

# THE ORBITS OF THE SPECTROSCOPIC BINARIES 52 PERSEI AND 35 CYGNI\*

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## ABSTRACT

The orbits of the two single-line supergiant spectroscopic binaries 52 Persei and 35 Cygni have been determined from radial-velocity observations with the Mills spectrograph.

### I. 52 PERSEI

$$\begin{aligned} \alpha &= 4^{\text{h}}08^{\text{m}}1 & \delta &= +40^{\circ}14' \text{ (1900)} \\ &= 4^{\text{h}}11^{\text{m}}5, & &= +40^{\circ}22' \text{ (1950)}. \end{aligned}$$

The spectrum of 52 Persei was described as composite (G0 + A5) in the *Henry Draper Catalogue*, and Slettebak (1955) has classified the components as approximately G5 Ib and A2 on the MK system. Bidelman (1951) has assigned types of G5 II and "A or B." The measurable features in the  $\lambda$  4500 region, for which the Mills spectrograph is adjusted, are all due to the later-type star. Six Mills spectrograms taken between 1907 and 1918 revealed a velocity change of +17 to -16 km/sec (Campbell 1918), while a Yerkes observation in 1933 suggested to Hynek (1938) that the period might be very long. Thirty more Lick three-prism spectrograms obtained in 1921 and in 1942-1955 show clearly, however, that the period is about 4 years.

All the Lick spectrograms of 52 Persei have been measured anew in a Hartmann spectrocomparator by the author, against a standard plate of  $\gamma$  Cygni (type F8 Ib). Three spectrograms of  $\alpha$  Aquarii (G2 Ib), four of  $\alpha$  Leporis (F0 Ib), four of  $\beta$  Aquarii (G0 Ib), and six of  $\alpha$  Persei (F5 Ib) were also measured against the same standard plate. These results indicated that velocities determined by the author with the aid of this particular standard spectrogram require a correction of +1.6 km/sec to reduce them to the Lick system values given in *Lick Publications*, Vol. 18 (Moore 1932) or in Wilson's *General Catalogue of Stellar Radial Velocities*. This correction has been applied to the velocities of the G-type component of 52 Persei given in Table 1.

A preliminary set of orbital elements was adjusted by least squares; Table 2 shows the set of corrected values obtained, together with their probable errors. The probable error of an observation of unit weight is  $\pm 0.63$  km/sec. The results are plotted in Figure 1, and the data are tabulated in Table 1. The weights given in Table 1 have been assigned on the basis of plate quality. The phases are referred to  $T$ .

If the radius of the later-type component of 52 Persei is about 150 times the solar radius, there is some possibility that an eclipse of the A-type star can be observed at conjunction, which occurs at phase 1001 days. The next such conjunction will take place on July 1, 1958. It would be important to observe 52 Persei photometrically at that time.

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TABLE 1  
RADIAL-VELOCITY OBSERVATIONS OF THE G-TYPE COMPONENT OF 52 PERSEI

Plate No	JD (Geocentric) 2400000+	Phase (Days)	Observed Velocity (km/sec)	Weight	Residual, O-C (km/sec)
4981	17857 021	1388 2	+16 6	1.0	+1 3
5064	17906 900	1438 1	+15 9	0 4	-0 6
5076	17911 758	1443 0	+16 6	1 0	+0 1
5088	17943 795	1475 0	+15 1	1 0	-1 0
9130	21269 741	71 7	- 7 0	1 0	-0 1
9715	21632 685	434 6	-16 4	1.0	+1 5
11953	22960 906	186 4	-15 9	1 0	+1 9
28269	30645 990	1565 7	+ 6 8	1 0	-0.5
28336	30663 944	7.2	+ 5.7	1.0	+1 4
29042	30997 916	341 2	-19 6	1 0	-0 2
29108	31022 042	365 3	-19 1	1 0	0 0
29176	31042 926	386 2	-19 3	1 0	-0 5
30746	31725 023	1068 3	+ 1 3	1 0	+0 3
31473	32194 816	1538 1	+11.6	1 0	+0 2
33134	33167 985	934 9	- 4 5	1 0	-0 5
33236	33224 936	991 8	- 1 8	1 0	+0 1
33265	33262 908	1029 8	- 0 4	1 0	0 0
33324	33374 663	1141 5	+ 5 5	1 0	+1.4
33694	33513 960	1280 9	+10 2	1 0	-1 3
33906	33573 998	1340 9	+13.2	1 0	-0 2
34031	33637 874	1404 7	+15 8	1 0	0 0
34589	33865 989	56 4	- 5 0	1 0	+0 4
34722	33917 021	107 4	-14 2	1 0	-2 4
34799	33950 958	141 4	-14 6	1 0	+0.5
34818	33978.902	169 3	-17 1	1 0	-0 1
34884	34051 776	242 2	-20 3	1 0	-1 0
36471	34454 750	645 1	-12 0	0.4	+0 9
36491	34463 729	654 1	-13 4	1 0	-1 0
36926	34594 986	785 4	- 9 5	0 8	-0 7
36963	34603 000	793 4	- 9 7	1 0	-1 1
37259	34681 031	871 4	- 6 3	1 0	-0 2
37316	34714 842	905 2	- 5 0	0 7	0 0
37357	34728 753	919 2	- 4 3	0 8	+0 2
37376	34740 782	931 2	- 3 4	0 3	+0 7
38183	35059 948	1250.4	+ 8.7	1 0	-0.4
39227	35441 841	55.8	- 4 3	1 0	0.0

TABLE 2

## ORBITAL ELEMENTS OF 52 PERSEI

$$P = 1576.44 \pm 0.50 \text{ days,}$$

$$\omega = 66^\circ.7 \pm 1^\circ.3,$$

$$K = 18.08 \pm 0.17 \text{ km/sec,}$$

$$T = \text{JD } 2425927.40 \pm 4^{\text{d}}1,$$

$$\gamma = -4.5 \text{ km/sec,}$$

$$a \sin i = 358 \times 10^6 \text{ km,}$$

$$e = 0.407 \pm 0.008,$$

$$f(m) = 0.737 m_\odot.$$

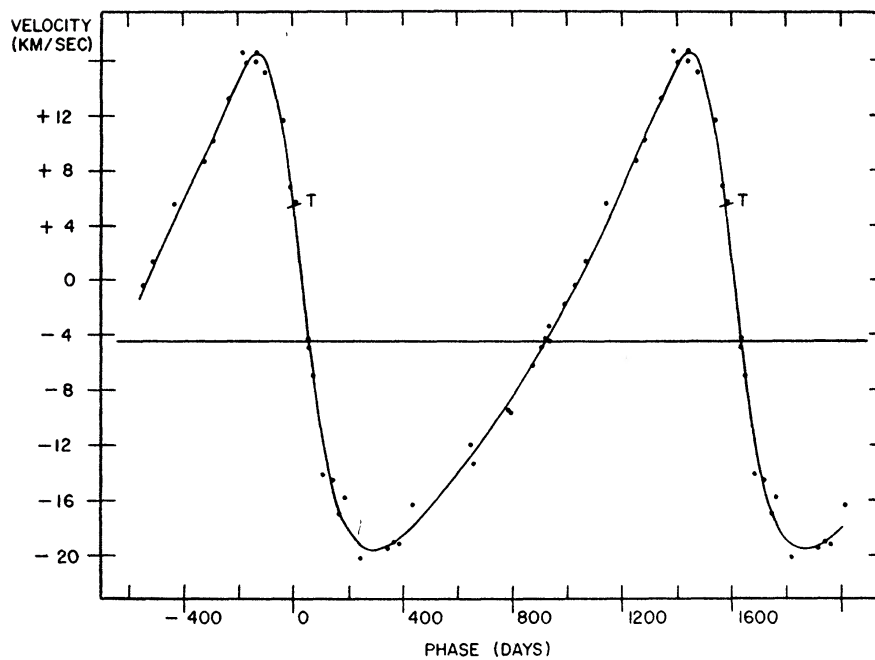


FIG. 1.—The radial-velocity-curve of 52 Persei; the curve corresponds to the elements of Table 2

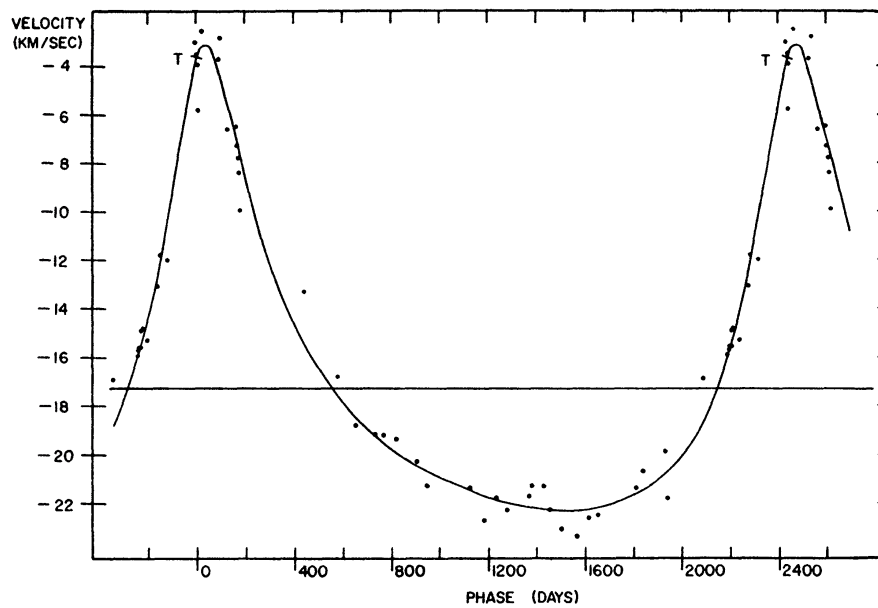


FIG. 2.—The radial-velocity-curve of 35 Cygni; the curve corresponds to the elements of Table 4

TABLE 3  
RADIAL-VELOCITY OBSERVATIONS OF 35 CYGNI

Plate No	JD (Geocentric) 2400000+	Phase (Days)	Observed Velocity (km/sec)	Weight	Residual, O - C (km/sec)
9382	21446 964	1378 2	-21 3	1 0	+0 8
10735	22157 806	2089 0	-16 9	1 0	+1 9
11386*	22514 963	6 2	- 5.8	1 0	-2 0
11920	22947 751	439 0	-13 3	1 0	+2 1
14962	24699 958	2191 2	-15 9	1 0	0 0
14972	24704 807	2196 0	-15 7	1 0	+0 3
14981	24708 938	2200 1	-15 6	0 8	+0 2
14993	24710 965	2202 2	-15 6	0.5	+0 2
14997	24715 949	2207 1	-14 9	1 0	+0 7
15008	24719 958	2211 2	-14 8	1 0	+0 6
15604	25119 881	171 1	- 8 4	1 0	-1 0
25917	29198 703	1809 9	-21 4	1 0	+0 3
27227	29917 672	88 9	- 3 7	1.0	+0 4
28134	30559 941	731 1	-19 2	1 0	0 0
28184	30597 889	769 1	-19 2	1.0	+0 4
28272	30648 704	819 9	-19 4	1 0	+0 5
28951	30952 879	1124 1	-21 4	1 0	+0 1
29660	31280 973	1452 2	-22 3	1 0	-0 1
30608	31656 965	1828 0	-21 3	1 0	+0 8
31408	32113 703	2284 9	-11 8	1 0	+0 2
31948	32432 818	164 0	- 7 3	1.0	-0 4
33136	33171 742	902 9	-20 3	1 0	+0 2
33209	33215 681	946 9	-21 3	1 0	-0 6
33429	33451 902	1183 1	-22 7	1 0	-1 0
33606	33498 996	1230 2	-21.8	1 0	+0 1
33795	33546 727	1277 9	-22 3	1 0	-0 3
34025	33637 574	1368 8	-21 7	1 0	+0 4
34305	33776 990	1508 2	-23 1	1 0	-0 8
34513	33836 917	1568 1	-23 4	1 0	-1 1
34609	33882 781	1614 0	-22 6	1 0	-0 4
34778	33929 710	1660 9	-22 5	1 0	-0 3
34991	34107 992	1839 2	-20 7	0 4	+0.8
35276	34198 978	1930 2	-19 9	0 2	+1 0
35300	34206 969	1938 2	-21 8	1 0	-1 2
36614	34502 924	2234 1	-15 3	1 0	-0 9
36739	34544 986	2276 2	-13 1	1 0	-0 6
36891	34584 892	2316 1	-12 0	0 7	-1 7
37285	34700 740	2431 9	- 3 0	0 4	+0 8
37291	34706 632	2437 8	- 3 5	1.0	+0.1
37306	34710 594	1 8	- 3 9	1 0	-0 4
37355	34728 620	19 8	- 2 5	0 6	+0 7
37517	34806 033	97 2	- 2 8	1 0	+1 6
37617	34835 996	127 2	- 6 6	1 0	-1 0
37630	34867 966	159 2	- 6 5	1 0	+0 4
37646	34876 840	168 0	- 7 8	1 0	-0 5
37694	34882 952	174 2	- 9 9	1.0	-2 4
38578	35293 838	585 0	-16 8	1.0	+0 9
38931	35359 793	651 0	-18 8	1.0	-0 4

\* Plate No 11386 was not included in the least-squares solution

## II. 35 CYGNI

$$\begin{aligned} \alpha &= 20^{\text{h}}14^{\text{m}}8 & \delta &= +34^{\circ}40' \text{ (1900)} \\ &= 20^{\text{h}}16^{\text{m}}7, & &= +34^{\circ}50' \text{ (1950)}. \end{aligned}$$

35 Cygni is a supergiant of type F5 Ib in the MK system. The velocity variation was announced by Campbell (1922); no second spectrum has been reported. Although the radial velocity has been observed at several other observatories as well (Bonn, four spectrograms in 1908–1911 [Küstner 1914]; Mount Wilson, three spectrograms in 1913 [Adams 1915]; Victoria, ten spectrograms in 1923–1924 [Harper 1934]), only forty-three Lick velocities, obtained in the years 1917–1955 with the Mills spectrograph and a dispersion of 11 Å/mm, have been used to determine the present orbital elements of 35 Cygni. The Bonn and Victoria velocities are of relatively lower weight, since they were determined with the moderate dispersion of about 30 Å/mm, but the Mount Wilson values were obtained at 16 Å/mm and have furnished an important check on the present results. I am indebted to Miss Louise Lowen, of the Mount Wilson and Palomar Observatories, for furnishing the unpublished details of the Mount Wilson observations.

As in the case of 52 Persei, the spectrograms of 35 Cygni were measured in a spectro-comparator against a standard plate of  $\gamma$  Cygni; a correction of +1.6 km/sec has been applied to reduce the results to the Lick system. The “observed velocities” of Table 3 contain this correction. The elements and their probable errors given in Table 4 result

TABLE 4

## ORBITAL ELEMENTS OF 35 CYGNI

$$\begin{aligned} P &= 2440.0 \pm 1.0 \text{ days}, & \omega &= 342^{\circ}7 \pm 6^{\circ}3, \\ K &= 9.57 \pm 0.20 \text{ km/sec}, & T &= \text{JD } 2427388.8 \pm 12^{\text{d}}8, \\ \gamma &= -17.3 \text{ km/sec}, & a \sin i &= 277 \times 10^6 \text{ km}, \\ e &= 0.506 \pm 0.013, & f(m) &= 0.142 m_{\odot}. \end{aligned}$$

from a least-squares adjustment of preliminary elements. The probable error of a plate of unit weight is  $\pm 0.72$  km/sec. There seems to be a slight tendency for the earlier observations to have positive, rather than negative, residuals. This tendency is most pronounced for the Mount Wilson velocities, which were obtained before the Lick series began. If the Mount Wilson observations were included in the least-squares solution, somewhat different orbital elements would have been obtained. The effect may be interpreted as a gradual change of the orbital elements, but the present observational material is not sufficient to test this possibility.

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