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Spectroscopic Binaries near the North Galactic Pole Paper 17: HD 111425

R. F. Griffin *The Observatories, Madingley Road, Cambridge, England CB3 0HA*

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Abstract. Photoelectric radial-velocity measurements show that HD 111425 is a double-lined spectroscopic binary, whose components probably have types of about F8 V and G6 V and are in a 51-day orbit of moderate eccentricity.

Key words: radial velocities—spectroscopic binaries—orbits—stars, individual—HD 111425

1. Introduction

The previous two papers in this series (Griffin 1988) have described double-lined spectroscopic binaries with periods of 50-odd days. The present paper gives details of another such object, HD 111425; it is a ninth-magnitude system in the southern part of the constellation Canes Venatici, 3½° south-preceding α CVn.

Ljunggren (1965) has published the photoelectrically determined magnitudes V = 9.30, (B – V) = 0.58 for HD 111425 (under the aliases Malmquist (1936) 360 and BD + 35°2375). There is no other astrophysical information available for the system apart from the HD spectral type of G5 and the 'Uppsala types' dG5 (Malmquist 1960) and dGO (Ljunggren 1965), which were derived from measurements of low-dispersion objective-prism plates rather than by actual spectral classification.

2. Radial velocities and orbit

For the same reason as that given in Paper 16 (Griffin 1988) for HD 116093, HD 111425 was not observed for radial velocity until 1980. It gave only a shallow dip on the radial-velocity trace, so the discrepancy of 4 km s^{-1} noticed in 1982 when the second measurement was made was not considered to be necessarily very significant. However, in 1984 a third measurement showed a discrepancy of 70 km s^{-1}—very significant!—so the object was transferred to the binary programme and observed systematically. Intensive coverage in 1986 established the period as being nearly 51 days. A couple of observations made at Palomar in late 1986 confirmed a suspicion that the object is double-lined (see Fig. 1) and permitted good measurements of the secondary velocity near a node. Three other measures of the secondary have since been obtained with the radial-velocity spectrometer at the Dominion Astrophysical Observatory's 48-inch telescope, and one with 'Coravel'. Table 1 lists the 41 velocities that have been obtained of the primary and the six of the secondary.

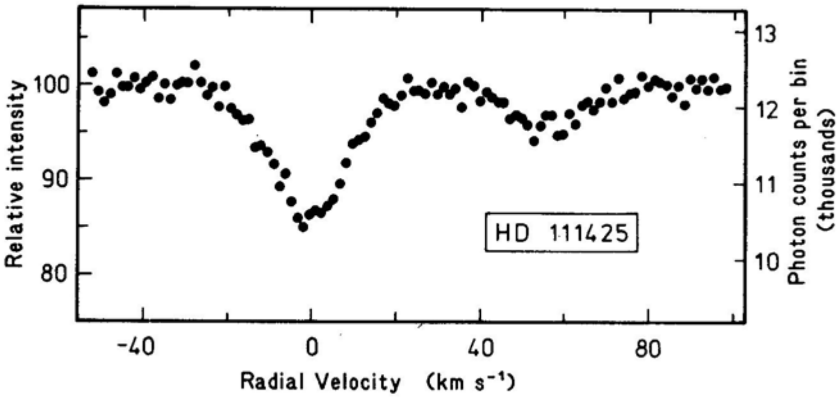

Figure 1. Palomar radial-velocity trace of HD 111425, obtained on 1986 November 23 and illustrating the double-lined nature of the object.

Table 1. Photoelectric radial-velocity measurements of HD 111425.

Date			MJD	Velocity km s^{-1}	Phase	$(O-C)$ km s^{-1}
1980	May	16.95	44375.95	−19.8	0.943	0.0
1982	Mar	8.12	45036.12	−23.9	13.953	−1.9
1984	Apr	28.94	45818.94	+46.3	29.380	+0.9
	May	12.95	832.95	+35.5	.657	+0.1
1985	Jan	24.19	46089.19	+29.2	34.706	−1.3
	Feb	17.46*	113.46	+31.2	35.185	−0.7
	May	31.95	216.95	+38.4	37.224	+1.1
1986	Jan	25.18	46455.18	−13.0	41.919	+0.5
	Feb	27.13	488.13	+41.5	42.568	+0.1
	Mar	6.12	495.12	+29.1	.706	−1.4
		26.04	515.04	+7.0	43.099	−3.5
	Apr	10.08†	530.08	+44.8	.395	−0.7
		10.89†	530.89	+45.1	.411	−0.4
	May	5.96	555.96	−7.7	.905	+1.7
		7.91	557.91	−18.8	.943	+1.1
		12.99	562.99	−9.0	44.044	+1.7
		15.93	565.93	+11.0	.102	−0.5
		18.90	568.90	+26.9	.160	−0.4
		25.90	575.90	+40.9	.298	−2.1
		26.91	576.91	+45.9	.318	+2.0
		27.90	577.90	+44.3	.337	−0.3
		28.97	578.97	+44.1	.358	−1.0
		30.91	580.91	+46.6	.397	+1.1
	June	3.92	584.92	+44.6	.476	−0.2
		10.94	591.94	+38.1	.614	−0.6
		14.91	595.91	+35.3	.692	+3.3
	Nov	23.56‡	757.56	−0.7	47.878	+1.0
		26.55‡	760.55	−18.8	.937	−0.5
1987	Jan	31.18	46826.18	+38.6	49.230	+0.7
	Feb	21.12	847.12	+37.4	.643	+0.9
		28.17†	854.17	+22.9	.782	+3.0

Table 1. Continued.

Date			MJD	Velocity km s^{-1}	Phase	$(O-C)$ km s^{-1}
	Mar	4.16†	858.16	+1.7	.861	−1.3
		20.04	874.04	+28.9	50.173	−1.0
		26.03	880.03	+43.3	.292	+0.6
	May	7.88	922.88	+21.9	51.136	+0.1
		8.95	923.95	+26.3	.157	−0.4
1988	Jan	23.52*	47183.52	+41.5	56.272	0.0
		30.55*	190.55	+45.8	.411	+0.3
	Feb	1.46*	192.46	+44.7	.449	−0.6
	Mar	14.97†	234.97	+42.7	57.286	+0.3
	Apr	12.99	263.99	+4.5	.858	+0.9
1986	Nov	23.56‡§	46757.56	+54.8	47.878	+0.6
		26.55‡§	760.55	+74.4	.937	−0.2
1988	Jan	23.52*§	47183.52	+0.6	56.272	−0.6
		30.55*§	190.55	−2.9	.411	+0.8
	Feb	1.46*§	192.46	−3.0	.449	+0.3
	Mar	14.97†§	234.97	−0.2	57.286	−0.3

* Observed with the Dominion Astrophysical Observatory 48-inch telescope (Fletcher *et al.* 1982).
† Observed with 'Coravel' at Haute-Provence (Baranne *et al.* 1979).
‡ Observed, in collaboration with Dr J. E. Gunn, with the 200-inch telescope (Griffin & Gunn 1974).
§ Observation of the secondary star.

The orbital solution is illustrated in Fig. 2. As is to be expected, the radial velocities measured when the dips given by the two components were blended together are perceptibly dragged towards the γ-velocity; all seven of the measures made when the primary was within 10 km s^{-1} of the γ-velocity have residuals of the expected sign, averaging 1.1 km s^{-1}. The seven measures have therefore been rejected from the solution. The Cambridge velocities have been considered to be only half as accurate as those made with integrating spectrometers, *i.e.* they have been weighted ¼. At first sight rather surprisingly, the observations of the secondary seem to be just as accurate as those of the primary, and have been given equal weight; but traces that were intended for measurements of the secondary were naturally given more integration than would have been considered necessary for the primary alone, and the accuracy of the secondary's velocities could be seen as a vindication of that policy. The final orbital elements are:

$P = 50.743 \pm 0.006$ days
$\gamma = +23.43 \pm 0.16$ km s^{-1}
$K_1 = 35.2 \pm 0.4$ km s^{-1}
$K_2 = 43.1 \pm 0.8$ km s^{-1}
$q = 1.226 \pm 0.016$ $(= m_1/m_2)$
$e = 0.387 \pm 0.009$
$\omega = 196.2 \pm 1.1$ degrees

$(T)_{49} = \text{MJD } 46814.49 \pm 0.12$
$a_1 \sin i = 22.6 \pm 0.3$ Gm
$a_2 \sin i = 27.7 \pm 0.5$ Gm
$f(m_1) = 0.180 \pm 0.007\ M_\odot$
$f(m_2) = 0.331 \pm 0.018\ M_\odot$
$m_1 \sin^3 i = 1.09 \pm 0.05\ M_\odot$
$m_2 \sin^3 i = 0.89 \pm 0.04\ M_\odot$

R.m.s. residual (weight 1) = 0.7 km s^{-1}

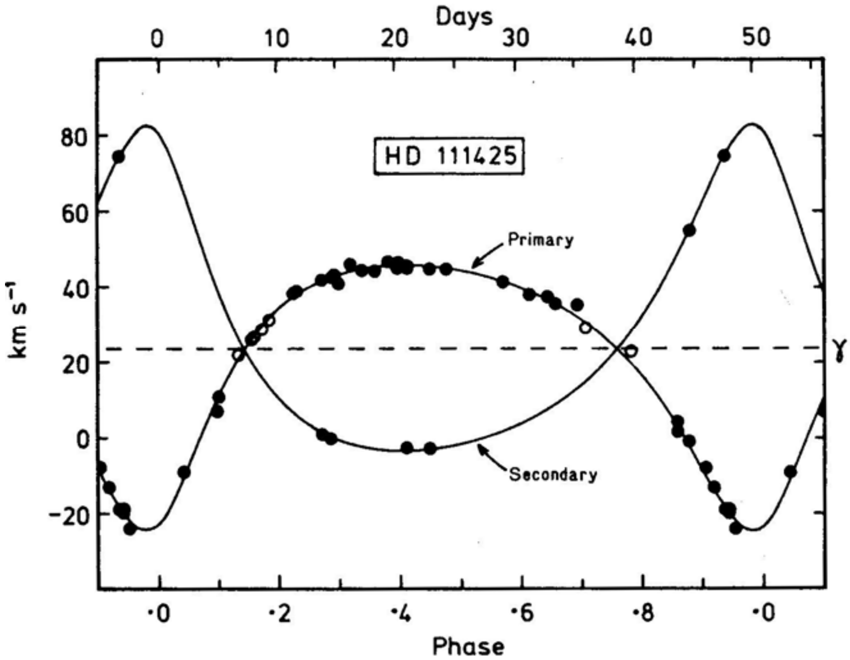

Figure 2. The computed radial-velocity curve of HD 111425, with the measured radial velocities plotted. Open symbols indicate data which may be affected by blending between the two components and were not used in the solution.

3. Discussion

We can establish a model of the binary system by using the mass ratio, *q*, and the ratio of the areas of the primary and secondary dips in Fig. 1 (it is 1:0.31) to guide our choice of the difference between the components' spectral types, while the type of the primary is virtually fixed by the measured *(B – V)* colour of the system. The existence of two unbroadened dips *(v* sin *i* ~ 0) in the radial-velocity trace, together with the assignment of a dwarf type by Malmquist (1960) and Ljunggren (1965), practically guarantees that we are dealing with a pair of main-sequence stars. The tabular data invoked in the following discussion are all taken from Allen (1973), by interpolation in the tables where necessary.

The primary's spectral type must be close to F8: such a star, in combination with a secondary anywhere in the mid- to late-G range, gives an integrated *(B – V)* colour close to the observed colour of HD 111425. A spectral type of G5 for the secondary matches the mass ratio (*q* = 1.23) closely, but the ratio expected for the dip areas on radial-velocity traces from that combination of types is 1:0.41 whereas the observed ratio (Fig. 1) is 1:0.31. To obtain the observed relationship between the dip areas requires a secondary of type G7; the mass ratio ought then to be 1.35. The discrepancy between the two criteria is perhaps not too great in relation to their overall accuracy to prevent a compromise of type G6 from satisfying both of them tolerably well; the properties of the F8 + G6 model are set out in Table 2.

Table 2. Model for HD 111425.

Spectral Type	Absolute Mag. V m	B m	Colour $(B-V)$ m	Mass $M_\odot$	Mass Ratio q
Model F8 V	4.0	4.52	0.52	1.17	1.30
Model G6 V	5.26	6.00	0.74	0.90	
Model F8 V + G6 V	3.70	4.27	0.57	2.07	
HD 111425 (observed)			0.58	> 1.98	1.23

The minimum masses required by the orbit are nearly the same as the tabular masses in the model, showing that sin i ~ 1 and suggesting the possibility of eclipses. The conjunction that is more favourable to an eclipse (being nearer to periastron) is the one at phase .098, at which the eclipse, if any, would be of the secondary star. The times of conjunction are predicted by the orbit to an accuracy of about six hours; an eclipse could last up to about eight hours if central. Potential eclipse dates include 1990 February 13.8, April 5.6, December 15.3, and 1991 February 4.0, March 26.8, May 16.5.

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Bulletin on ED 116093 (*Paper* 16). In the previous paper in this series (Griffin 1988) I adduced, some very oblique evidence that HD 116093 exhibited eclipses. The paper included some dates of possible eclipses, one of which was 1989 March 19.61. I alerted the Japanese photometrist Mr. O. Ohshima (who lives in an appropriate longitude) to that prediction; he and Mr. Y. Ito kindly made the necessary observations and did in fact see an eclipse (Ohshima & Ito 1989).

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