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# CHROMOSPHERICALLY ACTIVE STARS. XX. THE GIANT SINGLE-LINED BINARY HD 161570

FRANCIS C. FEKEL,[1] GREGORY W. HENRY, AND STEPHEN M. HENRY
Center of Excellence in Information Systems, Tennessee State University, 330 10th Avenue North, Nashville, TN 37203; fekel@evans.tsuniv.edu, henry@schwab.tsuniv.edu
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## ABSTRACT

Spectroscopy of HD 161570 shows it to be a single-lined spectroscopic binary with a period of 45.623 days and a nearly circular orbit. The primary star has spectral type G7 III, and the secondary is most likely a G or K dwarf. A high-resolution spectrum of the 3950 Å region confirms that the primary has Ca II H and K emission lines. The logarithm of the giant's lithium abundance is less than 0.9, indicating that it is not lithium-rich. From photometric observations covering six seasons, we detected periodic short-term light variability with an amplitude ranging from 0.02 to 0.04 mag. We interpret these short-term variations as due to stellar rotation and find that the rotation period varied somewhat from season to season, with a representative value of 64.1 days. Thus, the very different orbital and rotation periods make HD 161570 an asynchronous rotator. Low-amplitude, long-term photometric variability was also seen. The giant's weak Ca II H and K emission, low-amplitude photometric variations, and relatively low $v \sin i$ of 7.0 km s$^{-1}$ indicate that this star is only modestly chromospherically active. This result, plus the spectral type and asynchronous rotation of the primary, suggest that it is just beginning to ascend the red giant branch.

*Key words:* binaries: spectroscopic — stars: spots — stars: variables: other

*On-line material:* machine-readable table

## 1. INTRODUCTION

HD 161570 ($\alpha = 17^h44^m07.6^s$, $\delta = 44°04'52''$ [J2000.0], $V = 8.2$ mag) is a little-observed star in the constellation Hercules. Our interest in it was aroused after W. Bidelman (1996, private communication), who examined its spectrum on an objective-prism plate, estimated a spectral type of G5–G8 III and noted that it has possible weak Ca II H and K emission. As a result, HD 161570 was included in our spectroscopic and photometric surveys of chromospherically active stars. From four of our spectra, Fekel (1997) found that HD 161570 is a single-lined spectroscopic binary and determined $v \sin i = 7.0$ km s$^{-1}$.

Over the past six years we have obtained numerous red-wavelength spectra and photometric observations of HD 161570. From our analyses of these observations, we have determined both its orbital and rotation periods and examined its evolutionary status.

## 2. SPECTROSCOPIC OBSERVATIONS AND REDUCTIONS

From 1996 June to 2001 April, we obtained 48 high-resolution spectrograms of HD 161570. All the observations were made with the Kitt Peak National Observatory (KPNO) coudé feed telescope, coudé spectrograph, and a TI CCD detector. The vast majority of the KPNO spectrograms are centered in the red at 6430 Å, cover a wavelength range of about 80 Å, and have a resolution of 0.21 Å. However, four are centered at either 6565 Å, the H$\alpha$ region, or 6695 Å, the lithium line region. The spectra have typical signal-to-noise ratios of 150. In addition, one spectrogram was made at blue wavelengths and included the Ca II H and K lines. It has a central wavelength of 3950 Å, a wavelength range of 56 Å, and a resolution of 0.21 Å.

We determined the radial velocities of the KPNO spectra with the IRAF cross-correlation program FXCOR (Fitzpatrick 1993). $\beta$ Aquilae was used as the cross-correlation reference star, and a velocity of $-40.2$ km s$^{-1}$, measured relative to the IAU velocity standard HR 7560, was adopted from our unpublished results. The radial velocity of the lone blue-wavelength spectrum was determined by cross-correlating the 3945–3960 Å region between the Ca II H and K lines. All our radial velocities are given in Table 1.

## 3. PHOTOMETRIC OBSERVATIONS AND REDUCTIONS

We obtained our photometry of HD 161570 with the T3 0.4 m automatic photoelectric telescope (APT) at Fairborn Observatory in the Patagonia Mountains of southern Arizona. This APT uses a temperature-stabilized EMI 9924B bi-alkali photomultiplier tube to acquire data through Johnson $B$ and $V$ filters. The APT is programmed to measure stars in the following sequence, termed a group observation: K, sky, C, V, C, V, C, V, C, sky, K, where K is a check star, C is the comparison star, and V is the program star. A total of 592 group observations of HD 161570 were obtained with the APT during six observing seasons from 1996 to 2001 with HD 162261 ($V = 7.70$, $B-V = 0.84$, G5) as the comparison star and HD 160950 = HR 6599 ($V = 6.36$, $B-V = 1.20$, K2) as the check star.

To create group means for each group observation, three variable minus comparison and two check minus comparison differential magnitudes in each photometric band were computed and averaged. The group means were then corrected for differential extinction with nightly extinction coefficients, transformed to the Johnson system with yearly mean transformation coefficients, and treated as single observations thereafter. The external precision of the group

[1] Visiting Astronomer, Kitt Peak National Observatory, National Optical Astronomy Observatory, operated by the Association of Universities for Research in Astronomy, Inc., under cooperative agreement with the National Science Foundation.

TABLE 1

Radial Velocities of HD 161570

| HJD (2,400,000+) | Phase | Velocity (km s$^{-1}$) | $O-C$ (km s$^{-1}$) |
|---|---|---|---|
| 50,262.870…… | 0.519 | −52.0 | 0.1 |
| 50,265.961…… | 0.587 | −46.3 | −0.4 |
| 50,363.604…… | 0.727 | −26.2 | 0.4 |
| 50,364.615…… | 0.749 | −22.7 | 0.8 |
| 50,365.577…… | 0.771 | −21.2 | −0.6 |
| 50,399.580…… | 0.516 | −52.3 | 0.1 |
| 50,400.561…… | 0.537 | −50.8[a] | 0.0 |
| 50,401.563…… | 0.559 | −48.8 | 0.1 |
| 50,402.557…… | 0.581 | −46.6 | 0.0 |
| 50,404.556…… | 0.625 | −41.1[b] | 0.2 |
| 50,576.983…… | 0.404 | −54.1[a] | 0.0 |
| 50,577.794…… | 0.422 | −54.4 | 0.1 |
| 50,630.836…… | 0.585 | −46.4 | −0.2 |
| 50,631.829…… | 0.606 | −43.8 | −0.2 |
| 50,632.793…… | 0.628 | −41.1 | −0.2 |
| 50,633.782…… | 0.649 | −38.1[a] | −0.2 |
| 50,634.860…… | 0.673 | −34.3 | 0.3 |
| 50,635.811…… | 0.694 | −31.6 | −0.1 |
| 50,636.818…… | 0.716 | −28.5 | −0.2 |
| 50,637.787…… | 0.737 | −25.6 | −0.4 |
| 50,718.638…… | 0.509 | −52.5 | 0.3 |
| 50,753.559…… | 0.275 | −43.3 | −0.3 |
| 50,754.605…… | 0.298 | −45.9 | −0.1 |
| 50,755.596…… | 0.319 | −47.7 | 0.4 |
| 50,756.610…… | 0.342 | −50.0 | 0.2 |
| 50,757.604…… | 0.363 | −51.8 | 0.1 |
| 50,758.584…… | 0.385 | −53.5 | −0.3 |
| 50,926.936…… | 0.075 | −15.2 | 0.2 |
| 50,927.933…… | 0.097 | −18.1 | −0.1 |
| 50,928.968…… | 0.119 | −21.0 | −0.1 |
| 50,931.922…… | 0.184 | −30.4 | −0.2 |
| 51,005.793…… | 0.803 | −16.5 | 0.0 |
| 51,093.578…… | 0.727 | −26.4 | 0.2 |
| 51,303.941…… | 0.338 | −50.1 | −0.1 |
| 51,304.917…… | 0.360 | −51.8 | −0.1 |
| 51,305.905…… | 0.381 | −53.0[c] | 0.0 |
| 51,306.888…… | 0.403 | −54.1 | −0.1 |
| 51,471.595…… | 0.013 | −10.0 | 0.0 |
| 51,472.591…… | 0.035 | −11.4 | 0.2 |
| 51,473.617…… | 0.057 | −13.4 | 0.2 |
| 51,474.576…… | 0.079 | −15.3 | 0.5 |
| 51,735.826…… | 0.805 | −16.2 | 0.2 |
| 51,736.794…… | 0.826 | −14.2 | −0.1 |
| 52,013.917…… | 0.900 | −8.7 | 0.0 |
| 52,014.970…… | 0.923 | −7.6 | 0.3 |
| 52,015.972…… | 0.945 | −7.8 | −0.1 |
| 52,016.989…… | 0.968 | −8.2 | −0.2 |
| 52,017.978…… | 0.989 | −9.3 | −0.6 |

[a] Lithium region.
[b] Hα region.
[c] Ca II H and K region.

means, based on standard deviations for pairs of constant stars, is typically ∼0.004 mag on good nights with this telescope. Group mean differential magnitudes with internal standard deviations greater than 0.01 mag were discarded. The individual differential magnitudes[2] are given in Table 2. Further details of telescope operations and data reduction procedures can be found in Henry (1995a, 1995b).

TABLE 2

Photometric Observations of HD 161570

| HJD (2,400,000+) (1) | Var. $B$ (mag) (2) | Var. $V$ (mag) (3) | Chk. $B$ (mag) (4) | Chk. $V$ (mag) (5) |
|---|---|---|---|---|
| 50,219.8760…… | 0.592 | 0.476 | −0.973 | −1.350 |
| 50,221.8700…… | 0.596 | 0.482 | −0.979 | −1.355 |
| 50,223.8666…… | 0.597 | 0.481 | −0.970 | −1.359 |
| 50,224.8606…… | 0.595 | 0.476 | −0.972 | −1.358 |
| 50,225.8575…… | 0.595 | 0.480 | −0.980 | −1.357 |

Note.—Table 2 is presented in its entirety in the electronic edition of the Astronomical Journal. A portion is shown here for guidance regarding its form and content.

## 4. SPECTROSCOPIC ORBIT

To determine the orbital period of HD 161570, a sine curve was fitted to the velocities, and the sum of the residuals squared was computed for trial periods between 1 and 200 days with a step size of 0.01 days. The best period was 45.62 days with its sum of the residuals squared being over 500 times smaller than that of the next-best period. Adopting this period value, we computed preliminary orbital elements with BISP, a computer program that uses a slightly modified version of the Wilsing-Russell method (Wolfe, Horak, & Storer 1967). We refined those elements with a differential corrections program, called SB1, of Barker, Evans, & Laing (1967). This solution produced an orbit with a very low eccentricity $e = 0.0075 \pm 0.0029$. Thus, we computed a circular orbit with SB1C (D. Barlow 1998, private communication), which also uses differential corrections to determine the orbital elements. The precepts of Lucy & Sweeney (1971) indicate that the eccentric-orbit solution is to be preferred, but the results are close to the dividing lines of both tests. Because of those results and the moderately long orbital period, we have adopted the elements for the eccentric orbit (Table 3). Orbital phases of the observations and velocity residuals to the eccentric-orbit solution are listed in Table 1. Zero phase is a time of periastron passage. Figure 1 compares our velocities with the computed velocity curve.

## 5. PHOTOMETRIC PERIOD ANALYSIS

The 557 good variable minus comparison differential magnitudes in the Johnson $V$ photometric band from

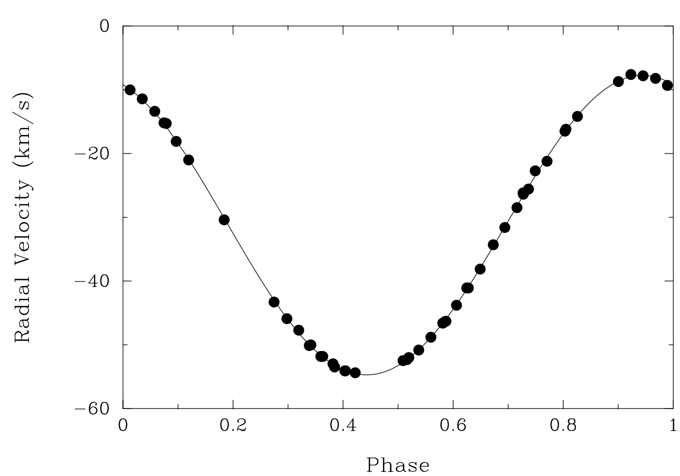


Fig. 1.—Plot of the computed radial velocity curve of HD 161570 compared with the observations. Zero phase is a time of periastron.

[2] The photometric observations are also available on the Tennessee State University Automated Astronomy Group Web site, at http://schwab.tsuniv.edu/t3/hd161570/hd161570.html.

TABLE 3

Orbital Elements of HD 161570

| Parameter | Value |
|---|---|
| $P$ (days) | 45.6228 ± 0.0028 |
| $T$ (HJD) | 2,450,604.2 ± 2.8 |
| $\gamma$ (km s$^{-1}$) | −31.39 ± 0.05 |
| $K$ (km s$^{-1}$) | 23.50 ± 0.06 |
| $e$ | 0.0075 ± 0.0029 |
| $\omega$ (deg) | 20.3 ± 22.1 |
| $a \sin i$ (km) | (14.74 ± 0.04) × $10^6$ |
| $f(m)$ ($M_\odot$) | 0.06146 ± 0.00047 |
| Standard error of an observation of unit weight (km s$^{-1}$) | 0.3 |

column (3) of Table 2 are plotted in Figure 2 (*top*). Our check minus comparison differential magnitudes are constant from night to night to about 0.005 mag, a scatter comparable to the typical 0.004 mag precision for this telescope. Thus, there is no significant contribution from the comparison star to the variability in the variable minus comparison differential magnitudes. The photometric amplitude of HD 161570 is quite small and ranges from about 0.02 to 0.04 mag. Year-to-year variations of about 0.02 mag are also present.

We performed separate period searches on the $V$ and $B$ observations during each observing season by using the method of Vanîcek (1971), which is based on least-squares fitting of sinusoids. A description of the use of this technique can be found in § 3.2 of Henry et al. (2001 and references therein). In the resulting least-squares spectra, we plot the fractional reduction of the variance (reduction factor) versus trial frequency. The results of our period analyses for the six observing seasons are given in Table 4. For each season, we also computed the mean magnitude in $V$ and $B$ and estimated the total photometric amplitudes from the individual light curves. The $V$ photometric observations from the fifth observing season and the resulting least-squares spectrum are shown, respectively, in Figure 2 (*middle and bottom*).

Although we find a significant range of photometric periods from the six observing seasons, we conclude that the most likely rotation period of HD 161570 is the 64 day period determined from the fifth season (see § 9 below).

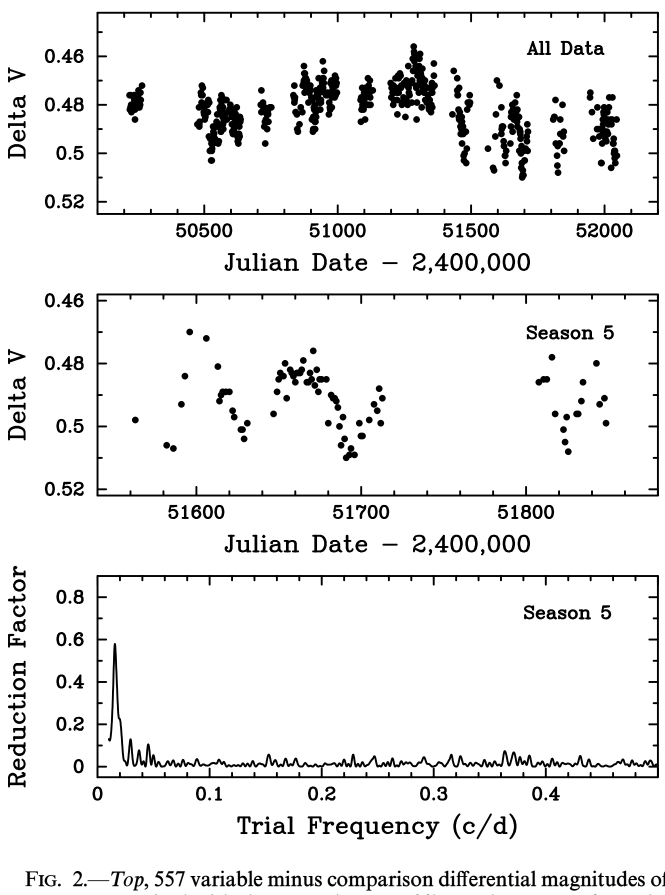


Fig. 2.—*Top*, 557 variable minus comparison differential magnitudes of HD 161570 acquired with the 0.4 m APT; *middle*, $V$ photometry from the fifth observing season plotted on an expanded abscissa; *bottom*, frequency spectrum of the $V$ photometry from season 5, revealing the 64.1 ± 0.1 day rotation period.

## 6. SPECTRAL TYPE

The spectral type of HD 161570 was determined by visual comparison with the spectra of late G and early K subgiant and giant stars from the list of Keenan & McNeil (1989). The spectra of those reference stars were obtained at KPNO with the same telescope, spectrograph, and detector as those of our spectra of HD 161570. Strassmeier & Fekel (1990) identified several luminosity-sensitive and temperature-sensitive line ratios in the 6430–6465 Å region. Those critical line ratios and the general appearance of the spectrum were employed as spectral-type criteria. Our red-wavelength spectra of HD 161570 appear very similar to the spectrum of $\kappa$ Gem, which has spectral type G8 III (Keenan & McNeil 1989). An even better match was found with the spectrum of $\iota$ Cap, which Keenan & McNeil (1989) classified as G7 III. Thus, we assign this latter spectral type to HD 161570. Both $\kappa$ Gem and $\iota$ Cap have iron abundances that are slightly less than the Sun's (e.g., Brown et al. 1989; McWilliam 1990). Therefore, the iron abundance of HD 161570 is also likely to be similar to the solar value.

## 7. CHROMOSPHERIC ACTIVITY CHARACTERISTICS

The detection of Ca II H and K emission features has long been used as a primary indicator of chromospheric activity in late-type stars. Our high-resolution spectrum of the Ca II H and K region (Fig. 3) confirms W. Bidelman's (1996, private communication) detection of weak Ca emission features. We computed Ca II H and K surface fluxes for HD 161570 with the procedures outlined by Linsky et al. (1979) as discussed by Strassmeier et al. (1990). To correct for the photospheric flux, we used the relation of Noyes et al. (1984). Following Strassmeier et al. (1990, 1994), who obtained Ca II H and K observations with the same spectrograph setup and determined fluxes in a similar manner,

TABLE 4

RESULTS FROM PHOTOMETRIC ANALYSIS

| Season | Photometric Band | HJD Range (2,400,000+) | $N_{obs}$ | Mean Brightness (mag) | Period (days) | Full Amplitude (mag) |
|---|---|---|---|---|---|---|
| 1 ...... | *V* | 50,219–50,266 | 31 | 0.4791 | ... | ... |
| | *B* | 50,219–50,263 | 32 | 0.5909 | ... | ... |
| 2 ...... | *V* | 50,474–50,751 | 121 | 0.4861 | 82.0 ± 3.0 | 0.02 |
| | *B* | 50,474–50,751 | 126 | 0.5981 | 75.9 ± 1.7 | 0.02 |
| 3 ...... | *V* | 50,834–51,131 | 129 | 0.4768 | 58.8 ± 1.4 | 0.02 |
| | *B* | 50,834–51,131 | 129 | 0.5876 | 56.5 ± 0.6 | 0.02 |
| 4 ...... | *V* | 51,199–51,495 | 141 | 0.4758 | 70.4 ± 1.0 | 0.04 |
| | *B* | 51,201–51,495 | 139 | 0.5864 | 70.4 ± 1.0 | 0.04 |
| 5 ...... | *V* | 51,563–51,848 | 86 | 0.4916 | 64.1 ± 1.2 | 0.04 |
| | *B* | 51,586–51,848 | 86 | 0.6025 | 64.1 ± 1.4 | 0.04 |
| 6 ...... | *V* | 51,946–52,045 | 49 | 0.4907 | 61.3 ± 3.6 | 0.03 |
| | *B* | 51,946–52,045 | 52 | 0.6009 | 57.2 ± 3.6 | 0.03 |

we estimate flux uncertainties of ±25%. In addition we calculated the chromospheric radiative loss in the H and K lines normalized to the total surface luminosity of the star, log $R'(\mathrm{HK}) = -4.31$. Strassmeier et al. (1993) used log $R'(\mathrm{HK}) = -4.7$ as a lower limit criterion for inclusion of stars in their Catalog of Chromospherically Active Binaries (2d ed.). We note, however, that most stars considered to be chromospherically active have much larger values, log $R'(\mathrm{HK}) > -4.0$ (Fig. 5*b* of Strassmeier et al. 1990). Such comparisons confirm the visual impression from Figure 3 that the chromospheric activity of HD 161570 is relatively weak.

In addition to Ca II H and K emission, rapid rotation is another diagnostic of chromospheric activity in late-type stars. De Medeiros, da Rocha, & Mayor (1996) surveyed 1100 F5–K5 giants and found a mean projected rotational velocity of 2.1 km s$^{-1}$ for G7 III stars. Thus, even with its relatively low $v \sin i$ value of 7.0 ± 1.0 km s$^{-1}$ (Fekel 1997), HD 161570 is rotating rapidly for its spectral type.

## 8. LITHIUM ABUNDANCE

Standard theory (Iben 1967a, 1967b) predicts that the lithium abundance of a star is significantly diluted as it ascends the red giant branch. Over the past decade, however, a small number of post–main-sequence stars (for a recent list, see Charbonnel & Balachandran 2000) have been discovered with lithium abundances greater than those predicted from standard theory. In fact, at least two giants, both of which are chromospherically active, have lithium abundances that are greater than the initial value for Population I stars (Balachandran et al. 2000). To explain the lithium-rich giants, Charbonnel & Balachandran (2000) recently proposed a scenario in which mixing episodes on the red giant branch and early asymptotic giant branch result in brief periods of enhanced lithium. Because several lithium-rich giants have been found in surveys of chromospherically active stars (e.g., Fekel & Balachandran 1993), we obtained spectra of HD 161570 in the 6700 Å lithium region.

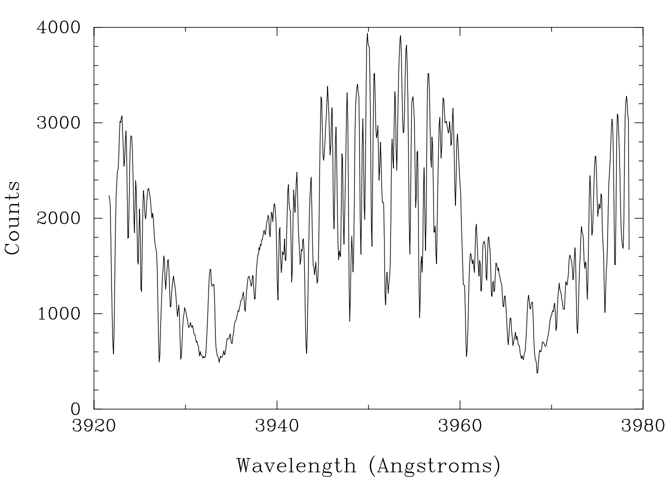


FIG. 3.—Spectrum of HD 161570 in the 3950 Å region. Modest emission lines in the center of the broad Ca II H and K absorption features are evident.

From a visual inspection of the spectra it was obvious that HD 161570 does not have a strong lithium line. In fact, the strongest line near the lithium wavelength is that of the Fe I line at 6707.44 Å, and thus, any possible lithium line at 6707.8 Å is weaker than and significantly blended with the Fe I line. We used a double Gaussian fit to determine equivalent widths of the Fe I and possible lithium line. The fit resulted in an equivalent width of 22 mÅ for the Fe I line and an upper limit of 5 mÅ for the lithium feature. From the non-LTE curves of growth of Pavlenko & Magazzù (1996), this corresponds to an upper limit of 0.9 for the logarithm of the lithium abundance. This result is consistent with the scenario of Charbonnel & Balachandran (2000), since HD 161570 is likely just beginning its first ascent of the red giant branch.

## 9. DISCUSSION

In a chromospherically active star, the day-to-day photometric variations are due primarily to the star's rotation, which modulates the visibility of an asymmetric distribution of dark starspots, while the slower month-to-month and year-to-year variations are caused by the growth and decay of individual starspot regions and by changes in the total filling factor of spots (e.g., Eaton, Henry, & Fekel 1996). Although HD 161570 is weakly active compared with most chromospherically active stars (see § 7 above), it is still capable of generating photospheric starspots detectable in our APT photometry. Our measured photometric periods of HD 161570 (Table 4) range from about 57 to 82 days. For most chromospherically active stars with larger photometric amplitudes, we would interpret this as evidence for differential rotation in the star combined with latitude changes in the predominant starspot groups (Henry et al. 1995). In the case of HD 161570, however, the spread in photometric periods probably results from the combination of a very small photometric amplitude and the evolution of individual starspot groups on the timescale of the stellar rotation. Therefore, it is somewhat difficult in this case to decide which photometric period most closely corresponds to the stellar rotation period. The light curve from the fifth observing season, plotted in Figure 2 (*middle*), is the most coherent of the 6 yr of observation and gives the highest reduction factor in its least-squares spectrum, shown in Figure 2 (*bottom*). Therefore, we take the photometric period of $64.1 \pm 0.9$ days, found from the fifth season's $V$ and $B$ light curves, as our best determination of the rotation period of HD 161570.

A check of the SIMBAD database indicated no other photoelectric photometry of HD 161570, so we searched our APT data for its brightest known visual magnitude and corresponding $B-V$. From Figure 2, HD 161570 is brightest in season 4, where its differential $V$ magnitude is 0.46. To convert this to an apparent $V$ magnitude, we adopted $V = 7.70$ mag (ESA 1997) for our comparison star, HD 162261. This resulted in a maximum $V$ magnitude of 8.16 for HD 161570. In a similar manner, we obtained $B-V = 0.95$. O'Neal, Saar, & Neff (1996) showed that on some heavily spotted stars the observed maximum $V$ magnitude underestimates the brightness of the unspotted star by 0.3–0.4 mag. However, the weak chromospheric emission flux and low-amplitude light variations of HD 161570 suggest that it is not heavily spotted. Thus, we have adopted the historical maximum as the unspotted $V$ magnitude for the primary of HD 161570.

Unfortunately, HD 161570 has no *Hipparcos* parallax (ESA 1997), and so some of its basic parameters can be determined only with the help of canonical values. According to Gray (1992), our spectral type of G7 III corresponds to $B-V = 0.934$, which is in good accord with our value of 0.95. As a result, we assumed no correction for interstellar extinction in the following distance determination. From Gray (1992), we adopted an absolute visual magnitude of 0.7 mag and obtained a distance of 310 pc. A $B-V$ of 0.95 mag from our data was used in conjunction with Table 3 of Flower (1996) to obtain a bolometric correction of $-0.33$ mag and an effective temperature of 4943 K. These values lead to an estimated luminosity of 56 $L_{\odot}$ and a radius of 10.3 $R_{\odot}$. This radius can be compared with an independent determination of the minimum radius of HD 161570. With a rotation period of $64.1 \pm 0.9$ days and $v \sin i = 7.0 \pm 1.0$ km s$^{-1}$, we found a minimum radius of $8.9 \pm 1.3$ $R_{\odot}$. This suggests a rotational inclination of 60°.

With our mass function of 0.0615 $M_{\odot}$ and an adopted primary mass of 1.5 $M_{\odot}$, typical for evolved chromospherically active stars (Popper 1980), we computed the orbital inclination for several secondary masses. One limit for the secondary mass comes from the lack of detection of its lines in our spectra. Using the program of Huenemoerder & Barden (1984) and Barden (1985), we created an artificial spectrum of HD 161570 by combining a spectrum of $\kappa$ Gem with an appropriately scaled spectrum of either $\alpha$ CMi (F5 IV–V) or $\beta$ Vir (F9 V). The lines of the F stars were redshifted by 50 km s$^{-1}$ relative to those of $\kappa$ Gem. Absorption lines of $\beta$ Vir were visible in the artificial spectrum for a magnitude difference up to about 3 mag. From canonical tables of basic properties such as those of Gray (1992), this magnitude difference suggests that for HD 161570 lines of a main-sequence secondary should have been found if it had a mass greater than about 1.25 $M_{\odot}$. This secondary mass, combined with an adopted primary mass of 1.5 $M_{\odot}$, leads to an orbital inclination of 38°. An inclination of 90° results in a minimum mass of 0.66 $M_{\odot}$ for the secondary. Increasing the adopted primary mass to 2.0 $M_{\odot}$ increases the minimum mass to 0.78 $M_{\odot}$. Since our photometric observations show no evidence of eclipses, the maximum inclination must be a bit less than 90°. The mass range indicates that the secondary is likely a late F, G, or K dwarf, although a white dwarf cannot be excluded. An orbital inclination of about 60° is in the middle of the inclination range and similar to the estimated rotational inclination.

The two main theories of orbital circularization and rotational synchronization (e.g., Zahn 1977; Tassoul & Tassoul 1992) disagree significantly on absolute timescales but do agree that synchronization should occur first. While the orbit of HD 161570 is nearly circular, its rotation period of 64.1 days, compared with an orbital period of 45.6 days, clearly makes the giant star an asynchronous rotator. Such a situation is relatively common for chromospherically active giants with orbital periods greater than 1 month. Fekel & Eitter (1989) used the data from the first edition of the Catalog of Chromospherically Active Binary Stars (Strassmeier et al. 1988) to determine that about half of the systems with periods between 30 and 70 days are asynchronously rotating. That its orbital and rotation periods are so discordant argues that HD 161570 is currently ascending the first-ascent red giant branch, causing the radius of the giant to expand quickly. This rapid evolution has led to the observed asynchronous rotation.

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## REFERENCES

Balachandran, S. C., Fekel, F. C., Henry, G. W., & Uitenbroek, H. 2000, ApJ, 542, 978
Barden, S. C. 1985, ApJ, 295, 162
Barker, E. S., Evans, D. S., & Laing, J. D. 1967, R. Obs. Bull., 130, 355
Brown, J. A., Sneden, C., Lambert, D. L., & Dutchover, E. 1989, ApJS, 71, 293
Charbonnel, C., & Balachandran, S. C. 2000, A&A, 359, 563
de Medeiros, J. R., da Rocha, C., & Mayor, M. 1996, A&A, 314, 499
Eaton, J. A., Henry, G. W., & Fekel, F. C. 1996, ApJ, 462, 888
ESA. 1997, The Hipparcos and Tycho Catalogues (ESA SP-1200) (Noordwijk: ESA)
Fekel, F. C. 1997, PASP, 109, 514
Fekel, F. C., & Balachandran, S. 1993, ApJ, 403, 708
Fekel, F. C., & Eitter, J. J. 1989, AJ, 97, 1139
Fitzpatrick, M. J. 1993, in ASP Conf. Ser. 52, Astronomical Data Analysis Software and Systems II, ed. R. J. Hanisch, R. V. J. Brissenden, & J. Barnes (San Francisco: ASP), 472
Flower, P. J. 1996, ApJ, 469, 355

Gray, D. F. 1992, The Observation and Analysis of Stellar Photospheres (Cambridge: Cambridge Univ. Press)
Henry, G. W. 1995a, in ASP Conf. Ser. 79, Robotic Telescopes: Current Capabilities, Present Developments, and Future Prospects for Automated Astronomy, ed. G. W. Henry & J. A. Eaton (San Francisco: ASP), 37
———. 1995b, in ASP Conf. Ser. 79, Robotic Telescopes: Current Capabilities, Present Developments, and Future Prospects for Automated Astronomy, ed. G. W. Henry & J. A. Eaton (San Francisco: ASP), 44
Henry, G. W., Eaton, J. A., Hamer, J., & Hall, D. S. 1995, ApJS, 97, 513
Henry, G. W., Fekel, F. C., Kaye, A. B., & Kaul, A. 2001, AJ, 122, 3383
Huenemoerder, D. P., & Barden, S. C. 1984, BAAS, 16, 510
Iben, I. 1967a, ApJ, 147, 624
———. 1967b, ApJ, 147, 650
Keenan, P. C., & McNeil, R. C. 1989, ApJS, 71, 245
Linsky, J. L., Worden, S. P., McClintock, W., & Robertson, R. M. 1979, ApJS, 41, 47
Lucy, L. B., & Sweeney, M. A. 1971, AJ, 76, 544
McWilliam, A. 1990, ApJS, 74, 1075
Noyes, R. W., Hartmann, L. W., Baliunas, S. L., Duncan, D. K., & Vaughan, A. H. 1984, ApJ, 279, 763
O'Neal, D., Saar, S., & Neff, J. E. 1996, ApJ, 463, 766
Pavlenko, Ya. V., & Magazzù, A. 1996, A&A, 311, 961
Popper, D. M. 1980, ARA&A, 18, 115
Strassmeier, K. G., & Fekel, F. C. 1990, A&A, 230, 389
Strassmeier, K. G., Fekel, F. C., Bopp, B. W., Dempsey, R. C., & Henry, G. W. 1990, ApJS, 72, 191
Strassmeier, K. G., Hall, D. S., Fekel, F. C., & Scheck, M. 1993, A&AS, 100, 173
Strassmeier, K. G., Hall, D. S., Zeilik, M., Nelson, E., Eker, Z., & Fekel, F. C. 1988, A&AS, 72, 291
Strassmeier, K. G., Handler, G., Paunzen, E., & Rauth, M. 1994, A&A, 281, 855
Tassoul, J.-L., & Tassoul, M. 1992, ApJ, 395, 259
Vaniĉek, P. 1971, Ap&SS, 12, 10
Wolfe, R. H., Horak, H. G., & Storer, N. W. 1967, in Modern Astrophysics, ed. M. Hack (New York: Gordon & Breach), 251
Zahn, J.-P. 1977, A&A, 57, 383