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HD 12545: A RECORD PHOTOMETRIC AMPLITUDE FOR AN RS CVn STAR

INTRODUCTION

HD 12545 = SAO 55233 = BD +34^{o}363 is a 7th magnitude G5IV single-line spectroscopic binary star which shows RS CVn-type light variations. Bidelman (1985) initially identified the star as a good candidate to study for RS CVn behavior based on objective prism spectra showing remarkably strong H and K ionized calcium emission. Hall added the star to his list of suspected variables (Fekel and Hall 1985), and 16 observations by Ingvarsson and Milton between August 1986 and April 1987 showed a large but not unusual range of 0.16 magnitude in V (Hooten and Hall 1990), and a best fit photometric period 5% longer than the 23.9 day orbital period (Strassmeier, et al. 1988).

OBSERVATIONS

The star was added to the observing program at Cabrillo College Observatory because of the unusual strength of the H and K emission and the small amount of follow-up photometry. The observatory has a 0.25m f/10 Schmidt-Cassegrain equipped with an SSP-3A photometer and BVRI filters. The data were taken and reduced with the RPHOT software package. Differential magnitudes in Johnson/Cousins BVRI are relative to Bidelman's suggested comparison star of HD 12478 = SAO 55221, spectral type K0.

Observations between early September 1990 and late December 1990 show the classic RS CVn pattern (higher amplitude at short wavelengths, progressively less at longer wavelengths where the cooler spot contributes more light) but with a remarkable amplitude of 0.8 magnitude in B, 0.6 in V, 0.5 in R, and 0.4 in I. Figure 1 shows the V observations. An observation consisted of of four 10-second integrations bracketed by the comparison star and sky. Typically 2 to 5 such data points were obtained each night. The typical internal dispersion in these readings is ±.05 magnitude, leading to an estimated uncertainty of .03 magnitude in the plotted points. Assuming the variability is due entirely to spots, this is the largest observed amplitude in a spotted star so far (Hall, 1991). The highest previous star-spot amplitude until now was 0.50 in V for II Peg in late 1986 (Doyle, et al. 1988)

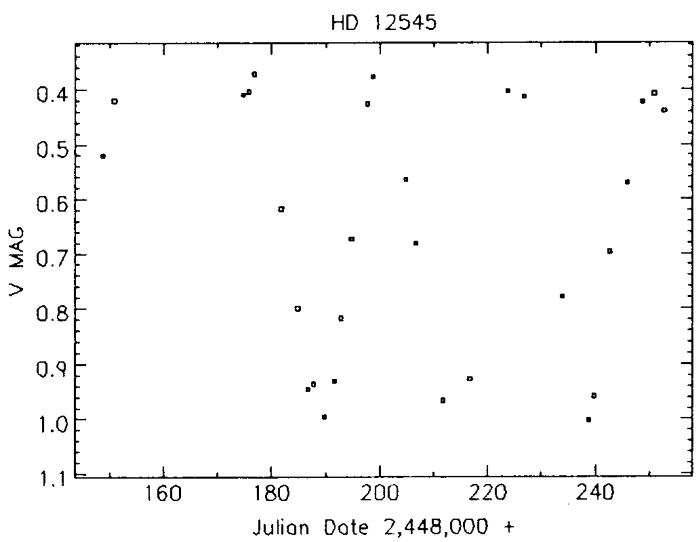

Figure 1: Differential Johnson V magnitudes smoothed over each night, from September through December 1990. Larger squares average more observations. Included are parts of 5 cycles.

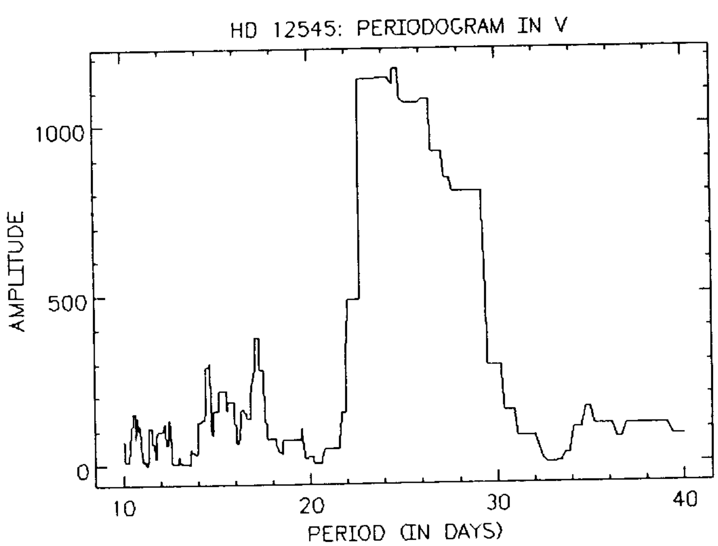

Figure 2: Jurkevich periodogram of the Figure 1 data. Synchronous rotation (P=23.9 days) cannot be ruled out, but a 24.4 day period is a better fit to this data. Hall (Strassmeier, et al. 1988) found 25.1 days for 1986 data.

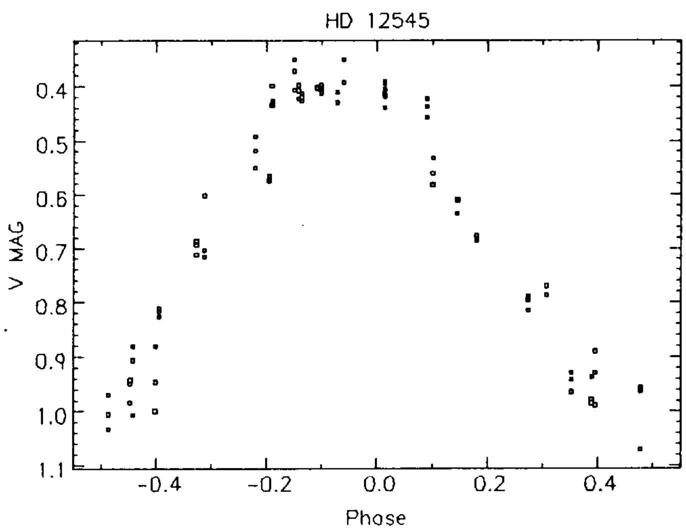

Figure 3: Folded phase plot of the unsmoothed full data set, assuming a period of 24.4 days. The 5 day flat spot at maximum indicates the spot(s) occupy less than 180 degrees of longitude.

INTERPRETATION

A Jurkevich period analysis in V (Figure 2) gives a broad maximum to the Jurkevich index between 23.9 and 26.1 days, and is similar in the other bands. More careful replottings of the full data set on folded phase plots using a range of periods in this interval showed that the best period was 24.4 ± .1 days in all filters. Figure 3 shows the results in V. While 23.94 days is an excellent fit to the V data when the data is smoothed over a night, the unsmoothed data is better fit with 24.4 days. Using the unsmoothed data is preferred since this allows the night-to-night variations to be compared to the internal dispersion in each night's data.

The present observations lead to a number of questions. The large, nearly sinusoidal variation suggests a large spot centered at low stellar latitude with a rotation axis inclined very roughly perpendicular to the line of sight. If the orbital plane is similarly inclined there is a reasonable chance for eclipses. However, there is as yet no obvious evidence for eclipses in the light curves. The folded phase plot (using an assumed period of 24.4 days) of Figure 3 shows a short interval (approximately 5 days) of constant light near maximum, showing the spot(s) occupy less than 180 degrees of longitude. Ellipticity may contribute some part to the photometric variations if the large radius is an appreciable fraction of the Roche radius. However, the low photometric amplitude seen 4 years ago argues that this effect must be small. As pointed out by Hooten and Hall (1990), the v sin i of 17 km/sec together with his assumed 25-day rotation period implies a minimum radius of 8.4 solar radii, making the luminosity classification of IV suspiciously low. Unfortunately, Doppler image analysis of the spot(s) will not be productive, given the low v sin i.

The exaggerated behavior of this star offers a chance to study the RS CVn phenomenon in greater detail. One important question is the relation of asynchronous rotation to the formation of star spots. For this it is important to get photometry over a longer baseline, permitting a firmer photometric period to be established. The presently determined photometric period is not significantly different from the orbital period. Also, new spectroscopy is also needed to see if the dramatically increased photometric variation is accompanied by stronger H and K emission.

Hall and Henry have new photometry on this object, using the Vanderbilt 16-inch APT on Mt. Hopkins, partially overlapping the observations presented here. A preliminary look at these data confirms the Figure 1 light curve. A more complete set of combined observations and analysis will be presented later (Nolthenius, Hall, and Henry 1991).

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