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ONE NEW AND ONE SUSPECTED DELTA SCUTI STAR: HD 192871 AND HD 230990

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During surveys for photometric variability among λ Bootis stars (e.g. Paunzen et al. 1998) and among central stars of young Planetary Nebulae (Handler 1998), we serendipitously discovered two new δ Scuti stars. These were preliminarily announced elsewhere (Handler & Paunzen 1995), and got the variable designations V383 Vul and V336 Sge. Here we would like to give a more complete account on those stars together with an astrophysical interpretation supplemented by additional data.

We obtained differential photoelectric photometry relative to two comparison stars with the Texas two-channel photometer — employing only channel 1 — attached to the 90-cm telescope at McDonald Observatory. An aperture of 27″ was used to minimize the influence of seeing and guiding. Filters and integration times used depended on the observing programme and will be described separately. Data reduction comprised deadtime correction, sky background subtraction, extinction correction and conversion to Heliocentric Julian Date (HJD).

HD 192871 was used as a comparison star for the λ Bootis star HD 192424; the second comparison star was HD 193668. These three stars are all around 7th magnitude and were observed for 40 seconds in each of the Strömgren v and b filters before switching to the next object. Whereas HD 192424 and HD 193668 turned out to be constant within the level of measurement accuracy, HD 192871 showed conspicious light variations. Reduced v filter light curves of all three stars are shown in Fig. 1.

A single-frequency solution to the differential v filter light curve of HD 192871 results in a formal period of 265 minutes and in a photometric amplitude of 28 mmag. However, it is obvious from Fig. 1 that the star is a multiperiodic variable; hence our period should not be taken at face value.

HD 192871 was also a target of the HIPPARCOS mission (ESA 1997). Indeed it was detected to be variable, but its light curve was classified as “unsolved”. From a new analysis, Koen & Eyer (2001) reported a period of 283 minutes for the star. We also performed a frequency analysis of the HIPPARCOS observations and obtained a complicated amplitude spectrum, with an attempted two-frequency solution not being sufficient to decrease the scatter down to measurement accuracy. It appears that the

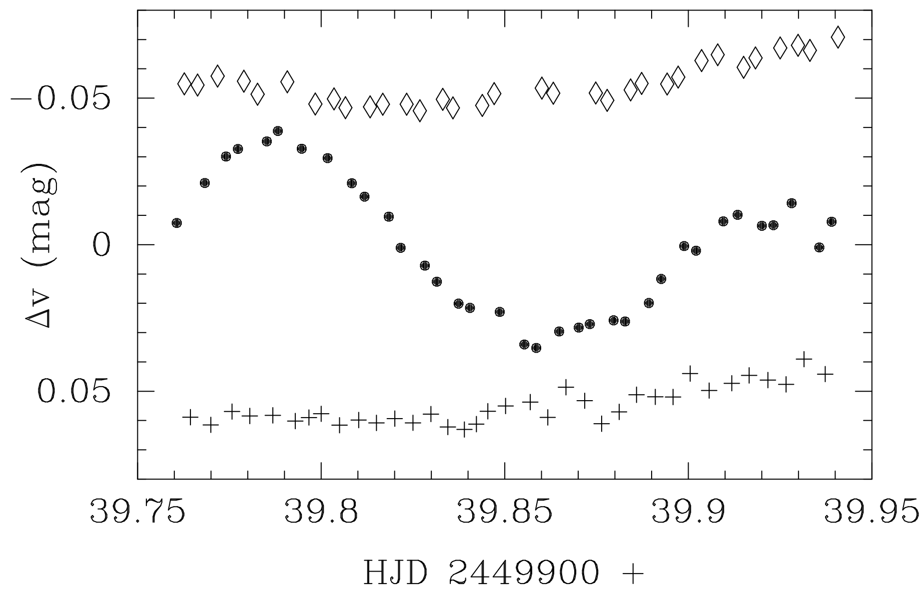

Figure 1. Reduced v filter time series of HD 193668 (diamonds), HD 192871 (filled circles) and HD 192424 (plus signs) as zero-point shifted instrumental magnitude variations. No correction for variations in sky transparency was applied to allow the reader to judge the quality of the data better

star has a rich frequency spectrum thus requiring further observations for a satisfactory solution of its light curve.

Turning to a discussion of the pulsational behaviour of the star, we first determined its absolute visual magnitude from its HIPPARCOS parallax and arrived at $M_v = 0.7 \pm 0.3$. Standard Strömgren indices from Hauck & Mermilliod (1998) are $b{-}y = 0.205$, $m_1 = 0.173$ and $c_1 = 0.884$. Since no Hβ photometry of the star was available, we obtained such a measurement as part of a larger programme (Handler 1999) and determined $\beta = 2.741$.

Applying calibrations for Strömgren photometry (Crawford 1979) and results of model atmosphere calculations (Kurucz 1991), this yields $\delta m_1 = 0.002$, $\delta c_1 = 0.218$, $M_v = 1.0 \pm 0.3$ (the latter in reasonable agreement with the HIPPARCOS results) as well as $T_{\rm eff} = 7100 \pm 100$ K and $\log g = 3.2 \pm 0.1$. A 265-minute pulsation period used in the equation

$$\log Q_i = -6.456 + 0.5 \log g + 0.1 M_{\rm bol} + \log T_{\rm eff} + \log P_i \qquad (1)$$

resulting from the period-mean density relation then gives a pulsation "constant" $Q = 0.022 \pm 0.004$. The quoted error estimates are to be seen as rough guides. A comparison with published Q values (e.g. Fitch 1981) suggests that the star pulsates in modes around the second radial overtone.

Finally, we would like to comment on the spectral classification of the star. Its published spectral type is F3 II originating from the Case–Hamburg Northern Milky Way Luminous Stars Survey (Stock et al. 1960). Bouw (1981) gives an infrared spectral type of F6 II. However, our results supported by the consistent pulsational behaviour suggest that the star is rather F1 III. Our δm_1 value implies that the star is slightly more metal-rich than the Sun which could be part of the explanation for this discrepancy.

A second δ Scuti candidate we report here is HD 230990. It was used together with HD 231007 as comparison star for the Planetary Nebula WhMe 1. For these observations, the V filter was used. We adopted 60-second integrations for the 9th-magnitude comparison stars. However, we measured the much fainter WhMe 1 (instrumental $V \approx 13.4$) for

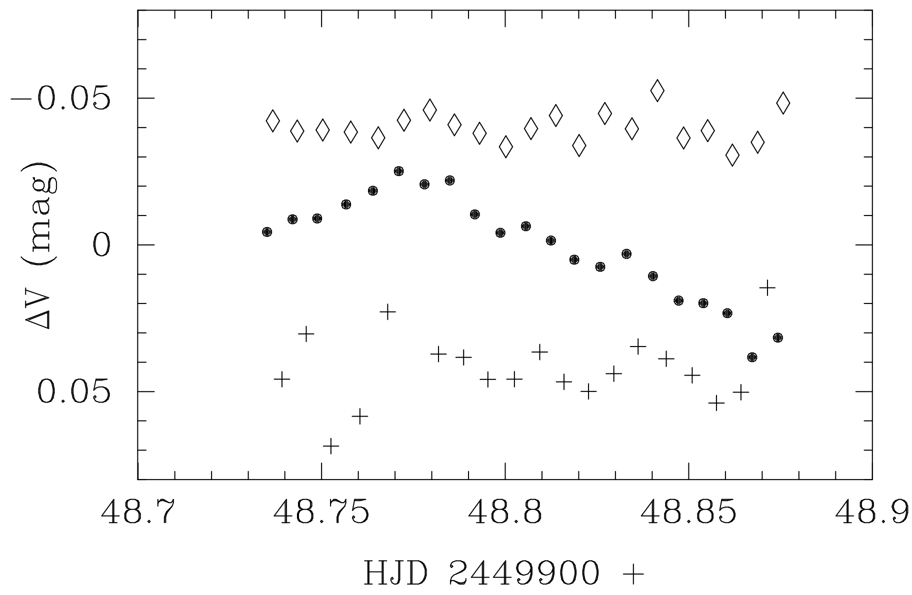

Figure 2. Reduced V filter time series of HD 231007 (diamonds), HD 230990 (filled circles) and WhMe 1 (plus signs) as zero-point shifted instrumental magnitude variations. No correction for variations in sky transparency was applied to allow the reader to judge the quality of the data better. The lower precision of the measurements of WhMe 1 is due to the faintness of this object, but they are of sufficient quality to show that HD 230990 is variable

3 minutes per observing cycle followed by a 30 second sky measurement. The variability of HD 230990 is demonstrated in Fig. 2.

Our derived time scale of the light variations of HD 230990 is coincidentally the same as for HD 192871, 265 minutes. We stress that this is only a lower limit, since we did not cover a full cycle of the light curve. The associated V amplitude is 22 mmag.

Owing to the faintness of HD 230990, little is known about this star, e.g. there are no HIPPARCOS observations and there were no published Strömgren colour indices at the time of the discovery of its variability. Consequently, we obtained $uvby\beta$ photometry of this star with the 0.5-m telescope and the Modular Photometer at the South African Astronomical Observatory. The β index, 2.781, was published by Handler (1999), but new $uvby$ colours were acquired in the night of July 18/19, 2000 as well. These yield standard values of $V = 9.34 \pm 0.02$, $b-y = 0.323 \pm 0.007$, $m_1 = 0.127 \pm 0.012$ and $c_1 = 0.893 \pm 0.012$, placing the star well inside the δ Scuti instability strip after dereddening.

Using the same procedures as before, we obtain $E(b-y) = 0.170$, $\delta m_1 = 0.016$, $\delta c_1 = 0.117$, $M_v = 1.8 \pm 0.3$, $T_{\rm eff} = 7600 \pm 100$ K and $\log g = 4.0 \pm 0.1$. This yields an uncomfortably high $Q > 0.074$ for a 265-minute lower limit to the period, which suggests that the star could pulsate in a gravity mode; we have no reason to doubt any of our measurements. It is also possible that HD 230990 is some short-period binary, but we add that such high Q values are unusual for δ Scuti stars, but not unprecedented. For instance, Koen et al. (1999) discussed several cases. Obviously, more observations of HD 230990 are required to infer a more reliable period and to prove its δ Scuti nature fully.

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