A new determination of the orbit of the Hyades double-lined spectroscopic binary HD 27149 is presented. The well-defined orbit provides the spectroscopic basis for an extremely accurate orbital parallax for the system — in particular, the size of the relative orbit \( (a \sin i = (a_1 + a_2) \sin i = (67.075 \pm 0.045) \times 10^6 \text{ km}) \) is accurate to \( \pm 0.07\% \). The minimum masses for the primary and secondary — \( m_1 \sin^3 i = 1.096 \pm 0.002 \, M_\odot \) and \( m_2 \sin^3 i = 1.010 \pm 0.002 \, M_\odot \) — are unexpectedly large for the spectral types thus suggesting the possibility of eclipses. Although the probability of eclipses is not large, the system being composed of G3V and G6V stars in a 75-day orbit, the possibility is of great interest. A rediscussion of a search for eclipses made by Jørgensen & Olsen\(^1\) in 1972 shows that central eclipses can be excluded, but that shorter duration off-centre eclipses cannot be ruled out. Ephemerides for possible primary and secondary eclipses are given.

**Introduction**

These papers report the determination of new orbits for double-lined spectroscopic binaries in the Hyades cluster. When complemented by visual orbits determined by means of optical interferometry, which may soon start becoming available, the results will provide accurate distances, by means of orbital parallax, for these systems and, thus, the Hyades cluster. In this paper we examine HD 27149.
Basic data for HD 27149, which has a Hyades cluster designation vB 23, are as follows: \( \alpha (2000) = 4^h 18^m 01.8^s \), \( \delta (2000) = +18^\circ 15' 24'' \); spectral type G5 (from HD catalogue); \( V = 7.53, B - V = 0.68 \). An earlier spectral type of dG3 is given by Wilson\(^2\) in the *General Catalogue of Stellar Radial Velocities*. The secondary is not much fainter than the primary and, at the low or medium dispersions generally used for spectral typing, the two spectra are always blended so the spectral type is much more uncertain than that of a single star and is not the spectral type of the primary, but is intermediate between those of the primary and secondary. Batten & Wallerstein\(^3\) have used the \( B - V \) and \( U - B \) colours and the magnitude difference between the primary and secondary to indirectly estimate individual spectral types of G4V and G8V. More recently Barrado y Navascués & Stauffer\(^4\) have used the same method to estimate individual spectral types of G3V and G6V. As Hyades cluster members go, the system is quite bright and may well be within the reach of the newest optical interferometers, such as the CHARA telescope now in operation at Mt Wilson. In the infrared it will almost certainly be accessible to these telescopes — Patience et al.\(^5\) use its \( B \) and \( B - V \) to estimate \( K = 5.88 \).

The cluster membership of HD 27149 is not in doubt — van Bueren\(^6\) identified it as a member in his early major investigation of the cluster; more recently Griffin et al.\(^7\), in their comprehensive radial-velocity survey of the cluster, identified it as a member in their list of spectroscopic binaries awaiting orbit determinations; Perryman et al.\(^8\) likewise recognise it as a member in their recent study of the cluster based on parallaxes and proper motions measured with the *Hipparcos* satellite; and Madsen et al.\(^9\), who also used the *Hipparcos* data but with more stringent selection criteria for membership than Perryman et al., include it in their very recent list of members. We now briefly review the history of HD 27149 as a spectroscopic binary.

Wilson\(^10\) discovered the spectroscopic-binary nature of HD 27149 during a survey, mostly carried out between 1942 and 1946, of the radial velocities of 204 known and candidate Hyades cluster members, one of which was HD 27149. In the main table of his paper Wilson gave a mean radial velocity for HD 27149 of \( +44.0 \text{ km s}^{-1} \) and classified
it as a cluster member. The four individual velocities, given in the footnotes to the table, are all different and span a range of 21 km s$^{-1}$. (The dates of the observations are not given, but can be found in the later useful compilation of Abt$^{11}$. ) The dispersions of Wilson’s spectra — three of 80 and one of 36 Å/mm — were such that the primary and secondary spectra of HD 27149 would have been blended so these velocities must have been intermediate between those of the primary and secondary and weighted towards the primary. Wilson clearly identified HD 27149 as a spectroscopic binary — he stated in the text of his paper “[t]he probable spectroscopic binaries number 23” and HD 27149 is one of 23 stars in the footnotes to his main table for which he either gives individual velocities or says two spectra are visible. Woolley et al.$^{12}$ first detected the secondary spectrum. Their four discovery spectra were observed on the 2.5-m telescope at Mt Wilson in October and November 1959 with a dispersion of 10 Å/mm. An analysis of these spectra by Lambert et al.$^{13}$ provided the first estimate of the magnitude difference between the primary and secondary — $\Delta m = 0.69$ in B. In 1973 Batten & Wallerstein$^{3}$ published the first determination of the orbit. Their analysis, which was based on radial velocities from spectra observed with the 5-m at Palomar, the 2.5-m at Mt Wilson and the 1.8-m and 1.2-m telescopes at the Dominion Astrophysical Observatory, revealed an orbital period of 75 days, moderate eccentricity ($e = 0.23$), a mass ratio $m_1/m_2 = 1.14$ and minimum masses ($m_1 \sin^3 i = 1.04 M_\odot$ and $m_2 \sin^3 i = 0.91 M_\odot$) sufficiently close to the masses demanded by the spectral types to show that the inclination of the plane of the orbit must be close to 90°. Most recently, in 1982, McClure$^{14}$ reported five new observations with the radial velocity spectrometer on the 1.2-m telescope at the Dominion Astrophysical Observatory, which he used to improve the Batten & Wallerstein orbit. And there matters have rested with respect to our knowledge of the radial velocities and orbit of HD 27149.

Two recent surveys of multiplicity among Hyades members — one by Mason et al.$^{15}$ made in 1991 with the KPNO 4-m Mayall telescope and optical speckle imaging and one by Patience et al.$^5$ carried out between 1993 and 1996 with the 5-m telescope at
Palomar and speckle imaging at 2.2 $\mu$m — both scrutinised HD 27149 and found no sign of a visual companion. The system, thus, consists solely of the spectroscopic binary pair so far as we know.

This paper reports a new determination of the orbit of HD 27149 based on new high-resolution spectra from McDonald Observatory.

**Observations and radial velocities**

The observations were made on the 2.7-m and 2.1-m telescopes at McDonald Observatory between 1995 and 2002. As shown in Table I, the first 33 observations were made with the 2.7-m telescope and the last 17 were made with the 2.1-m. The instrumentation and observing procedure were the same as those used for the Hyades binary examined in the first paper in this series\(^1^\) and have been described there. Here it is enough to recall that the observations on the 2.7-m telescope used the 2dcoudé echelle spectrometer\(^2\), have a resolving power of 60 000 and nearly complete wavelength coverage from $\sim 4000$ – $\sim 9000$ Å, while those on the 2.1-m telescope used the Sandiford Cassegrain echelle spectrograph\(^3\), also have a resolving power of 60 000 and complete wavelength coverage from $\sim 5600$ – $\sim 7000$ Å.

The data were processed and wavelength-calibrated in a conventional manner with the IRAF package of programs. The spectra are double-lined with primary and secondary lines of similar strength and, at most orbital phases, the secondary lines are well separated from their primary counterparts. Fig. 1 shows an example in which we see primary and secondary Ni\(\text{I}\) and Fe\(\text{I}\) lines near 6400 Å.

The procedure used to measure the radial velocities was the same as in Paper 1 of this series and has been described there. To summarise: the wavelengths of well-defined primary and secondary lines were measured by fitting Gaussian profiles with the IRAF \textit{splot} routine, the wavelength differences between the measured and rest wavelengths of the lines provided the topocentric radial velocities, telluric O\(_2\) lines were measured in the same way so as to determine the wavelength offset between the stellar spectrum and
its associated Th–Ar comparison spectrum, the stellar topocentric velocities were then corrected by subtracting from them the telluric line offsets in velocity form and, finally, the heliocentric correction led to the heliocentric radial velocities. The velocities are, thus, absolute velocities.

In Paper 1 a tiny additional adjustment of the stellar velocities was made in order to force the averages for similarly measured velocities from observations of the radial-velocity standard $\epsilon$ Tau (G9.5III, itself a member of the Hyades) on the 2.7-m and 2.1-m telescopes to be the same as the average of all the velocities from both telescopes; the corrections were a decrease of 70 m s$^{-1}$ for the 2.7-m data and an increase of 140 m s$^{-1}$ for the 2.1-m. In view of the growing realisation that K giants are subject to intrinsic low amplitude radial-velocity variations of $\sim 50 - 400$ m s$^{-1}$ over a large range of timescales — see, for example, Hatzes et al.$^{19}$ — it is evident $\epsilon$ Tau might be subject to similar radial-velocity variations so the small difference between the velocities from the two telescopes might be real. There is thus no compelling reason for making an adjustment and so it was decided not to do so — the measured velocities from the 2.7-m and 2.1-m telescopes are used as they stand. Table I gives the UT dates, heliocentric Julian dates and heliocentric radial velocities for the McDonald observations. We now turn to the determination of the primary-secondary orbit.

The orbit

The method of differential corrections was used to determine the primary-secondary orbit from the primary and secondary velocities. A necessary preliminary to the orbit calculation was the assignment of suitable weights for the various velocities — namely velocities for observations with blended primary and secondary spectra, velocities from the 2.7-m telescope versus those from the 2.1-m and primary versus secondary velocities.

Observations with blended primary and secondary spectra: In a few observations the small wavelength separation between the primary and secondary spectra meant the primary lines and their secondary counterparts were blended, to a greater or lesser
degree. For these observations the *deblend* option in *splot* had been used to fit double Gaussian profiles to the pairs of blended primary and secondary lines and successfully measure separate primary and secondary velocities. For three observations, however, the primary-secondary wavelength separations were so small and the blending so severe that it proved best to give zero weight to the velocities from these observations. In one of these cases the observation was so close to a single-lined phase that only a single velocity representative of the blended primary and secondary spectra could be measured (see Table I and Fig. 2). In the other two observations (see Table I) the use of *deblend* had provided separate primary and secondary velocities, but a trial orbital solution showed their $O - C$ were unusually large indicating the residual malign influence of blending.

2.7-m *versus* 2.1-m telescope: A trial orbital solution in which the velocities from the 2.7-m and 2.1-m observations had equal weight showed that the velocity residuals are somewhat larger for the 2.1-m observations, which is not surprising when one recalls that the 2.7-m observations were made at the *coudé* focus while those on the 2.1-m were made at the Cassegrain focus. The criterion that the weight multiplied by the average of the residuals squared should be equal for the 2.7-m and 2.1-m velocities requires the weight of the 2.1-m velocities to be $0.3 \times$ the weight of the 2.7-m velocities.

Primary *versus* secondary velocities: The secondary lines are slightly weaker than the primary lines so one expects the weights for the secondary velocities to be somewhat less than those for the primary velocities. In a trial solution, in which the primary and secondary velocities had equal weight, it was found that for the 2.7-m observations the averages of the residuals squared for the primary and secondary velocities demanded that the weight of the secondary velocities be $0.5 \times$ that of the primary velocities, while for the 2.1-m observations the averages of the residuals squared for the primary and secondary velocities demanded that the weight of the secondary velocities be $1.8 \times$ that of the primary velocities. The cause of the unrealistic secondary weight indicated by the 2.1-m velocity residuals could, perhaps, be due to the small number of 2.1-m observations.
(15 with non-zero weight) and the fact that a relatively large number (6) of them happen to have been made when there was some blending of the primary and secondary lines. A recalculation of the weights for primary and secondary velocities for the 2.1-m residuals using only observations in which the velocity separation between primary and secondary is 30 km s$^{-1}$ or more gives a much more reasonable weight of 0.95 for secondary velocities relative to primary velocities. It was decided to adopt the result required by the 2.7-m observations and make the secondary velocities half the weight of the primary velocities for both the 2.7-m and 2.1-m observations, so the 2.7-m primary and secondary velocities have weights 1 and 0.5, respectively, and the 2.1-m primary and secondary velocities have weights 0.3 and 0.15, respectively.

With the weights of the various categories of velocity fixed, a new solution of the 2.7-m and 2.1-m velocities was done. It gave excellent agreement of the observed and calculated velocities — the r.m.s. residual for the velocities of unit weight (i.e., 2.7-m primary velocities) is only 0.06 km s$^{-1}$. Within reasonable limits the orbital solution is impervious to the relative weights of the primary and secondary velocities; for example, if instead of making the secondary velocities half the weight of the primary velocities, we were to adopt equal weights for the 2.7-m primary and secondary velocities and do likewise for the 2.1-m primary and secondary velocities the corresponding changes in the orbital elements are all much less than the estimated errors of the orbital elements. With the solution of the McDonald velocities accomplished, the next step is to assemble and assess the velocities of HD 27149 available in the literature and see if a solution of these velocities and the McDonald velocities combined is an improvement over the solution of the McDonald velocities alone.

The previously published primary and secondary radial velocities of HD 27149 are those of Woolley et al.$^{12}$ (4 observations made at Mt Wilson), those of Batten and Wallerstein$^{3}$ (15 observations from Palomar or Mt Wilson, 18 from the Dominion Astrophysical Observatory, and 1 from the Lick Observatory) and those of McClure$^{14}$ (5 observations from the Dominion Astrophysical Observatory). With the exception of Mc-
Clure’s radial velocities which were measured with a radial velocity spectrometer, all of
these radial velocities were measured by means of photographic spectra. A trial orbital
solution of these and the McDonald radial velocities together indicated that these ra-
dial velocities, because of their lower accuracy compared with the McDonald ones, have
very low weight — about one thousandth for the photographic velocities and about one
hundredth for McClure’s velocities. This idea, therefore, was dropped and the solution
of the McDonald velocities alone, described above, was adopted as the final solution.

The phases and velocity residuals for this solution are given in Table I, the orbital
elements are given in Table II and Fig. 2 shows the observed radial velocities and
calculated radial velocity curves. We now examine the most interesting features of the
orbit.

Discussion

The new orbit confirms the characteristics of HD 27149 discovered by Batten &
Wallerstein$^3$ — a period of 75 days, moderate eccentricity and a longitude of periastron
($\omega = 178.32 \pm 0.15$ degrees) which is very close to 180 degrees so the major axis lies
almost across the line of sight with periastron passage very close to the descending node.
The new orbit and precise orbital parameters promise to provide, when complemented
by a visual orbit of similar quality, accurate masses for the two components of HD 27149
and an accurate orbital parallax for the system; the linear separation of the primary
and secondary — $a \sin i = (a_1 + a_2) \sin i = (67.075 \pm 0.045) \times 10^6$ km — is accurate to
$\pm 0.07\%$. This linear separation combined with a distance to HD 27149 of 47.6 pc$^5$ lead
to a corresponding angular separation of 9.4 mas for the visual orbit.

The new systemic velocity — $\gamma = 38.461 \pm 0.014$ km s$^{-1}$ — is little different from
Batten & Wallerstein’s result — $38.0 \pm 0.3$ km s$^{-1}$ — so the new orbit does not change
the radial velocity contribution to HD 27149’s kinematic situation very much. It is of
interest, however, to compare the systemic velocity of HD 27149 with Madsen et al.’s$^9$
recent determination of its astrometric radial velocity.
Astrometric radial velocities, which are determined from proper motions and trigonometric parallaxes along with the assumption that the stars in the cluster share the same velocity vector, are entirely independent of spectroscopy. Madsen et al., who identify HD 27149 by its Hipparcos Catalogue number (20056), estimate its astrometric radial velocity to be $38.46 \pm 0.6 \text{ km s}^{-1}$, which compares with the spectroscopic radial velocity of $38.461 \pm 0.014 \text{ km s}^{-1}$ determined here. The excellent agreement of these two completely independent results is most pleasing, although the sizes of the errors, especially in the astrometric radial velocity, suggest that the exactness of the agreement is at least partially fortuitous. Also it must be recognised that the spectroscopic radial velocity includes two effects — the gravitational redshift and the convective blueshift — which do not complicate the astrometric radial velocity. The gravitational redshifts of the two G dwarf components of HD 27149 must be similar to the $0.64 \text{ km s}^{-1}$ gravitational redshift of the Sun\textsuperscript{20}. The convective blueshift, which is an effect of stellar surface convection, arises because the hotter rising convective cells make a larger contribution to the total light from the stellar disk than the cooler sinking cells. The shift is dependent on the strength of the absorption lines being used for radial velocity measurement, being most marked for weak lines and almost non-existent for very strong lines. From Figure 2 of Allende Prieto & García López\textsuperscript{20} one finds that for the mostly medium strength lines (intrinsic equivalent widths of between 50 and 100 mÅ) used to measure the radial velocities of the primary and secondary of HD 27149 the solar convective blueshift, which we use as an approximation to the situation in the components of HD 27149, is $\sim 0.30 \pm 0.05 \text{ km s}^{-1}$. Although it might appear that the next step is to remove the gravitational redshift and convective blueshift from the spectroscopic radial velocity of HD 27149 so as to obtain a modified spectroscopic radial velocity that is directly comparable with the astrometric radial velocity, one more factor must first be reckoned with. We recall that each individual spectroscopic radial velocity is derived from the differences between the measured and rest wavelengths for the set of measured stellar absorption lines and, furthermore, the rest wavelengths adopted for the lines are their measured...
wavelengths in the Sun. These solar wavelengths include the solar gravitational redshift and convective blueshift. The spectroscopic radial velocity of HD 27149, thus, not only has the gravitational redshift and convective blueshift of HD 27149 added to it but also has the solar gravitational redshift and convective blueshift subtracted from it. The gravitational redshifts of the primary and secondary of HD 27149 and the Sun must be quite similar, because all three stars lie on the same part of the main sequence, and likewise the convective blueshifts of the three stars must also be quite similar so for both types of shift the stellar and solar contributions to the spectroscopic radial velocity essentially cancel each other. The gravitational redshift and convective blueshift thus have little effect on the spectroscopic radial velocity of HD 27149 and so allowance for their presence hardly changes the excellent agreement between the spectroscopic and astrometric radial velocities noted above. Next we look at the minimum masses of the primary and secondary and the possibility of eclipses.

The minimum masses of the primary and secondary are similar to the actual masses inferred from the spectral types which suggests the possibility of eclipses — a circumstance already recognised by Batten & Wallerstein. In fact the revised minimum masses of the primary and secondary — $m_1 \sin^3 i = 1.096 \pm 0.002 M_\odot$ and $m_2 \sin^3 i = 1.010 \pm 0.002 M_\odot$ — are slightly larger than those determined by Batten & Wallerstein — $m_1 \sin^3 i = 1.04 M_\odot$ and $m_2 \sin^3 i = 0.91 M_\odot$ — so the case for eclipses is underlined. We note that the minimum masses are in fact somewhat larger than the actual masses indicated by the spectral types. For example, with the primary and secondary spectral types of G3 and G6, respectively, recommended by Barrado y Navascués & Stauffer and a standard mass versus spectral type calibration one arrives at masses of 0.98 and 0.89 $M_\odot$ for the primary and secondary. In view of the inherent uncertainty in spectral typing a double-lined spectroscopic binary in which the strengths of the primary and secondary lines are not very different — Batten & Wallerstein, for example, note that an “an (unresolved) spectrogram of dispersion 30 Å/mm, obtained at Victoria, is consistent with a spectral class between G2V and G8V” — it is not worth making anything of the
discrepancy, but it does highlight the possibility of eclipses.

The phases of the conjunctions, which are when eclipses will occur if the system is eclipsing, are 0.1715 (primary in front) and 0.8369 (secondary in front). The linear separations between the primary and secondary at the two conjunctions are similar — projected onto the line of sight they are \( r \sin i = 62.94 \times 10^6 \text{ km} \) (primary in front) and \( 61.96 \times 10^6 \text{ km} \) (secondary in front) — so if there are eclipses it is likely that there are both primary and secondary eclipses. If for the purposes of the present speculative discussion we assume that the primary and secondary are both of one solar radius, then the total duration of a central eclipse, primary or secondary, would be \( \sim 11 \) hours. The primary eclipse would be about one magnitude deep, while the secondary eclipse would be somewhat less deep. None of the McDonald observations has a phase close enough to the phases of conjunction that it might have been made during a primary or secondary eclipse so the spectroscopic observations are mute with respect to the question of eclipses. Eclipses require the orbital inclination to be within \( \sim 1.3 \) of 90° so, although their probability is small, there is still a sporting chance of their occurrence. We now re-examine photometric observations of HD 27149 made in January and February 1972 by Jørgensen & Olsen\(^1\), who searched for eclipses at the suggestion of Batten & Wallerstein.

Every night from 1972 January 4 to March 1 inclusive Jørgensen & Olsen observed HD 27149 once in \( uvby \) with a simultaneous four-channel photometer on the Danish 50 cm reflector at the European Southern Observatory. Two nights near conjunctions when they observed it twice and seven nights when they did not observe it were exceptions to this routine. There was no sign of eclipses. But the ephemerides for predicting conjunctions available to Jørgensen & Olsen were uncertain by ±1 day so they did not know how the conjunctions were placed with respect to their regular once-a-night scrutiny, a circumstance which, combined with the fact that even central eclipses would have a duration of only about 11 hours, meant that “any eclipse could easily have been overlooked” — as they pointed out. Now, thanks to the accuracy of the new orbit, the times of conjunction it provides can be projected back into the past to see how the
two conjunctions that occurred during January and February 1972 were placed with respect to Jørgensen & Olsen’s photometric observations. The ±0.12 day uncertainty of this backward projection is almost entirely due to the accumulation of the period error over the 145 orbits that separate the epoch (January 2002) of the new orbit from 1972. Fig. 3 compares a schematic light curve for central eclipses with Jørgensen & Olsen’s photometric observations during the nights of the January and February 1972 conjunctions. It turns out they timed their observations quite well; central eclipses are excluded, but shorter duration off-centre eclipses are not ruled out. We now consider the photometry of HD 27149 provided by the Hipparcos satellite.

This much more recent photometry consists of 41 observations, on the Hipparcos $H_p$ magnitude system, made from January 1990 to July 1992. Inspection of the observations, which are available at the Hipparcos website, shows no sign of eclipses, but a comparison of the calculated conjunction dates with the dates of the Hipparcos photometry shows that all of the photometry falls well outside the times of possible eclipses and so does not throw any light on the eclipse question.

Ephemerides for future conjunctions are: J.D. 2452291.8523 + 75.6587$E$ (primary in front) and 2452266.5298 + 75.6587$E$ (secondary in front). At present and for the next four years, or so, the error in these predicted times of conjunction is about 55 minutes. Further into the future the error will slowly increase as the accumulation of the period error makes its presence felt. Table III gives the Julian and UT dates provided by these ephemerides for the last three months of 2002 and all of 2003. Photometrists who find themselves on the night side of the Earth at these times are encouraged to turn their telescopes towards HD 27149 and see if it eclipses. The probability is small, but the prospective reward is great.

In conclusion we summarise our picture of HD 27149 as follows: The new spectroscopic orbit provides the basis for an accurate orbital parallax, the expected angular separation is $\sim 9$ mas, the minimum masses must be very close to the actual masses and, although the photometric observations rule out central eclipses, the door to off-centre
eclipses is still open.

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Figure captions

Fig. 1: The spectrum of HD 27149 at 6380 Å showing a Ni I line (rest wavelength 6378.3 Å) and a Fe I line (rest wavelength 6380.8 Å) in the primary and secondary.

Fig. 2: The radial velocities for the primary and secondary of HD 27149 and the calculated radial velocity curves. The filled circle near phase 0.8 is the velocity for the blended primary and secondary spectra in an observation at a single-lined phase; the velocity has zero weight in the solution for the orbits.

Fig. 3: The Jørgensen & Olsen photometry of HD 27149 at the January 1972 conjunction (possible secondary eclipse) and the February 1972 conjunction (possible primary eclipse) compared with a schematic light curve for central eclipses. Times of mid-eclipse are estimated by projecting the times of conjunction for the new orbit back into the past; the dotted lines show how much earlier or later these eclipses might have been as a result of the 0.12 day uncertainty in the projection. The two observations close together on the night of 1972 February 24 exclude a central eclipse. If the conjunctions were earlier, within the limit set by the uncertainty in the projection, these two points would exclude central eclipses even more firmly, while, if the conjunctions were later, then these two points in combination with that for the night of 1972 January 5 would also exclude central eclipses. The Jørgensen & Olsen photometry, thus, rules out central eclipses. Shorter duration off-centre eclipses, however, may still have managed to fit themselves into the gaps between the photometric observations.
| Date (UT)   | Tel | HJD | Phase | Velocity | (O − C) |
|------------|-----|-----|-------|----------|---------|
|            |     | −2400000 |       |          |         |
|            |     | Pri km s⁻¹ | Sec km s⁻¹ | Pri km s⁻¹ | Sec km s⁻¹ |
| 1995 Aug 09 | 2.7 | 49938.932 | 0.0724 | 6.52 | 73.16 | 0.03 | 0.02 |
| 1995 Sep 30 | 2.7 | 49990.854 | 0.7587 | 45.02 | 31.46 | 0.01 | 0.11 |
| 1995 Oct 01* | 2.7 | 49991.847 | 0.7718 | 43.16 | 33.84 | 0.26 | 0.20 |
| 1995 Oct 12 | 2.7 | 50002.931 | 0.9183 | 9.93 | 69.40 | −0.04 | 0.04 |
| 1995 Oct 13 | 2.7 | 50003.942 | 0.9317 | 6.83 | 72.59 | −0.06 | −0.12 |
| 1995 Oct 14 | 2.7 | 50004.886 | 0.9441 | 4.36 | 75.45 | 0.09 | −0.10 |
| 1995 Oct 15 | 2.7 | 50005.914 | 0.9577 | 1.71 | 78.24 | −0.11 | 0.03 |
| 1995 Dec 02 | 2.7 | 50053.778 | 0.5904 | 60.52 | 14.60 | 0.04 | 0.02 |
| 1995 Dec 03 | 2.7 | 50054.749 | 0.6032 | 59.97 | 15.20 | 0.05 | 0.02 |
| 1995 Dec 03 | 2.7 | 50054.896 | 0.6051 | 59.82 | 15.36 | −0.01 | 0.08 |
| 1995 Dec 04 | 2.7 | 50055.752 | 0.6164 | 59.26 | 15.88 | 0.00 | −0.03 |
| 1995 Dec 04 | 2.7 | 50055.918 | 0.6186 | 59.15 | 16.10 | 0.01 | 0.06 |
| 1996 Jan 04 | 2.7 | 50086.650 | 0.0248 | −1.18 | 81.21 | −0.13 | −0.10 |
| 1996 Jan 05 | 2.7 | 50087.698 | 0.0387 | 0.45 | 79.58 | −0.03 | −0.08 |
| 1996 Jan 06 | 2.7 | 50088.586 | 0.0504 | 2.23 | 77.70 | −0.02 | −0.04 |
| 1996 Jan 06 | 2.7 | 50088.836 | 0.0537 | 2.71 | 77.21 | −0.10 | 0.08 |
| 1996 Feb 06 | 2.7 | 50119.610 | 0.4605 | 61.54 | 13.41 | −0.04 | 0.02 |
| 1996 Feb 07 | 2.7 | 50120.582 | 0.4733 | 61.74 | 13.09 | −0.08 | −0.04 |
| 1996 Feb 08 | 2.7 | 50121.579 | 0.4865 | 61.94 | 12.76 | −0.05 | −0.18 |
| 1996 Feb 09 | 2.7 | 50122.602 | 0.5000 | 62.02 | 12.83 | −0.06 | −0.01 |
| 1997 Jan 14 | 2.7 | 50462.743 | 0.9958 | −1.83 | 82.36 | 0.09 | 0.10 |
| 1997 Jan 19 | 2.7 | 50467.693 | 0.0612 | 4.21 | 75.58 | 0.02 | −0.05 |
| 1997 Aug 29 | 2.7 | 50689.964 | 0.9990 | −1.96 | 82.40 | 0.03 | 0.07 |
| Date (UT) | Tel | HJD      | Phase  | Velocity | (O − C) |
|----------|-----|----------|--------|----------|---------|
|          |     | − 2400000 |        |          |         |
|          |     | Pri | Sec | Pri | Sec |
|          |     | km s$^{-1}$ | km s$^{-1}$ | km s$^{-1}$ | km s$^{-1}$ |
| 1997 Aug 30 | 2.7 | 50690.960 | 0.0122 | −1.75 | 82.19 | 0.08 |
| 1997 Aug 31 | 2.7 | 50691.948 | 0.0252 | −0.99 | 81.34 | 0.02 |
| 1997 Sep 01 | 2.7 | 50692.936 | 0.0383 | 0.46  | 79.85 | 0.04 |
| 1997 Sep 02 | 2.7 | 50693.946 | 0.0516 | 2.52  | 77.60 | 0.07 |
| 1997 Dec 10 | 2.7 | 50792.874 | 0.3592 | 56.81 | 18.73 | 0.02 |
| 1997 Dec 13 | 2.7 | 50795.702 | 0.3966 | 59.24 | 16.06 | 0.06 |
| 1997 Dec 14 | 2.7 | 50796.741 | 0.4103 | 59.84 | 15.28 | −0.02 |
| 1997 Dec 15 | 2.7 | 50797.749 | 0.4236 | 60.50 | 14.75 | 0.06 |
| 1998 Oct 01 | 2.7 | 51087.954 | 0.2593 | 46.09 | 30.28 | 0.03 |
| 1998 Oct 05 | 2.7 | 51091.928 | 0.3118 | 52.66 | 23.21 | 0.09 |
| 2000 Feb 03 | 2.1 | 51577.665 | 0.7320 | 48.72 | 27.08 | −0.12 |
| 2000 Oct 26 | 2.1 | 51843.796 | 0.2495 | 44.74 | 31.80 | 0.14 |
| 2000 Nov 11 | 2.1 | 51859.848 | 0.4616 | 61.72 | 13.50 | 0.12 |
| 2000 Nov 12 | 2.1 | 51860.742 | 0.4735 | 61.64 | 12.89 | −0.18 |
| 2000 Nov 13 | 2.1 | 51861.746 | 0.4867 | 62.04 | 12.88 | 0.05 |
| 2000 Dec 07* | 2.1 | 51885.704 | 0.8034 | 38.44 | 1.28  | −1.44 |
| 2000 Dec 08* | 2.1 | 51886.652 | 0.8159 | 34.26 | 42.43 | −0.35 |
| 2000 Dec 09 | 2.1 | 51887.678 | 0.8295 | 31.55 | 45.93 | −0.15 |
| 2001 Jan 11 | 2.1 | 51920.669 | 0.2655 | 46.69 | 29.16 | −0.25 |
| 2001 Jan 12 | 2.1 | 51921.622 | 0.2781 | 48.33 | 27.33 | −0.30 |
| 2001 Oct 30 | 2.1 | 52212.918 | 0.1282 | 19.62 | 58.39 | −0.23 |
| 2001 Oct 31 | 2.1 | 52213.947 | 0.1418 | 23.08 | 55.03 | −0.08 |
| 2001 Nov 01 | 2.1 | 52214.886 | 0.1543 | 26.13 | 51.82 | 0.02 |
| Date (UT) | Tel | HJD   | Phase | Velocity | (O − C) |
|----------|-----|-------|-------|----------|---------|
|          |     | − 2400000 |       | Pri | Sec | Pri | Sec |
|          |     | km s$^{-1}$ | km s$^{-1}$ | km s$^{-1}$ | km s$^{-1}$ |
| 2001 Nov 25 | 2.1 | 52238.806 | 0.4704 | 61.73 | 13.11 | −0.04 | −0.07 |
| 2001 Dec 31 | 2.1 | 52274.679 | 0.9446 | 4.14 | 75.65 | −0.04 | 0.01 |
| 2002 Feb 01 | 2.1 | 52306.648 | 0.3671 | 57.34 | 17.97 | −0.02 | 0.01 |
| 2002 Feb 02 | 2.1 | 52307.678 | 0.3807 | 58.18 | 17.00 | −0.08 | 0.01 |

The 2.7-m primary and secondary velocities have weights 1 and 0.5, respectively; the 2.1-m primary and secondary velocities have weights 0.3 and 0.15, respectively. The velocities for the three asterisked observations have zero weight; one of these observations — the one with only one velocity, representing the blended primary and secondary spectra — is single-lined and the other two are nearly so.
**Table II**

*Orbital elements of HD 27149*

| Parameter         | Value                  |
|-------------------|------------------------|
| $P$ (days)        | $75.6587 \pm 0.0008$   |
| $T$ (HJD)         | $2452278.874 \pm 0.036$|
| $\gamma$ (km s$^{-1}$) | $38.461 \pm 0.014$ |
| $q$ ($= m_1/m_2$) | $1.085 \pm 0.001$     |
| $K_1$ (km s$^{-1}$) | $32.054 \pm 0.019$   |
| $m_1 \sin^3 i$ ($M_\odot$) | $1.096 \pm 0.002$ |
| $K_2$ (km s$^{-1}$) | $34.767 \pm 0.040$   |
| $m_2 \sin^3 i$ ($M_\odot$) | $1.010 \pm 0.002$ |
| $e$               | $0.2628 \pm 0.0006$   |
| $a_1 \sin i$ ($10^6$ km) | $32.176 \pm 0.020$ |
| $\omega$ (degrees) | $178.32 \pm 0.15$    |
| $a_2 \sin i$ ($10^6$ km) | $34.899 \pm 0.040$ |

R.m.s. residual (unit weight) = 0.06 km s$^{-1}$
Table III

Conjunctions of HD 27149, October 2002 to end of 2003

| JD         | UT date     | Pri/sec |
|------------|-------------|---------|
| 2452569.16 | 2002 Oct 21.66 | sec     |
| 2452594.49 | Nov 15.99   | pri     |
| 2452644.82 | 2003 Jan 05.32 | sec     |
| 2452670.15 | Jan 30.65   | pri     |
| 2452720.48 | Mar 21.98   | sec     |
| 2452745.80 | Apr 16.30   | pri     |
| 2452796.14 | Jun 05.64   | sec     |
| 2452821.46 | Jun 30.96   | pri     |
| 2452871.80 | Aug 20.30   | sec     |
| 2452897.12 | Sep 14.62   | pri     |
| 2452947.46 | Nov 03.96   | sec     |
| 2452972.78 | Nov 29.28   | pri     |

Dates are heliocentric — the difference between heliocentric and geocentric dates is insignificant compared to the 55 minute uncertainty of the predictions.
HD 27149

1972 Jan

1972 Feb