735.90	−9.6	.105	+0.1
24.92	736.92	−8.2	.139	−0.4
25.93	737.93	−5.9	.173	−0.5
26.95	738.95	−2.3	.207	+0.3
27.91	739.91	−0.9	.239	−1.0
29.89	741.89	+6.7	.305	+1.5

Table 6a. (*Continued*)

Date	MJD	Velocity km s^{-1}	Phase	(O – C) km s^{-1}
1992 Apr. 30.92	48742.92	+8.1	124.339	+0.4
June 27.92	800.92	+3.3	126.277	+0.2
Dec. 18.21	974.21	−10.5	132.066	+0.1
20.18	976.18	−7.4	.132	+0.9
1993 Feb. 12.13	49030.13	+0.6	133.934	−0.2
Mar. 19.04	065.04	−10.2	135.101	−0.3
Dec. 25.21	346.21	+15.5	144.494	−0.4
26.08	347.08	+17.8	.523	+0.8
27.15	348.15	+18.2	.559	+0.2
28.15	349.15	+18.1	.592	−0.7
29.16	350.16	+18.4	.626	−0.9
30.16	351.16	+20.0	.659	+0.6
1994 Jan. 1.24	49353.24	+18.6	144.729	0.0
3.16	355.16	+15.8	.793	0.0
8.13	360.13	−2.9	.959	−0.4
Feb. 21.05	404.05	+12.5	146.426	−0.3
Apr. 29.95	471.95	+20.3	148.694	+1.1
1995 Jan. 4.15	49721.15	−10.0	157.020	−1.0
June 2.95	870.95	−9.5	162.024	−0.2
1996 Apr. 2.98	50175.98	−2.8	172.214	−0.8
1997 Apr. 10.99§	50548.99	+19.6	184.676	+0.2
May 10.89§	578.89	+20.0	185.674	+0.6
1998 May 2.89	50935.89	+18.3	197.601	−0.6
2000 Jan. 9.14§	51552.14	−4.4	218.188	−0.3
Apr. 6.9§	640.96	−5.7	221.155	+1.0
May 30.92§	694.92	−2.0	222.958	+0.4

*Observed with original Cambridge spectrometer; not used in orbital solution.
†Observed with DAO 48-inch telescope.
‡Observed with ESO *Coravel*.
§Observed with Cambridge *Coravel*.
All others observed with Haute-Provence *Coravel*.

Table 6b. Radial-velocity observations of HD 109281.

Date	MJD	Velocity km s^{-1}	Phase	(O – C) km s^{-1}
1967 Mar. 30.88*	39579.88	+76.7	$\bar{1}$.343	−2.8
Apr. 13.82*	593.82	81.4	.350	+1.8
1970 May 11.80*	40717.80	69.8	$\bar{1}$.965	+2.6
1971 Feb. 27.08	41009.08	72.9	0.125	+0.4
1975 May 30.93	42562.93	66.5	0.975	−0.7
1977 Apr. 2.05	43235.05	79.0	1.343	−0.5
27.98	260.98	79.5	.357	−0.2
1978 Mar. 24.08	43591.08	78.0	1.537	−1.2
May 23.26†	651.26	79.6	.570	+0.9
June 18.93	677.93	79.5	.585	+1.1
1979 Jan. 3.25	43876.25	77.4	1.693	+1.8
Feb. 25.15	929.15	74.7	.722	+0.1
Mar. 8.10	940.10	76.7	.728	+2.3
Apr. 29.03	992.03	72.9	.757	−0.5
May 13.97	44006.97	72.3	.765	−0.8
June 22.94	046.94	71.5	.787	−0.7
Dec. 25.22	232.22	67.4	.888	−1.0
1980 Feb. 23.11	44292.11	66.1	1.921	−1.5
May 5.97	364.97	67.5	.961	+0.3
1981 Mar. 1.13	44664.13	72.5	2.125	0.0
Apr. 27.98	721.98	74.4	.156	+0.3
May 24.99	748.99	73.4	.171	−1.3
1982 Jan. 10.19	44979.19	79.0	2.297	+0.2
Mar. 4.06	45032.06	80.1	.326	+0.8
May 7.03	096.03	78.7	.361	−1.0
1983 Feb. 4.53‡	45369.53	80.0	2.510	+0.4
Mar. 7.08	400.08	80.9	.527	+1.5
June 12.93	497.93	76.8	.581	−1.7
Dec. 11.22	679.22	76.3	.680	+0.3
1984 Jan. 9.17	45708.17	75.2	2.696	−0.3
Apr. 3.01	793.01	74.0	.742	+0.1
May 10.94	830.94	73.3	.763	+0.1
Dec. 21.22	46055.22	68.7	.886	+0.2
1985 Jan. 24.13	46089.13	+67.2	2.904	−0.8

Table 6b. (*Continued*)

Date	MJD	Velocity km s^{-1}	Phase	(O – C) km s^{-1}
1985 Feb. 8.46‡	46104.46	+68.6	2.913	+0.8
Mar. 15.01	139.01	67.4	.932	0.0
May 31.90	216.90	68.2	.974	+1.0
1986 Jan. 25.10	46455.10	71.5	3.104	−0.1
Feb. 27.09	488.09	71.1	.123	−1.3
Mar. 7.04	496.04	71.7	.127	−1.0
Apr. 10.05§	530.05	73.9	.145	+0.3
May 12.95	562.95	75.0	.163	+0.6
June 14.91	595.91	75.7	.182	+0.5
Aug. 25.80§	667.80	77.0	.221	+0.3
Nov. 24.55†	758.55	78.9	.271	+0.7
1987 Jan. 6.18	46801.18	78.9	3.294	+0.2
Feb. 1.12	827.12	77.8	.308	−1.2
Mar. 1.13§	855.13	79.1	.323	−0.2
Apr. 27.91	912.91	78.9	.355	−0.8
May 31.92	946.92	80.3	.374	+0.5
June 22.93	968.93	79.2	.386	−0.7
Dec. 10.24	47139.24	79.1	.479	−0.8
1988 Jan. 8.22	47168.22	78.9	3.495	−0.8
Feb. 1.42‡	192.42	79.3	.508	−0.3
Mar. 11.07§	231.07	79.1	.529	−0.3
Apr. 12.91	263.91	+78.5	.547	−0.6

Table 6b. (*Continued*)

Date			MJD	Velocity km s^{-1}	Phase	(O – C) km s^{-1}
1988	May	6.90	47287.90	+79.6	3.560	+0.7
	June	2.98	314.98	78.2	.575	−0.4
	Nov.	5.20§	470.20	76.3	.660	−0.3
1989	Feb.	11.10	47568.10	73.7	3.713	−1.3
		24.23¶	581.23	74.4	.721	−0.3
	Mar.	18.03	603.03	74.6	.733	+0.3
	Apr.	28.93§	644.93	73.6	.756	+0.2
	May	26.91	672.91	73.2	.771	+0.4
	June	19.91	696.91	71.9	.784	−0.4
1990	Jan.	31.09§	47922.09	68.3	3.907	+0.4
	Feb.	12.31¶	934.31	68.0	.914	+0.2
	Mar.	26.96	976.96	67.0	.937	−0.4
	Apr.	30.87	48011.87	66.4	.956	−0.8
	May	26.95	037.95	65.1	.971	−2.1
	Dec.	27.20	252.20	71.5	4.088	+0.8
1991	Jan.	29.11§	48285.11	71.8	4.106	+0.2
	May	2.93	378.93	73.9	.157	−0.2
	Dec.	19.18§	609.18	77.9	.283	−0.6
1992	Jan.	16.11§	48637.11	78.8	4.298	0.0
	Feb.	28.37‡	680.37	79.4	.322	+0.2
	Apr.	23.91§	735.91	79.3	.352	−0.4
	June	25.88§	798.88	+80.6	.387	+0.7

Table 6b. (*Continued*)

Date	MJD	Velocity km s^{-1}	Phase	(O − C) km s^{-1}
1992 Aug. 12.85[§]	48846.85	+79.9	4.413	−0.1
Dec. 20.26[§]	976.26	79.8	.484	0.0
1993 Feb. 15.10[§]	49033.10	80.0	4.515	+0.5
Mar. 23.08[§]	069.08	79.3	.535	0.0
July 6.89[§]	174.89	78.5	.593	+0.2
Dec. 30.20[§]	351.20	76.0	.689	+0.2
1994 Feb. 21.09[§]	49404.09	74.6	4.718	−0.2
May 3.00[§]	475.00	73.2	.757	−0.2
Aug. 1.83[§]	565.83	71.1	.807	−0.3
1995 Jan. 5.16[§]	49722.16	67.9	4.892	−0.4
June 4.93[§]	872.93	66.8	.975	−0.4
1996 Mar. 30.98[§]	50172.98	73.5	5.139	+0.3
1997 Mar. 29.06[‖]	50536.06	79.7	5.337	+0.2
Apr. 16.02[‖]	554.02	79.6	.347	0.0
May 11.00[‖]	579.00	79.4	.361	−0.3
July 19.90[§]	648.90	80.4	.399	+0.4
Sept. 9.78[§]	700.78	80.2	.428	+0.2
1998 May 1.99[§]	50934.99	79.3	5.556	+0.3
July 12.90[§]	51006.90	78.0	.595	−0.2
1999 Dec. 20.26[‖]	51532.26	68.6	5.883	0.0
2000 Jan. 9.18[‖]	51552.18	68.8	5.893	+0.5
Mar. 25.00[‖]	628.00	67.9	.935	+0.5
Apr. 30.98[‖]	664.98	67.5	.955	+0.3
May 30.91[‖]	694.91	67.1	.972	−0.1
June 19.94[‖]	714.94	67.6	.983	+0.3
July 16.91[‖]	741.91	67.7	.997	+0.2
Aug. 1.87[‖]	757.87	+67.0	6.006	−0.7

[*]Observed at Kottamia by Woolley *et al.* (1981); not used in orbital solution.
[†]Observed with Palomar 200-inch telescope.
[‡]Observed with DAO 48-inch telescope.
[§]Observed with Haute-Provence *Coravel*.
[¶]Observed with ESO *Coravel*.
[‖]Observed with Cambridge *Coravel*.
All others observed with original Cambridge spectrometer; weighted 1/4 in orbital solution.

Table 6c. Radial-velocity observations of HD 109463.

Date	MJD	Velocity km s^{-1}	Phase	(O – C) km s^{-1}
1968 Apr. 26.92*	39972.92	−33.2	0.080	−0.4
1969 Jan. 1.21†	40222.21	−23.8	0.245	+5.0
3.12†	224.12	−27.9	.246	+0.9
1982 Mar. 6.06*	45034.06	−29.9	3.423	−0.1
1984 Apr. 24.93*	45814.93	−37.9	3.939	+0.1
1985 Feb. 24.03*	46120.03	−30.9	4.141	−0.2
1986 Jan. 26.15*	46456.15	−29.5	4.363	−0.4
Mar. 7.04*	496.04	−30.0	.389	−0.6
Apr. 10.06	530.06	−29.6	.412	+0.1
May 7.90*	557.90	−30.0	.430	−0.1
June 4.91*	585.91	−29.5	.449	+0.7
Aug. 25.81	667.81	−30.6	.503	+0.7
Nov. 24.55‡	758.55	−32.6	.563	0.0
1987 Jan. 6.21*	46801.21	−33.8	4.591	−0.6
Feb. 1.11*	827.11	−32.9	.608	+0.7
Mar. 1.14	855.14	−33.6	.626	+0.5
Apr. 27.92*	912.92	−34.7	.665	+0.3
May 24.96*	939.96	−36.0	.682	−0.5
31.92*	946.92	−36.5	.687	−0.9
Dec. 10.25*	47139.25	−38.9	.814	−0.6
1988 Jan. 8.17*	47168.17	−37.4	4.833	+1.1
Feb. 1.43§	192.43	−38.7	.849	−0.1
Mar. 11.06	231.06	−38.7	.875	0.0
May 26.93*	307.93	−38.1	.926	+0.2
June 12.91*	324.91	−37.2	.937	+0.9
Nov. 5.21	470.21	−34.7	5.033	+0.1
1989 Jan. 18.17*	47544.17	−32.2	5.082	+0.6
Feb. 24.24¶	581.24	−32.5	.106	−0.7
Apr. 28.93	644.93	−30.0	.148	+0.4
May 26.91*	672.91	−29.8	.167	+0.2
June 19.92*	696.92	−28.4	.183	+1.2
July 3.92*	710.92	−28.7	.192	+0.7
1990 Jan. 31.09	47922.09	−28.7	5.331	+0.1
Feb. 12.31¶	934.31	−28.9	.339	0.0
Mar. 26.97*	976.97	−28.8	.368	+0.3
Apr. 30.88*	48011.88	−29.1	.391	+0.3

Table 6c. (*Continued*)

Date	MJD	Velocity km s^{-1}	Phase	(O – C) km s^{-1}
1990 May 26.94[*]	48037.94	−29.7	5.408	−0.1
Dec. 27.20[*]	252.20	−31.0	.549	+1.3
1991 Jan. 29.11	48285.11	−32.6	5.571	+0.1
Apr. 4.00[*]	350.00	−35.2	.614	−1.4
May 2.94[*]	378.94	−34.1	.633	+0.1
June 12.91[*]	419.91	−34.4	.660	+0.5
Dec. 19.18	609.18	−37.7	.785	+0.1
1992 Jan. 16.11	48637.11	−38.1	5.804	0.0
Apr. 23.91	735.91	−38.8	.869	−0.1
June 25.88	798.88	−38.7	.910	−0.2
Aug. 13.82	847.82	−37.7	.943	+0.3
Dec. 20.26	976.26	−34.8	6.028	+0.3
1993 Feb. 15.10	49033.10	−33.3	6.065	+0.1
Mar. 23.12	069.12	−31.9	.089	+0.6
July 7.92	175.92	−30.3	.160	−0.2
Dec. 29.20	350.20	−28.3	.275	+0.4
1994 Jan. 8.16	49360.16	−28.5	6.281	+0.2
Feb. 18.12	401.12	−28.9	.308	−0.2
May 3.01	475.01	−28.9	.357	+0.1
Aug. 2.85	566.85	−30.0	.418	−0.3
Dec. 14.21	700.21	−32.1	.506	−0.8
1995 Jan. 3.18	49720.18	−32.1	6.519	−0.5
June 2.96	870.96	−33.9	.619	0.0
Dec. 27.17	50078.17	−37.4	.756	−0.2
1996 Mar. 30.98	50172.98	−38.3	6.818	0.0
Nov. 21.27[‖]	408.27	−37.8	.974	−0.7
Dec. 15.26	432.26	−36.6	.989	0.0
1997 Mar. 29.07[‖]	50536.07	−33.6	7.058	+0.2
Apr. 17.94[‖]	555.94	−33.1	.071	+0.1
May 13.01[‖]	581.01	−32.9	.088	−0.4
July 20.90	649.90	−31.5	.133	−0.6
Dec. 25.18	807.18	−29.3	.237	−0.5
1998 May 2.90	50935.90	−28.7	7.322	+0.1
July 27.84	51021.84	−29.1	.379	+0.1
1999 Apr. 18.27[§]	51286.27	−32.4	7.554	−0.1
Dec. 20.26[‖]	532.26	−36.2	.716	+0.1

Table 6c. (*Continued*)

Date	MJD	Velocity km s^{-1}	Phase	(O – C) km s^{-1}
2000 Jan. 9.18‖	51552.18	−36.3	7.729	+0.3
Feb. 11.18‖	585.18	−37.1	.751	0.0
Mar. 25.00‖	628.00	−37.7	.779	0.0
Apr. 30.98‖	664.98	−38.4	.804	−0.3
May 30.91‖	694.91	−38.4	.824	0.0
June 19.95‖	714.95	−38.4	.837	+0.1

*Observed with original Cambridge spectrometer; weighted 1/4 in orbital solution.
†Observed at Haute-Provence by Chériguene (1971).
‡Observed with Palomar 200-inch telescope.
§Observed with DAO 48-inch telescope.
¶Observed with ESO *Coravel*.
‖Observed with Cambridge *Coravel*.
All others observed with OHP *Coravel*.

Table 6d. Radial-velocity observations of HD 110743.

Date	MJD	Velocity km s^{-1}	Phase	(O – C) km s^{-1}
1973 May 16.93	41818.93	−9.5	0.500	+0.5
1977 Apr. 30.98	43263.98	−4.8	2.258	−0.9
1978 May 23.29*	43651.29	−5.1	2.729	−0.7
1979 May 18.91	44011.91	−2.1	3.168	−1.7
1980 Jan. 2.16	44240.16	−9.8	3.446	−0.2
May 6.00	365.00	−8.3	.597	+0.5
1981 Mar. 1.13	44664.13	+2.5	3.961	−0.1
Apr. 27.99	721.99	+3.8	4.032	+1.1
May 31.95	755.95	−0.3	.073	−2.4
1982 Jan. 10.20	44979.20	−6.9	4.345	+0.3
Mar. 4.09	45032.09	−8.6	.409	+0.3
May 5.01	094.01	−10.1	.484	−0.2
1983 Feb. 3.56†	45368.56	−0.6	4.818	+0.3
23.07	388.07	+0.2	.842	+0.3
Mar. 7.09	400.09	−0.1	.857	−0.5
15.05	408.05	+1.6	.866	+0.9
Apr. 15.94	439.94	+2.8	.905	+1.1
May 9.94	463.94	+3.1	.934	+0.9
June 8.94	493.94	+3.0	.971	+0.3
Dec. 11.23	679.23	−1.8	5.196	−0.3
1984 Jan. 2.24	45701.24	−1.8	5.223	+0.7
Apr. 13.97	803.97	−9.3	.348	−2.0
27.94	817.94	−7.0	.365	+0.8
May 11.91	831.91	−8.6	.382	−0.3
20.13‡	840.13	−17.1	.392	−8.6
1985 Jan. 1.21	46066.21	−6.7	5.667	+0.1
24.16	089.16	−5.8	.695	0.0
Feb. 8.50†	104.50	−5.8	.713	−0.8
18.37†	114.37	−5.4	.725	−0.8
Mar. 15.04	139.04	−3.4	.755	0.0
May 31.93	216.93	0.0	.850	−0.2
1986 Jan. 25.17	46455.17	+0.2	6.140	−0.3
Feb. 27.11	488.11	−2.0	.180	−1.1
Mar. 7.08	496.08	−1.0	.190	+0.2
26.03	515.03	−3.4	.213	−1.3

Table 6d. (*Continued*)

Date	MJD	Velocity km s^{-1}	Phase	(O – C) km s^{-1}
1986 Apr. 10.08§	46530.08	−1.8	6.231	+1.0
May 5.95	555.95	−3.9	.263	+0.2
June 3.96	584.96	−4.8	.298	+0.7
Aug. 25.81§	667.81	−8.6	.399	+0.1
Dec. 12.24	776.24	−9.7	.531	+0.1
1987 Jan. 7.22	46802.22	−8.3	6.562	+1.2
31.16	826.16	−8.3	.591	+0.6
Feb. 21.10	847.10	−7.9	.617	+0.4
Mar. 3.09§	857.09	−7.9	.629	+0.1
20.02	874.02	−6.9	.650	+0.4
Apr. 27.93	912.93	−6.0	.697	−0.3
May 8.94	923.94	−4.9	.710	+0.3
Dec. 10.26	47139.26	+3.0	.972	+0.3
22.24	151.24	+2.2	.987	−0.6
1988 Jan. 23.49†	47183.49	+2.5	7.026	−0.2
Feb. 1.44†	192.44	+2.2	.037	−0.4
Mar. 11.08§	231.08	+2.3	.084	+0.4
Apr. 12.98	263.98	+0.8	.124	−0.1
May 29.95	310.95	−0.4	.181	+0.5
Nov. 5.21§	470.21	−8.4	.375	−0.3
1989 Feb. 11.15	47568.15	−10.3	7.494	−0.3
24.24¶	581.24	−10.4	.510	−0.5
Mar. 25.09§	610.09	−9.4	.545	+0.3
Apr. 28.95§	644.95	−9.1	.587	−0.1
May 26.94	672.94	−6.9	.621	+1.3
1990 Jan. 27.13§	47918.13	+1.8	7.920	−0.2
Feb. 12.33¶	934.33	+2.6	.939	+0.3
Mar. 27.01	977.01	+3.6	.991	+0.8
Apr. 30.92	48011.92	+2.7	8.034	+0.1
1991 Jan. 29.13§	48285.13	−8.2	8.366	−0.4
Feb. 6.14§	293.14	−8.6	.376	−0.5
1992 Jan. 16.12§	48637.12	−1.9	8.794	−0.1
Feb. 28.41†	680.41	+0.1	.847	0.0
Apr. 22.02§	734.02	+1.1	.912	−0.7
June 25.89§	798.89	+3.4	.991	+0.6
Dec. 20.25§	976.25	−2.3	9.207	−0.4
1993 Feb. 15.11§	49033.11	−4.3	9.276	+0.3

Table 6d. (*Continued*)

Date	MJD	Velocity km s^{-1}	Phase	(O – C) km s^{-1}
1993 Mar. 24.99§	49070.99	−6.5	9.322	−0.1
July 8.90§	176.90	−9.6	.451	+0.1
Dec. 27.19§	348.19	−7.0	.659	0.0
1994 Feb. 18.13§	49401.13	−4.5	9.724	+0.1
May 3.05§	475.05	−1.1	.814	0.0
Aug. 3.85§	567.85	+2.0	.927	−0.1
Dec. 14.22§	700.22	+1.0	10.088	−0.8
1995 Jan. 5.17§	49722.17	+1.6	10.114	+0.4
June 2.97§	870.97	−5.5	.295	−0.1
1996 Mar. 30.99§	50172.99	−5.6	10.663	+1.3
1997 Mar. 31.96‖	50538.96	+1.9	11.108	+0.5
Apr. 17.98‖	555.98	+1.1	.129	+0.3
May 13.02‖	581.02	−0.5	.159	−0.4
July 19.91§	648.91	−2.9	.242	+0.4
1998 July 8.87§	51002.87	−6.9	11.672	−0.3
1999 July 12.26†	51371.26	+1.5	12.120	+0.5
Dec. 29.21‖	541.21	−6.6	.327	0.0
2000 Mar. 4.10‖	51607.10	−8.5	12.407	+0.4
Apr. 7.01‖	641.01	−9.6	.448	0.0
May 29.94‖	693.94	−10.2	.513	−0.3
June 19.96‖	714.96	−9.7	.538	+0.1

*Observed with Palomar 200-inch telescope.
†Observed with DAO 48-inch telescope.
‡Observed at KPNO by Yoss, Neese & Hartkopf (1987); not used in orbital solution.
§Observed with Haute-Provence *Coravel*.
¶Observed with ESO *Coravel*.
‖Observed with Cambridge *Coravel*.
All others observed with original Cambridge spectrometer; weighted 1/4 in orbital solution.

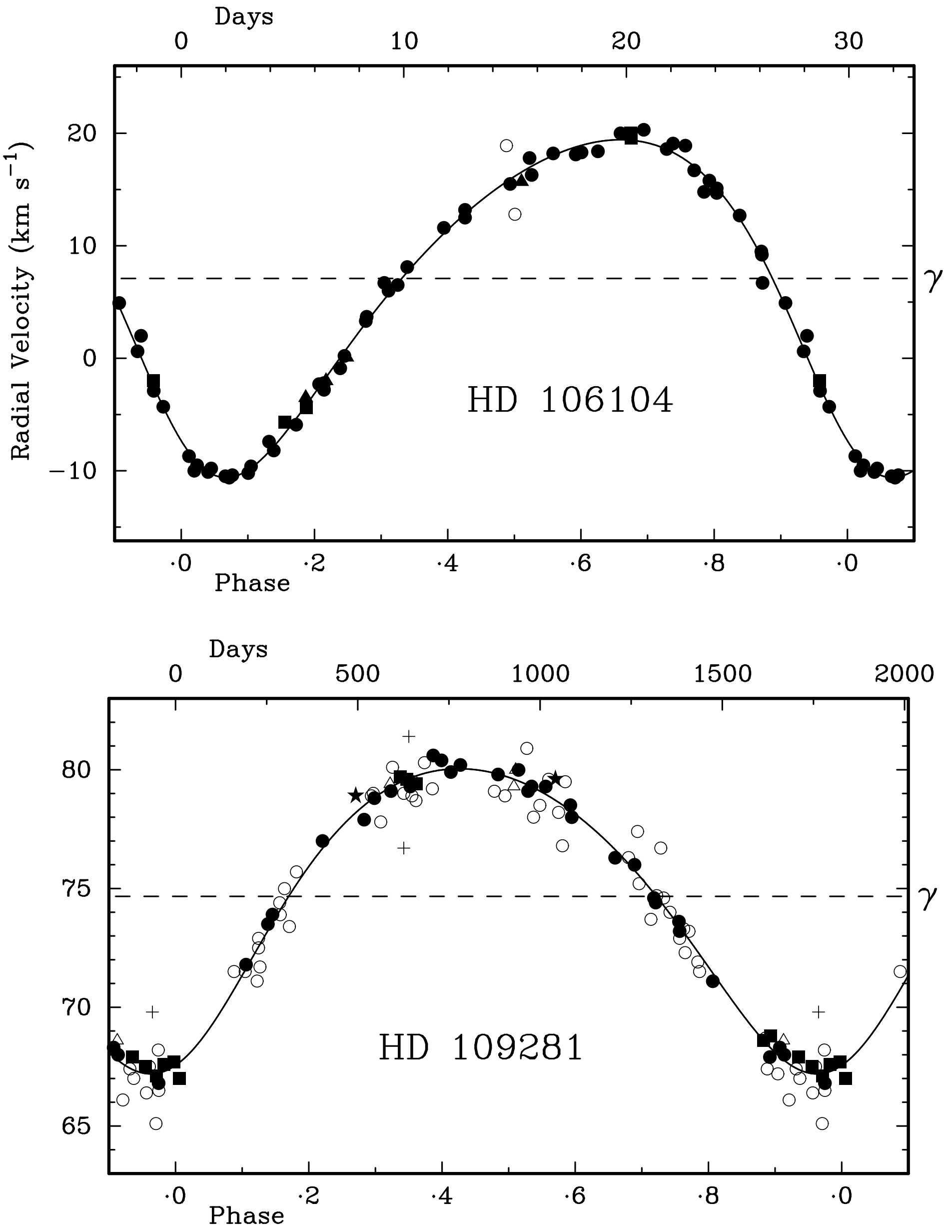
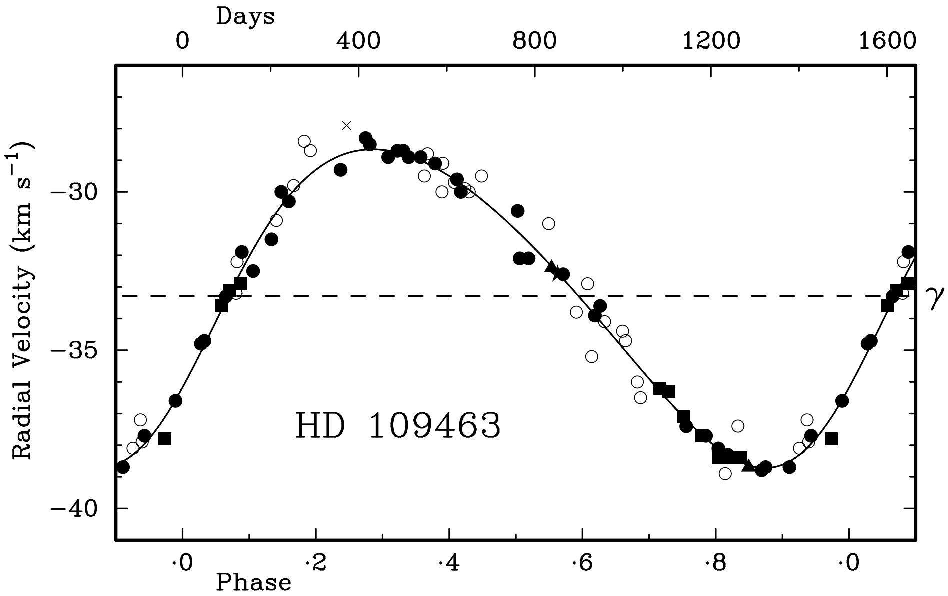


Figure 1. The observed radial velocities of the four stars plotted as functions of phase, with the velocity curves corresponding to the adopted orbital elements drawn through them. Filled circles represent measurements made with the Haute-Provence and ESO *Coravel*s, filled squares being used for the Cambridge one. Open circles refer to velocities obtained with the original Cambridge spectrometer; they were weighted $\frac{1}{4}$ in the orbital solutions, except in the case of HD 106104 where they were discarded altogether. Observations made at the Dominion Astrophysical Observatory are shown as filled triangles, those from Palomar as stars. Plusses and crosses represent the few measurements published by others, in cases where they fall within the confines of the diagrams; they are identified in Tables 6 and were not used in the solutions of the orbits.



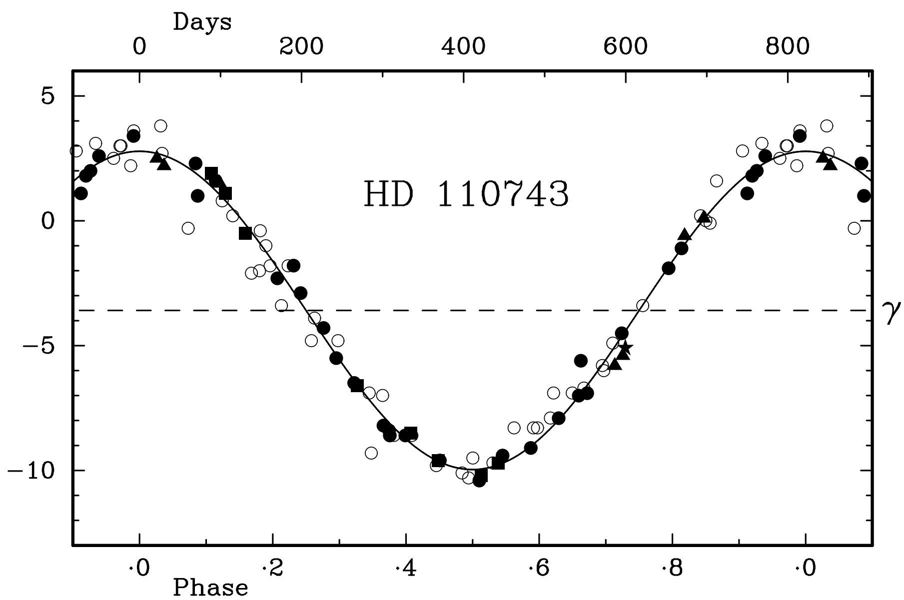


Figure 1. (*Continued*)

method was first developed, typically have (O – C) residuals about twice as large as those from the *Coravel* spectrometers, so they merit only $\frac{1}{4}$ of the weight. All the other instruments normally rate for unit weight, the same as the *Coravel*s. Some exceptions to the general rule have been made, as follows.

HD 106104. There are only two 'old Cambridge' measurements and they both give very bad residuals. The star is particularly faint and was difficult to measure with the

Table 7. Orbital elements for the four stars.

Element	HD 106104	HD 109281	HD 109463	HD 110743
P (days)	29.9335 ± 0.0013	1828 ± 3	1513.8 ± 2.4	822.1 ± 0.7
T (MJD)	48972.23 ± 0.19	48092 ± 22	48934 ± 19	47984.1 ± 1.7
γ (km s^{-1})	+7.10 ± 0.10	+74.67 ± 0.06	−33.29 ± 0.04	−3.59 ± 0.06
K (km s^{-1})	15.02 ± 0.13	6.42 ± 0.07	5.03 ± 0.07	6.37 ± 0.08
e	0.229 ± 0.008	0.173 ± 0.012	0.160 ± 0.010	0
ω (degrees)	141.4 ± 2.5	199 ± 4	240 ± 5	—
$a_1 \sin i$ (Gm)	6.02 ± 0.05	158.9 ± 1.9	103.4 ± 1.4	72.0 ± 0.9
$f(m)$ ($M_\odot$)	0.00970 ± 0.00026	0.0480 ± 0.0017	0.0193 ± 0.0008	0.0221 ± 0.0009

original instrument, which is why only two observations were made with it. They have been zero-weighted.

HD 109281. The scanning range of the Palomar spectrometer was fixed during any one series of measurements and could not be centred at will, star by star. HD 109281 has a high velocity which placed its 'dip' partly off the end of the two Palomar traces, impairing the accuracy of the resulting velocities, which have been given the same weight as the old Cambridge ones.

With those preliminaries settled, the orbits readily follow; they are plotted in Fig. 1 and their elements are set out in Table 7.

4. Discussion

4.1 *HD 106104*

At 30 days, the period of this star is by far the shortest of the four. *Coravel* traces show that HD 106104 is the only one of the four stars to have a significant rotational velocity — it is about 6 km s^{-1} . Since the spectral type is slightly earlier than that of the Sun and the orbital period is slightly longer than the Sun's period of rotation, synchronous rotation would necessitate an equatorial velocity almost identical with the solar one, *viz.* 2 km s^{-1} . The pseudo-synchronous velocity, that takes account of the eccentricity of the orbit, would be larger by about one-third (Hut 1981). Even so, and quite apart from the question of the unknown axial inclination, which would act to make the observed rotational velocity less than the true one, it is fairly certain that HD 106104 is spinning faster than synchronously with its orbital revolution.

The inclusion (purely out of curiosity) of the visual companion in the survey programme (Yoss & Griffin 1997), for which it did not meet the criteria for selection, provides an object lesson in serendipity. We have already seen, from Table 1, that the apparent magnitude of the companion is about $0^{\rm m}.9$ fainter than that of HD 106104 itself; the companion is also slightly redder, and its DDO 'pseudo-spectral' type is G3 V against the principal star's F9 V, so the two objects would very well pass for a physical pair. In fact the deduced distances of 164 and 182 pc are equal to well within their joint uncertainty, and are uncannily close to the distance implied by the *Hipparcos* parallax (Table 4). The radial velocity of the companion has been measured thirteen times, with the results given in Table 8.

There is no strong evidence for variability, and the mean velocity of $+6.9 \pm 0.3$ km s^{-1} differs by only -0.2 ± 0.3 km s^{-1} from that of HD 106104 and makes it extremely likely that the two stars really *are* physically associated with one another. The matter is clinched by the accurate proper motion derived for the companion, from *Tycho* (*Hipparcos* 1997) and preceding astrometric catalogues, in the *Tycho 2* catalogue described by Høg *et al.* (2000): in Table 9 it is compared with the proper motions derived both by *Hipparcos* and by *Tycho 2* for the principal star, and is seen to be sensibly identical.

At the distance of the pair, taken to be about 170 pc, the observed angular separation of 76 seconds of arc represents a projected (*i.e.* minimum) distance of about 13,000 AU or $\frac{1}{16}$ of a parsec. The system could be only loosely bound at such a separation, but bound it must be: if for the sake of illustration we suppose the relative orbit to be more or less circular and its diameter to be not much greater than the observed

Table 8. *Coravel* radial-velocity observations of HD 106104 B.

Date	Velocity km s^{-1}	Date	Velocity km s^{-1}
1990 Feb. 14.36*	+6.4	1994 Apr. 29.95	+9.3
1991 Jan. 28.11	+7.2	1995 Jan. 4.16	+7.0
Feb. 5.09	+6.0	June 2.95	+8.1
1992 Jan. 15.09	+6.7	1997 May 10.89	+7.4
Apr. 26.95	+6.1	1998 May 2.89	+6.5
Dec. 20.19	+6.4	2000 Apr. 6.96	+6.7
1993 Dec. 29.16	+5.2		

Observed at: *ESO † Cambridge All others: OHP

Table 9. Proper motions of HD 106104 and its companion.

		Arc-milliseconds/year α	δ
HD 106104	Hipparcos	−35.0 ± 2.0	+5.1 ± 0.9
	Tycho 2	−35.6 ± 1.3	+4.9 ± 1.3
HD 106104 B	Tycho 2	−33.9 ± 1.8	+7.5 ± 1.8

projected distance, the period is of the order of a million years and the relative orbital velocity about 0.3 km s^{-1}. If unbound, therefore, within at most a few million years — a time short compared with a revolution of the Galaxy — the system would disintegrate and not attract observers' attention (as it did ours) by the mutual proximity of its components. It would also seem to require a disturbance a great deal more localized than the general tidal field of the Galaxy to disrupt the system by giving the components differential accelerations sufficient to unbind them within a fraction of an orbital period.

4.2 *HD 109281*

The property that immediately catches attention concerning HD 109281 is its high γ-velocity of +74.7 km s^{-1} — fewer than a dozen of the 903 stars measured in the Galactic-Pole field proved to have velocities (taken without regard to sign) higher than that. Yet, according to the results derived from DDO photmetry, the high velocity is not accompanied by any diminution of metallic abundances in comparison with the Sun. The three radial velocities determined from Kottamia spectrograms by a Greenwich Observatory consortium under Woolley are excellent in their class and are consonant with the orbit derived from the photoelectric velocities, which have, however, only $\frac{1}{40}$ of the variance. The troublesome exactitude with which the orbital period equals an integral number of years was remarked upon in §2 above.

4.3 *HD 109463*

The V magnitude of $7^{\rm m}.81$ tabulated for HD 109463 by Hartkopf & Yoss (1982) in a paper that presents a great deal of photoelectric photometry would appear to constitute *prima facie* evidence for variability of that star; against that, the r.m.s. internal scatter in the *Hipparcos* magnitudes from the 87 individual transits is (at $0^{\rm m}.011$) the smallest for any of the four stars. Dr. Yoss has kindly informed me, however, that his magnitude was transcribed from the bibliographic catalogue of radial velocities by Abt & Biggs (1972) — a fact that cannot be divined from the published paper; it is my belief that Abt & Biggs copied that entry straight from the *Henry Draper Catalogue* (Cannon & Pickering 1920), which obtained it from visual photometry performed by Pickering (1890) in the spring of 1887. The unusual distance tabulated for HD 109463 (and the distances of all the other stars treated in the paper by Hartkopf & Yoss) arises from an error in the column headings and should be divided by a factor of a thousand.

The two radial velocities published by Chériguene (1971) do not agree with one another as well as might be expected of coudé velocities obtained at practically the same orbital phase; one of them falls well off the top of the plot in Fig. 1. The mean given by Heard (1956) for four (un-dated) velocities would also be above the top of the graph if the usual adjustment of $+0.8$ km s^{-1} were made in an effort to place them on the Cambridge scale. In a case in which eight radial velocities obtained with the same equipment (David Dunlap Cassegrain spectrograph, 66 Å mm^{-1} at Hγ) were known individually, however, it was found (Griffin 1980) that an offset of -5 km s^{-1} was needed to put them into systematic agreement with Cambridge measurements, and Heard himself was quoted there as having found in a substantial unpublished investigation of his own that his 66-Å mm^{-1} data needed such a correction. Such a change would place the mean of the four David Dunlap velocities at -31.1 km s^{-1}, which would be entirely reasonable. It may be inferred from the 'probable error' quoted for their mean that the individual values have an r.m.s. spread of 4.4 km s^{-1} around that value, but in the absence of information on the times of the observations it is not possible to tell how much the actual changes of HD 109463's velocity contributed to that spread.

4.4 *HD 110743*

HD 110743 is by far the nearest of the four stars treated in this paper; its proximity implies that the angular scale of its orbit as seen on the sky is much larger than in the cases of the other three objects. With the further circumstance, favourable from the point of view of the *Hipparcos* mission, that the orbital period is only a little shorter than the total duration of that mission, so the orbit is about as big as the satellite could have seen completely round a cycle, *Hipparcos* succeeded in discovering the duplicity of the star from the photocentric motion, from which was derived an orbital solution (*Hipparcos* 1997, **10**, p. DO2) entirely independent of the one given in the present paper. The astrometric orbit is in reasonable agreement with the radial-velocity one, as may be seen from the comparison given in Table 10; it is not nearly so precise, but it does provide values, which of course are not determinable spectroscopically, for the angular semi-axis major and the inclination.

The angular semi-axis of $0''.0221 \pm 0''.0016$ is practically identical with the parallax that was determined by *Hipparcos* at the same time, $0''.0229 \pm 0''.0016$, so the implied

Table 10. Comparison of orbital elements of HD 110743.

	Spectroscopic (This paper)	Astrometric (Hipparcos)
P (days)	822.1 $\pm$ 0.7	799 $\pm$ 15
T (MJD)	47984.1 $\pm$ 1.7	48039 $\pm$ 51
e	0	0.25 $\pm$ 0.13
ω (degrees)	(0)	49 $\pm$ 30
a (arcseconds)	—	0.0221 $\pm$ 0.0016
i (degrees)	—	49 $\pm$ 12
$a_1 \sin i$ (Gm)	72.0 $\pm$ 0.9	—

linear measurement of the semi-axis is just about 1 AU. That dimension refers to the orbit of the photocentre, and could of course be smaller to any degree than that of the orbit of the visible star around the centre of gravity, depending on the contribution of the secondary star to the total luminosity. Comparison with the value of $a_1 \sin i$ determined spectroscopically is therefore fraught with uncertainty: the spectroscopic value is less than the true separation by the factor $\sin i$, the 1-σ limits of whose value according to *Hipparcos* (cf. Table 10) is 0.60–0.87, leading to the expectation that $a_1 \sin i$ is within those limits in terms of astronomical units, or could be larger if the apparent size of the astrometric orbit is diminished because of significant light from the secondary star. In fact it is only 0.481 $\pm$ 0.006 AU; the discrepancy seems to suggest that (a) there is little scope for the secondary star to contribute any substantial luminosity to the system, and (b) *Hipparcos* must have significantly over-estimated i and/or a, or under-estimated π. Among those parameters the proportional uncertainty of the inclination i is several times worse than that of the others, so it would be natural to lay the principal error at its door.

A noteworthy feature of the orbit of HD 110743 is its circularity, despite a period 50 to 100 times longer than the maximum at which tidal effects are supposed to circularize the orbits of lower-main-sequence stars ($e.g.$ Mathieu *et al.* 1992). When the eccentricity is permitted as a free parameter in the orbital solution it takes the value 0.012, less than its own standard error, and in comparison with the result of the solution with the eccentricity fixed at zero the sum of the squares of the weighted residuals diminishes by barely 1% — far less than would constitute significance under Bassett's (1978) statistical tests. As a matter of general principle, therefore, since e is indistinguishable from zero and as a corollary ω is indeterminate, the exactly circular orbital solution is adopted. Astrophysically, however, the principle is hard to justify in this particular case: no mechanism of circularization can be proposed, so we are left to suppose that the HD 110743 system actually *formed* in a practically circular orbit. Even if the companion star has passed through its evolution as a giant — and to the best of the writer's knowledge no ultraviolet surveys have noticed evidence of a white dwarf in the system — it would have been unlikely to reduce the orbital eccentricity so very nearly (or quite) to zero: giant binaries are usually circularized up to periods only of the order of 200 days (Griffin 1990; Mermilliod & Mayor 1992), and even barium stars, which are all supposed to include a highly evolved component, normally show non-zero eccentricities (McClure & Woodsworth 1990).

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