

HD 208238 as a δ Scuti Variable Star

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Abstract We present observations that show HD 208238 to be a variable star with a period of 0.048622 day and with a range of 0.021 and 0.018 magnitude in the V and R filters, respectively. Its spectral type is determined to be A4V or A5V. We conclude that this star is a hot δ Scuti variable star.

1. Introduction

HD 208238 is a ninth magnitude star (R.A. $21^{\text{h}} 54^{\text{m}} 33.5^{\text{s}}$, Dec. $+14^{\circ} 32' 05.28''$ (2000)). Its HD catalogue spectral type is A3. The star is located just 2.7 arc minutes from the eclipsing binary DF Peg. While observing DF Peg, we discovered that HD 208238 is likely a δ Scuti variable star. δ Scuti variable stars are generally low amplitude variables, with spectral types usually between A5 and F2, and short periods (0.02 to 0.3 day), although most are multi-periodic. Variability is attributed to radial and non-radial pulsations. They are located at the intersection of the Cepheid instability strip and the main sequence on the HR diagram (see Percy 2007; Templeton 2004 for overviews).

2. Observations

HD 208238 was observed with a 0.4-meter telescope and an SBIG ST-10 CCD camera of the Ball State University observatory. The $f/6$ focal ratio gave a scale of 0.58 arc second per pixel. The exposures alternated between the V and R filters, with typical exposure times of 50 and 35 seconds, respectively. The CCD images were collected in an autonomous mode where the telescope and camera were controlled by CCDAUTOPILOT (Smith 2008). The observations are summarized in Table 1. They were made with Johnson-Cousins V and R filters. IRAF (Tody 1993) was used to subtract the bias and dark current, and to flat-field correct each image. Differential aperture photometry was done with the software package AIP4WIN (Berry and Burnell 2006). Information about the comparison and check stars can be found in Table 2. There are a total of 498 V and 495 R measurements. Photometric errors of each measurement were

determined by a signal-to-noise calculation involving camera read noise, camera gain, dark current, and the sky background. The error for each delta magnitude was found by adding the individual errors for the variable and comparison star in quadrature. The typical error of a differential measurement ranged between 0.002 and 0.004 magnitude.

3. Light Curves

Figure 1 shows the instrumental differential V and R magnitudes versus time for the night of August 8, 2008 (UT). There is a max-to-min variation of about 0.021 and 0.018 magnitude in V and R , respectively. A Lomb-Scargle power spectrum (Lomb 1976; Scargle 1982) of the V data produced with the PERANSO software package (Vanmunster 2007) is shown in Figure 2. There is a single strong period with the usual 24-hour aliases. This period is the same for both filters, 0.048622 ± 0.000026 day. Figure 3 shows the V data phased on this period. Figure 4 shows the period search after pre-whitening with this period. No significant residual periods are seen. Also, period searching a single night (August 8) produced the same period (0.0486d) without the aliases.

4. Spectral Classification and Color

HD 208238 was classified on an objective-prism plate taken with the 60-cm Burrell Schmidt at Kitt Peak National Observatory (KPNO). The exposure was 20 minutes on Kodak IIa-O using a 10-degree prism, yielding a dispersion of about $110\text{\AA}/\text{mm}$ at H γ ; the spectra are widened 0.8 mm. Matching directly against exposures of MK standards of similar photographic density, the star appears to be of type A4/5V (i.e., type A4 or A5) with no peculiarities evident at $\sim 2\text{\AA}$ resolution. The luminosity class was estimated by comparison of line ratios in giants and dwarf standard stars. Using the parallax from the Hipparcos catalog, an assumed interstellar extinction of 1 mag / kpc and $R = 3$, an intrinsic $(B-V)$ was estimated to be 0.15–0.18. This is consistent with the value of 0.15 for an A5V star (Lang 1992). Given the uncertainty in the extinction assumptions, a spectral type of A4V is not excluded by these estimates.

5. Conclusions

HD 208238 is a δ Scuti variable star. This classification is consistent with the amplitude and period of the light variations and its spectral type. This star appears to be one of the hotter members of the δ Scuti class of variable stars.

It is somewhat ironic that Soydugan *et al.* (2006) predicted that one component of the eclipsing binary DF Peg was likely to be a δ Scuti star. We found no evidence of DF Peg displaying this behavior, but a star just 2.7 arc minutes away, HD 208238, does.

6. Acknowledgment

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References

- Berry, R., and Burnell, J. 2006, "Astronomical Image Processing Software," provided with *The Handbook of Astronomical Image Processing*, Willmann-Bell, Richmond, VA.
- Lang, K. R. 1992, *Astrophysical Data: Planets and Stars*, Springer, New York
- Lomb, N. R. 1976, *Astrophys. Space Sci.*, **39**, 447.
- Percy, J. R. 2007, *Understanding Variable Stars*, Cambridge Univ. Press, New York, p. 182.
- Scargle, J. D. 1982, *Astrophys. J.*, **263**, 835.
- Smith, J. 2008, CCDAUTOPILOT 4.0, <http://www.ccdware.com/products/ccdap4/>
- Soydugan, E., Soydugan, F., Demircan, O., and Ibanoglu, C. 2006, *Mon. Not. Roy. Astron. Soc.*, **370**, 2013.
- Templeton, M. 2004, www.aavso.org/vstars/vsots/summer04.pdf
- Tody, D. 1993, *Astronomical Data Analysis Software and Systems II*, ASP Conf. Ser., Vol. 52, R. J. Hanisch, R. J. V. Brissenden, and J. Barnes, eds., San Francisco, Astronomical Society of the Pacific, p. 173.
- Vanmunster, T., 2007, PERANSO period analysis software, <http://www.peranso.com>
- Zacharias, N., Monet, D. G., Levine, S. E., Urban, S. E., Gaume, R., and Wycoff, G. L. 2004, *Bull. Amer. Astron. Soc.* **36**, 1418.

Table 1. HD 208238 observations summary.

UT Date	HJD Range	Mean Differential Error	
		ΔV	ΔR
2008 July 24	2454671.6990–.8731	0.00245	0.00234
2008 August 3	2454681.6369–.7646	0.00285	0.00302
2008 August 8	2454686.6335–.9142	0.00327	0.00345
2008 August 11	2454689.6243–.8629	0.00393	0.00407
2008 August 12	2454690.6187–.8043	0.00370	0.00377

Table 2. Comparison and check stars.

	<i>Designation</i>	<i>R.A. (2000)</i>	<i>Dec. (2000)</i>	<i>V</i> <i>(NOMAD)*</i>	<i>R</i> <i>(NOMAD)*</i>
Comp	BD+13 4805	21 ^h 54 ^m 40.1 ^s	+14° 37' 06.3"	10.90	10.61
Check	TYC 1134-0876-1	21 ^h 54 ^m 57.7 ^s	+14° 27' 37.8"	11.77	11.30

**Naval Observatory Merged Astrometric Dataset (NOMAD, Zacharias, et al. 2004).*

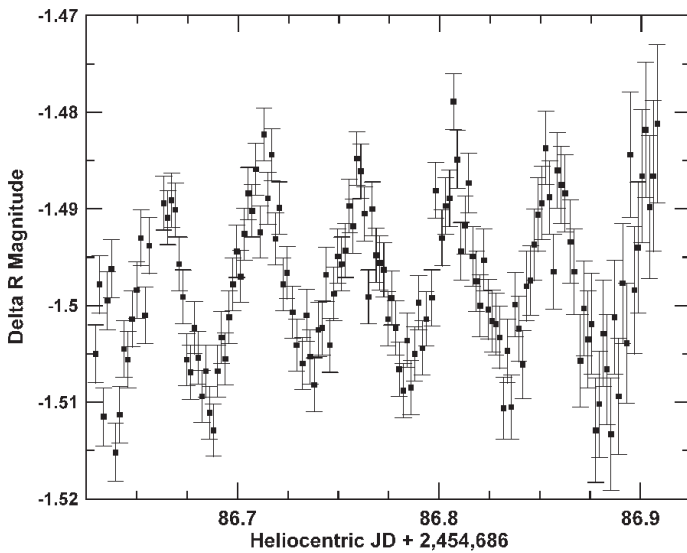


Figure 1a. ΔR magnitudes of HD 208238 on the night of 2008 August 8 (UT).

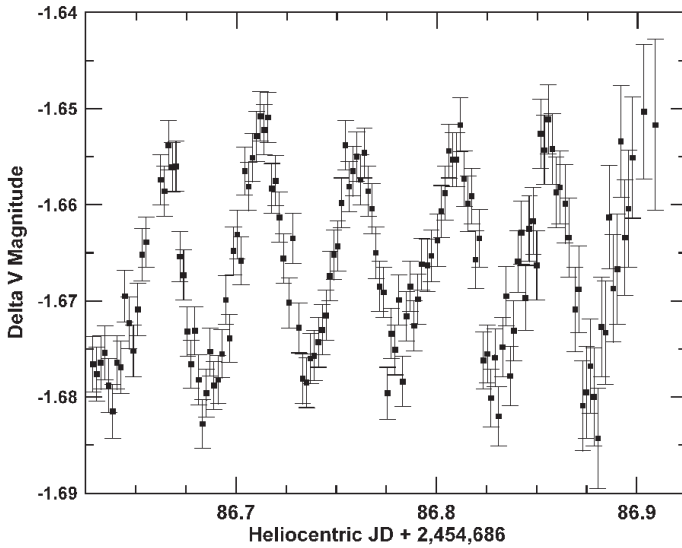


Figure 1b. ΔV magnitudes of HD 208238 on the night of 2008 August 8 (UT).

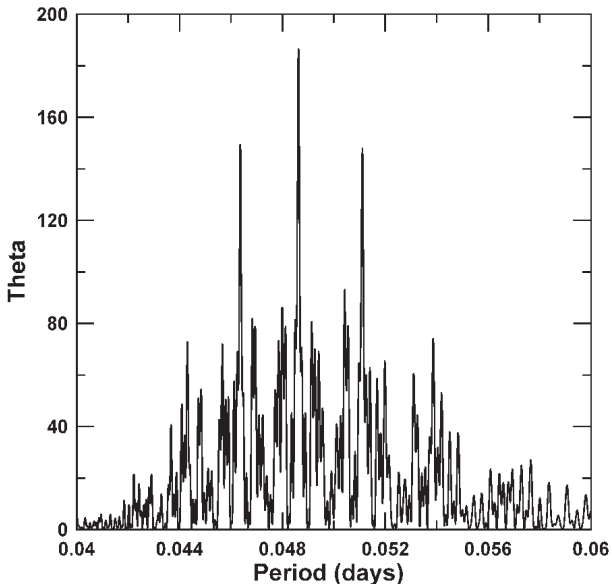


Figure 2. The power spectrum analysis of the differential V magnitudes of HD 208238.

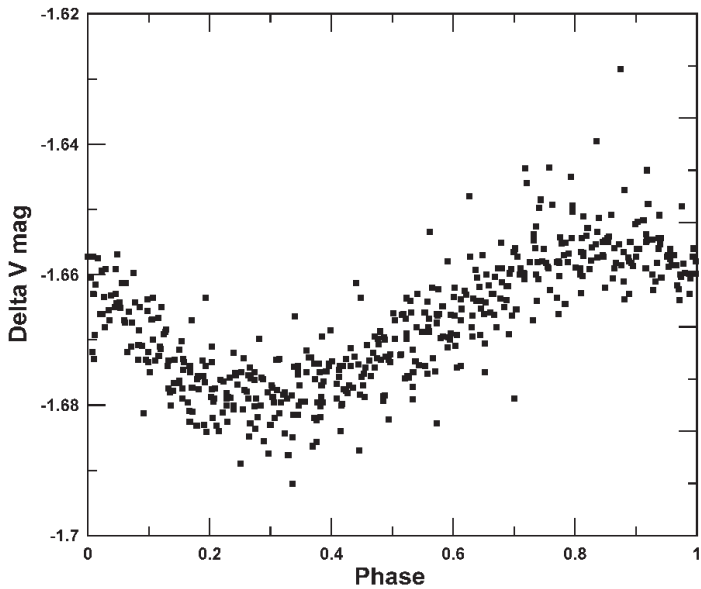


Figure 3. The differential V magnitudes of HD 208238 phased on the determined period.

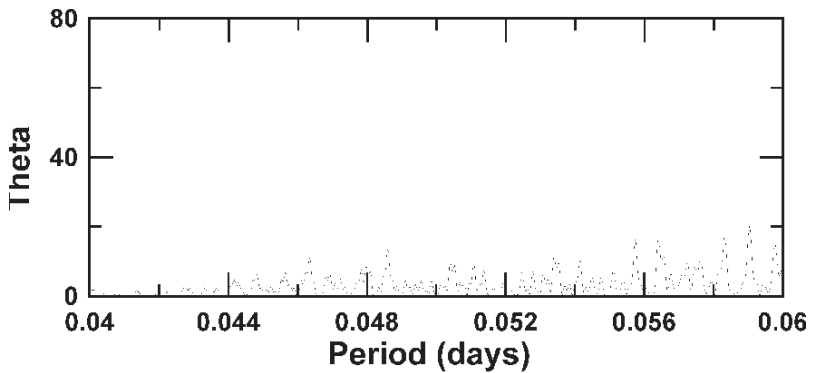


Figure 4. Results of period-searching the V data after removing the 0.048622-day period.