COMMISSIONS 27 AND 42 OF THE IAU
INFORMATION BULLETIN ON VARIABLE STARS
Number 4899

Konkoly Observatory
Budapest
8 May 2000

HU ISSN 0374 – 0676

HD 49015: A NEW LOW-AMPLITUDE γ DORADUS STAR?

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We find HD 49015 to be a new low-amplitude variable star, based on one season of photometric observations with a 0.80 m automatic photoelectric telescope (APT) located at Fairborn Observatory in Arizona. The star was on our observing program as a photometric comparison star.

Very little has been published on HD 49015. Karlsson (1969) gives a spectral type of F0 IV. Olsen (1983) derives $V = 7.038$, $b - y = 0.222$, $m_1 = 0.176$, and $c_1 = 0.646$ from his Strömgren photometry. Nordstroem et al. (1997) included the star in their survey of 595 nearby F dwarfs and found $v \sin i = 44.0$ km s^{-1} and a radial velocity of 43.9 km s^{-1}. The *HIPPARCOS* catalogue gives $V = 7.04$ and $B - V = 0.375$ (both from ground-based measurements), $\pi = 14.37$ mas, and does not classify the star as either photometrically variable or constant (Perryman et al. 1997). From these results, along with the $T_{\rm eff}$ calibration of Flower (1996), we compute $(B - V)_0 = 0.354$ and $M_V = 2.76$. When plotted on an HR diagram, these values suggest a spectral type around F2 V. *HIPPARCOS* detected a visual secondary star 0.4 arcseconds away from HD 49015, so the magnitudes and colors given above refer to the combined light of these two stars. However, the secondary is 4 magnitudes fainter than the primary and so has little effect on our derived $(B - V)_0$ and M_V.

From 2000 January 9 through April 13, the 0.80 m APT acquired 63 measurements of HD 49015 through Strömgren b and y filters. The observations were reduced differentially with respect to two comparison stars, HD 43856 ($V = 7.96$, $B - V = 0.51$, F6 V) and HD 46558 ($V = 6.90$, $B - V = 0.40$, F0), corrected for extinction with nightly extinction coefficients, and transformed to the Strömgren system with long-term mean transformation coefficients. The standard deviation of the HD 43856 minus HD 46558 differential magnitudes is 0.0012 mag, which indicates both comparison stars are constant to the limit of precision for this APT. Differential magnitudes in the sense HD 49015 minus HD 43856 are analyzed in this paper. Details of the observing and data-reduction procedures can be found in Henry (1999). The individual photometric observations are available at http://schwab.tsuniv.edu/t8/hd49015/hd49015.html.

Periodogram analysis shows HD 49015 to be a short-period variable. The periodogram between $0\overset{d}{.}01$ and $1\overset{d}{.}0$ of the Strömgren b differential magnitudes is shown in the top panel of Figure 1. The strongest period occurs at $0\overset{d}{.}3452 \pm 0\overset{d}{.}0002$, but periods nearly as strong occur at $0\overset{d}{.}5277 \pm 0\overset{d}{.}0002$ and $0\overset{d}{.}2565 \pm 0\overset{d}{.}0001$. The window function for the $0\overset{d}{.}3452$ period is plotted in the bottom panel of Figure 1 and indicates that the other significant dips in the periodogram match the expected aliases of the $0^{\mathrm{d}}.3452$ period. Analysis of the Strömgren y differential magnitudes gives identical results except that the periods at $0^{\mathrm{d}}.3452$ and $0^{\mathrm{d}}.5275$ have identical strength. Because the amplitude in b is significantly larger than in y (see below), we adopt the $0^{\mathrm{d}}.3452$ period preferred by the b observations as the one most likely to be correct.

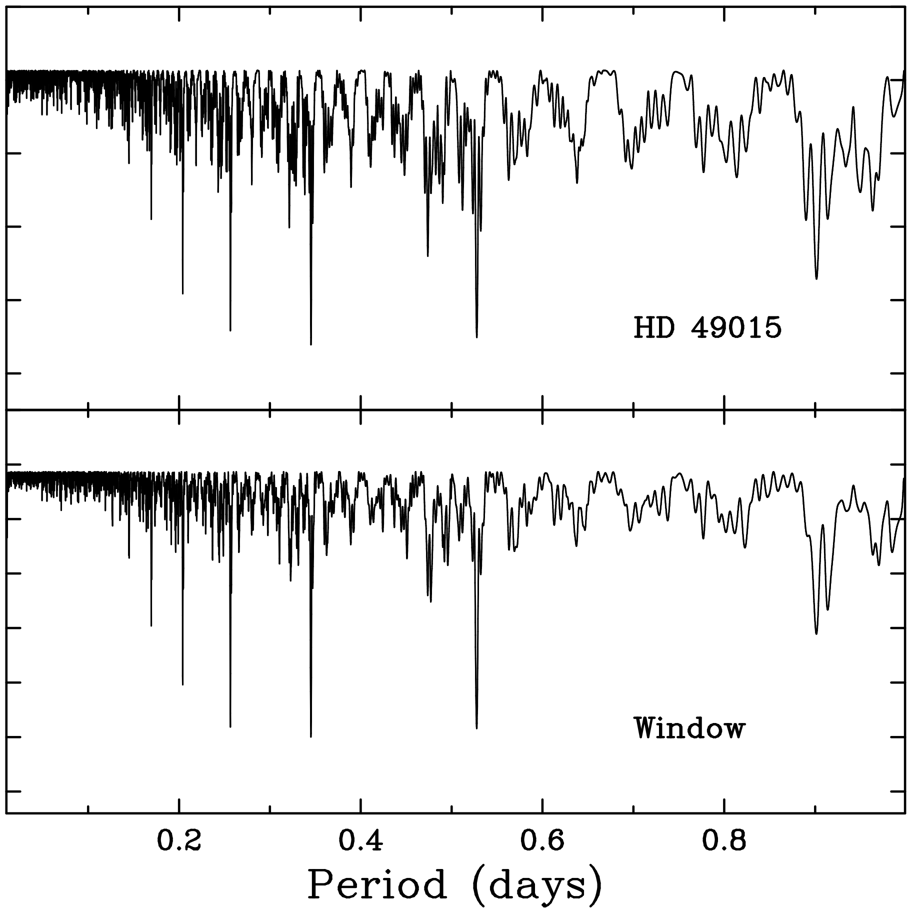

Figure 1. Periodogram analysis of HD 49015. The top panel plots the periodogram of the Strömgren b differential magnitudes and shows the strongest periodicity at $0^{\mathrm{d}}.3452 \pm 0^{\mathrm{d}}.0002$. The bottom panel plots the window function for the $0^{\mathrm{d}}.3452$ period and shows that the other significant dips match the expected aliases of the $0^{\mathrm{d}}.3452$ period.

The 63 Strömgren b differential magnitudes are plotted in Figure 2 against phase computed with the ephemeris

$$\mathrm{HJD} = 2,451,552.0 + 0^{\mathrm{d}}.3452E, \tag{1}$$

where the epoch is chosen arbitrarily at the beginning of the data set. A least-squares sine-fit to these data gives a full amplitude of $0^{\mathrm{m}}.0072 \pm 0^{\mathrm{m}}.0006$. The rms of the residuals from the sine-curve fit is $0^{\mathrm{m}}.0015$. A similar analysis of the y data on the same period gives a full amplitude of $0^{\mathrm{m}}.0053 \pm 0^{\mathrm{m}}.0007$ with an rms of $0^{\mathrm{m}}.0018$. Since the rms residuals closely match the precision of the observations, the light curve is adequately modelled by a single period with constant amplitude.

Breger (1979) defines the δ Scuti variables as stars of spectral type A or F with pulsation

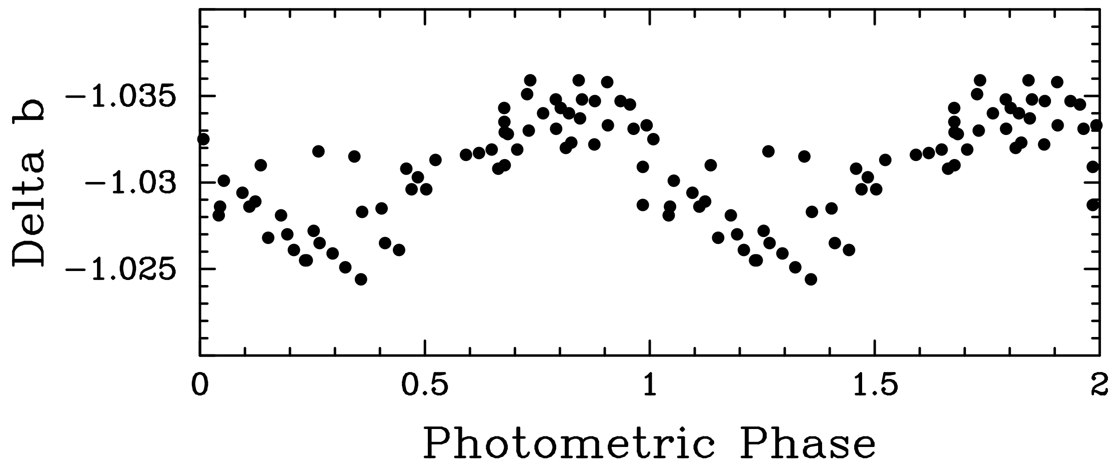

Figure 2. Strömgren *b* differential magnitudes plotted versus photometric phase computed with the ephemeris in Equation 1.

periods less than $0^{\mathrm{d}}.3$. He lists 130 δ Scuti stars in his Table I, and all have periods under this limit. Kaye et al. (1999) describe the γ Doradus stars as early-F variables with one to five periods in the range $0^{\mathrm{d}}.4$ to 3^{d}. Thus, if our $0^{\mathrm{d}}.3452$ period for HD 49015 is correct, it falls above the upper period limit of the known δ Scuti variables and below the lower limit for known γ Doradus variables. When HD 49015 is plotted in the color-magnitude diagram of Handler (1999, Figure 1), it lies outside the cool edge of the δ Scuti instability strip but falls comfortably within the distribution of γ Doradus variables. Its absolute magnitude is fainter than nearly all of the δ Scuti stars in Breger (1979) but is near the mid-range of the γ Doradus absolute magnitudes in Kaye et al. (1999). We conclude that HD 49015 may be a new γ Doradus variable with a period shorter than any other known γ Doradus star. Further observations are desirable to confirm the photometric period.

Astronomy with automated telescopes at Tennessee State University is supported through NASA grants NCC5-96 and NCC5-228, which funds the Center for Automated Space Science, and NSF grant HRD-9706268, which funds the Center for System Science Research.

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