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

Number 5575

Konkoly Observatory
Budapest
12 November 2004

HU ISSN 0374 – 0676

DETECTION OF THE ROTATIONAL PERIOD OF HD 179949?

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HD 179949 (HR 7291, HIP 94645, Spectral class F8-F9) was reported to be a 51 Peg-type star having a planetary companion with a minimum mass of 0.84 ± 0.05 $M_{\rm Jupiter}$ orbiting in a slightly eccentric orbit $e = 0.05$ with the period of 3.093 days (Tinney et al. 2001).

Recently, Shkolnik (2004) confirmed the planetary orbit. She detected sinusoidal radial-velocity variations of HD 179949 with the 3.093-d period and a full amplitude of about 250 $\rm ms^{-1}$. She also reported the modulation of the strength of the Ca II K emission of HD 179949 with the orbital period of the planetary companion and interpreted it as a convincing case of planet-induced activity. She pointed out the need for determination of the rotational period of HD 179949.

We attempted to detect the light variations of HD 179949. Our new photoelectric UBV observations were obtained with the modular photometer utilizing a Hamamatsu EA1516 photomultiplier attached to the 0.5-m telescope at the Sutherland site of the South African Astronomical Observatory (SAAO) during two weeks in April/May 2004. The photoelectric measurements were carried out by MW through the UBV filters of the Johnson's photometric system with 10-second integration time. All observations were carefully reduced to the Cousins E-region standard system (Menzies et al. 1989) and corrected for differential extinction using the reduction program HEC 22 rel. 14 (Harmanec & Horn 1998). The standard errors of these measurements were about $0\overset{\rm m}{.}009$, $0\overset{\rm m}{.}007$ and $0\overset{\rm m}{.}006$ in U, B and V filters, respectively. The nearby star 42 Sgr (also HR 7292, HIP 94643, Sp. K0), the constancy of which was verified from its Hipparcos H_p photometry (Perryman et al. 1997) served as the only comparison star. (Since the observations were carried out along with another observing program, we regrettably did not observe any check star.) Extinction and its mild time variability during each the night were taken into account, although the effect for differential photometry was small in this particular case. We derived the following very accurate mean all-sky values of UBV magnitudes and colour indices of the comparison 42 Sgr

$$V = 4\overset{\rm m}{.}860 \pm 0\overset{\rm m}{.}013,\ B-V = 0\overset{\rm m}{.}566,\ U-B = 0\overset{\rm m}{.}317$$

and of HD 179949:

$$V = 6\overset{\rm m}{.}237 \pm 0\overset{\rm m}{.}012,\ B-V = 0\overset{\rm m}{.}550,\ U-B = 0\overset{\rm m}{.}061\,.$$

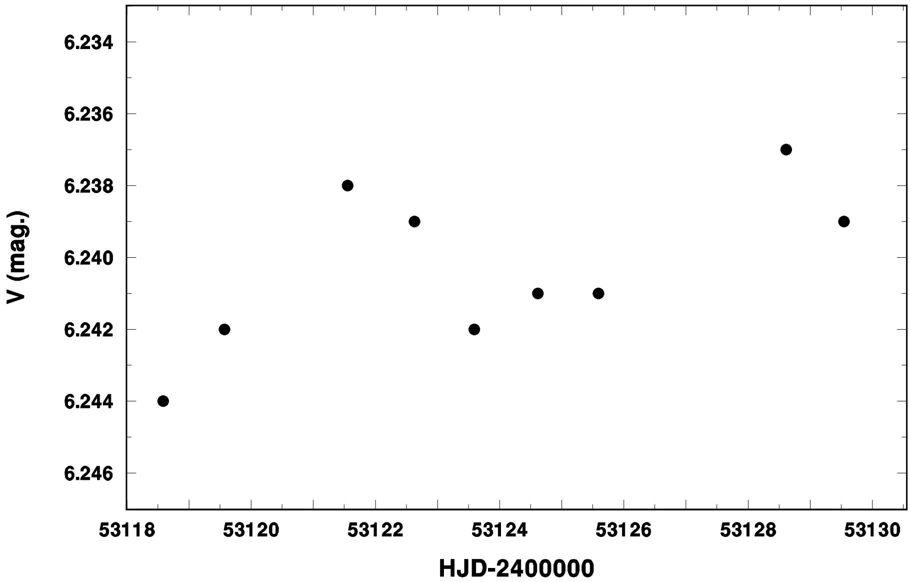

Figure 1. Normal points of SAAO V photometry of HD 179949.

The differential photometry of HD 179949 relative to 42 Sgr gives exactly the same values as the above quoted all-sky values, which indicates that the reduction to the standard system was reliable.

We also transformed the H_p Hipparcos photometry (Perryman et al. 1997) to Johnson V magnitudes using the colour indices derived by us and the transformation formula derived by Harmanec (1998) and obtained $V = 6\overset{\text{m}}{.}243 \pm 0\overset{\text{m}}{.}007$, in an excellent agreement with the SAAO result. Having such accurate determination, we used the Hipparcos parallax and the above V magnitude estimates, bolometric correction after Code et al. (1976) and Popper's (1980) T_{eff} scale to obtain the stellar radius:

$R = 1.25 \pm 0.03 R_\odot$ for F8 (SIMBAD database), or

$R = 1.30 \pm 0.03 R_\odot$ for F9 (Groot et al. 1996).

According to our experience, the V band photometry is the most accurate (lower extinction, small colour transformation terms, flat energy distribution) for detection of any brightness changes. The SAAO V photometry (normal points consisting of 3-5 individual observations for each night) is presented in Fig. 1. It seems to show smooth variation with a possible time scale of about 7 days. We also carried out a Stellingwerf (1978) period analysis of Hipparcos photometry from 20 days down to 0.5 days (with the standard (5,2) bin/cover structure) to find out independently a significant period of 7.07-day. Combining both data sets and allowing for the small zero point shift, we found finally a period of 7.06549 ± 0.00061 days from a sinusoidal fit to the combined data set. The phase plot in Fig. 2 is based on all SAAO and transformed Hipparcos *individual* V observations.

With the above derived radius and identifying the 7.065-day period with the stellar rotational period, one obtains the equatorial rotational velocity of HD 179949 of about 9.3 km/s. Groot et al. (1996) derived an accurate value of the projected rotational velocity of HD 179949: $v \sin i = 6.3$ km/s. This would imply an inclination of rotational axis of HD 179949 of about 45°. This is a very plausible value since such intermediate inclinations are usually most favourable to the detection of rotation-associated phenomena, both in the spectra and in photometry.

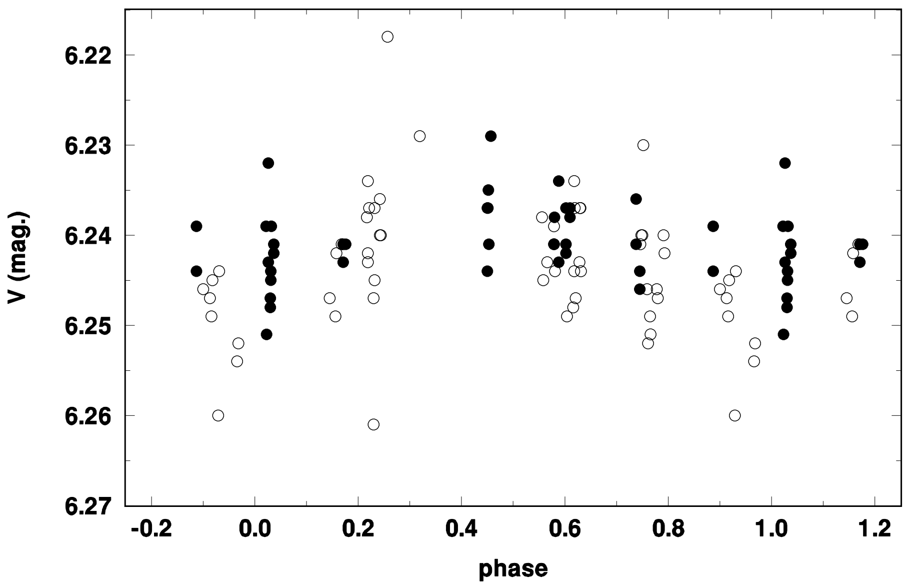

Figure 2. Individual SAAO (•) and Hipparcos V (∘) observations of HD 179949 plotted vs. phase of the 7.06549-d period.

We therefore tentatively conclude that the 7.06549-d period is indeed the rotational period of the star. No doubt, however, that more photometric observations in excellent observing conditions are needed to verify our result. The same is actually true also for the Ca II flux observations of Shkolnik (2004) although the phase dependence on the planetary period seems quite impressive. She claims that the PDM Stellingwerf period search detected a period near 3 days as the best one in her Ca II K data but does not mention which bin/cover structure she used. We found that using different bin/cover structures like (5,2), (4,3) or (4,4) we detected different possible periods as the best ones, never a period near 3 days. A very good phase diagram was found, for instance, for a period of 1.42079 days but this can be a fortuitous coincidence only. Plotting the Ca II flux vs. phase of the 7.065-d period does not give a convincingly looking phase diagram.

Acknowledgements This investigation was supported by from the research plan J13/98: 113200004 of Ministry of Education, Youth and Sports. The research of MW was also supported by the Grant Agency of the Czech Republic, grant 205/04/2063 and by allocation of SAAO observing time. MW thanks the staff at SAAO for their warm hospitality and help with the equipment. We also thank to Drs. Evgenya Shkolnik and Gordon A.H. Walker for calling our attention to HD 179949 and for the allowance to see their results prior to publication. This research has made use of the SIMBAD database, operated at CDS, Strasbourg, France, and of NASA's Astrophysics Data System Bibliographic Services.

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