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HD 67852: A NEW δ SCUTI VARIABLE

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The early-F star HD 67852 was used as a photometric comparison star with the T8 0.8 m automatic photoelectric telescope (APT) at Fairborn Observatory[1] in our program to follow brightness changes in a large sample of solar-type stars (Baliunas et al. 1998; Henry 1999). It was recognized as a low-amplitude variable from 51 Strömgren *by* observations in the 2000–2001 observing season and placed on the observing menu of the T3 0.40 m APT at Fairborn the next year to obtain additional Johnson BV measurements.

Very little is known about HD 67852. Olsen (1979) estimated it to be either a reddened Ap star, a λ Bootis star, or, less plausibly, a field horizontal branch star, based on its Strömgren indices. Gray (1989) obtained a spectrum and classified it as F0 Vn, noting that it was broad-lined and possibly somewhat metal-weak. The *Hipparcos* satellite made 64 photometric measurements and found no variability (ESA 1997). The *Hipparcos* mean $V = 7\overset{\mathrm{m}}{.}72$, $B-V = 0\overset{\mathrm{m}}{.}245$, and parallax of 0.00845 arcseconds place the star on the main sequence near the middle of the δ Scuti instability strip. García-Sánchez et al. (2001) found HD 67852 to be one of 156 stars that have passed or will pass closer than five parsecs to the Sun within ± 10 Myr of the present; their results show the star encountered the solar system about 4.3 Myr ago at a heliocentric distance of 2.9 pcs. By the *Hipparcos* epoch, the star had moved out to a distance of 118 pcs and continues to recede from the Sun with a radial velocity of 26 ± 7 km s^{-1} (García-Sánchez et al. 2001).

In this paper, I analyze the $\sim$360 Johnson BV observations obtained with the T3 APT between 2001 September and 2002 May. The data acquisition, reduction, and analysis methods, incorporating the method of Vaniĉek (1971), have been described in Henry et al. (2001). The photometric observations were made differentially with respect to HD 66950 ($V = 6\overset{\mathrm{m}}{.}40$, $B - V = 1\overset{\mathrm{m}}{.}06$, K0) as the comparison star and HD 65123 ($V = 6\overset{\mathrm{m}}{.}35$, $B - V = 0\overset{\mathrm{m}}{.}51$, F6 V) as a check star. The check minus comparison ($K - C$) differential magnitudes were constant to 0.006 and 0.007 mag (standard deviation) in B and V, respectively, which is close to the limit of precision for the T3 APT. The variable minus comparison ($V - C$) differential magnitudes had standard deviations of 0.013 and 0.011 mag in B and V, respectively, indicating definite variability in HD 67852. The individual photometric observations are available on the Tennessee State University Automated Astronomy Group web site[2].

[1]For further information on Fairborn Observatory see `http://www.fairobs.org`.
[2]See `http://schwab.tsuniv.edu/papers/ibvs/hd67852/hd67852.html`.

An important feature of the Vaniĉek technique is its ability to find multiple periods without prewhitening. Power spectra of the $(V-C)$ and $(K-C)$ differential magnitudes in both the B and V passbands were computed with the Vaniĉek method over the frequency range 0.01–50 day^{-1}, which corresponds to the period range 0.02–100 days. No evidence for periodic variability in the $(K-C)$ observations was found, confirming the suitability of the comparison and check stars as photometric references. The results for the $(V-C)$ observations in B are given in Figure 1, which has been truncated at a frequency of 20 day^{-1} since no variability at higher frequencies was found.

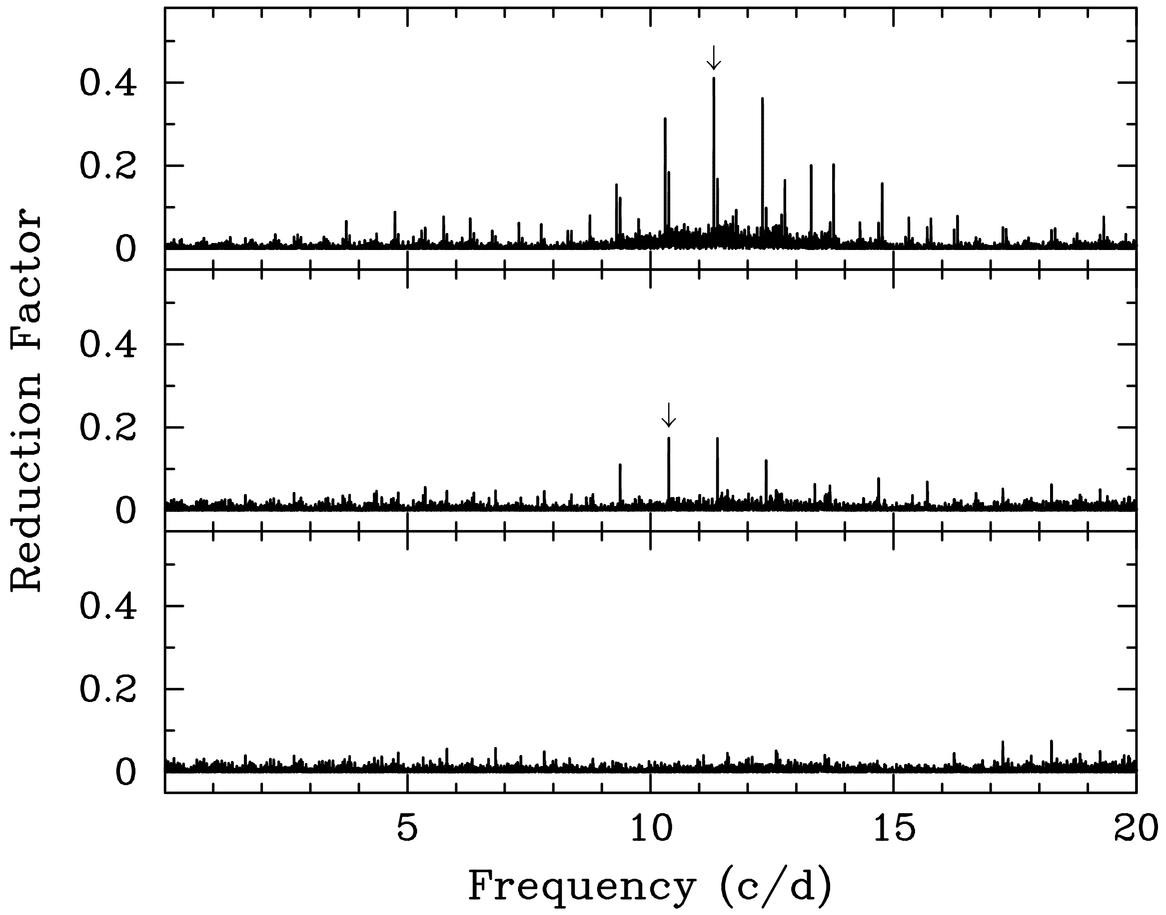

Figure 1. Power spectra of the HD 67852 Johnson B observations obtained with the T3 APT. The top panel reveals the strongest frequency at 11.3027 day^{-1}. With that frequency fixed, the power spectrum in the middle panel was computed, revealing a second frequency at 10.3756 day^{-1}. The power spectrum in the bottom panel was computed with the first two frequencies fixed and reveals no additional frequencies.

Two frequencies were detected, corresponding to periods of 0.088474 and 0.096380 days. The peak-to-peak amplitudes in B were 23.3 and 15.7 mag, respectively. As can be seen in the middle panel of Figure 1, the identification of the second frequency is somewhat ambiguous; it and its 1-day alias have similar reduction factors. Therefore, it is possible that 11.377 day^{-1} is the correct second frequency. Essentially the same results were obtained with the V dataset. The results are summarized in Table 1. The B/V amplitude ratios for the two periods are 1.46 and 1.63, respectively. The times of minimum in the two passbands agree within their errors for both periods.

Table 1. Photometric Analysis of HD 67852.

Photometric Band	$N_{\rm obs}$	Frequency (day^{-1})	Period (days)	Peak-to-Peak Amplitude (mmag)	$T_{\rm min}$ $(HJD - 2,450,000)$
B	371	11.3027	0.088474	23.3	2,300.031
		±0.0003	± 0.000002	± 1.5	± 0.001
		10.3756	0.096380	15.7	2,300.081
		±0.0002	± 0.000002	± 1.7	± 0.002
V	358	11.3028	0.088474	16.0	2,300.030
		±0.0002	± 0.000002	± 1.3	± 0.001
		10.3750	0.096386	9.6	2,300.082
		±0.0002	± 0.000002	± 1.5	± 0.002

The B observations are plotted in Figure 2, where they have been phased with the two periods and computed times of minimum from Table 1. To render the low-amplitude variability more evident, the observations in each panel have been prewhitened to remove the other period. The photometric variations at both periods closely approximate sinusoids.

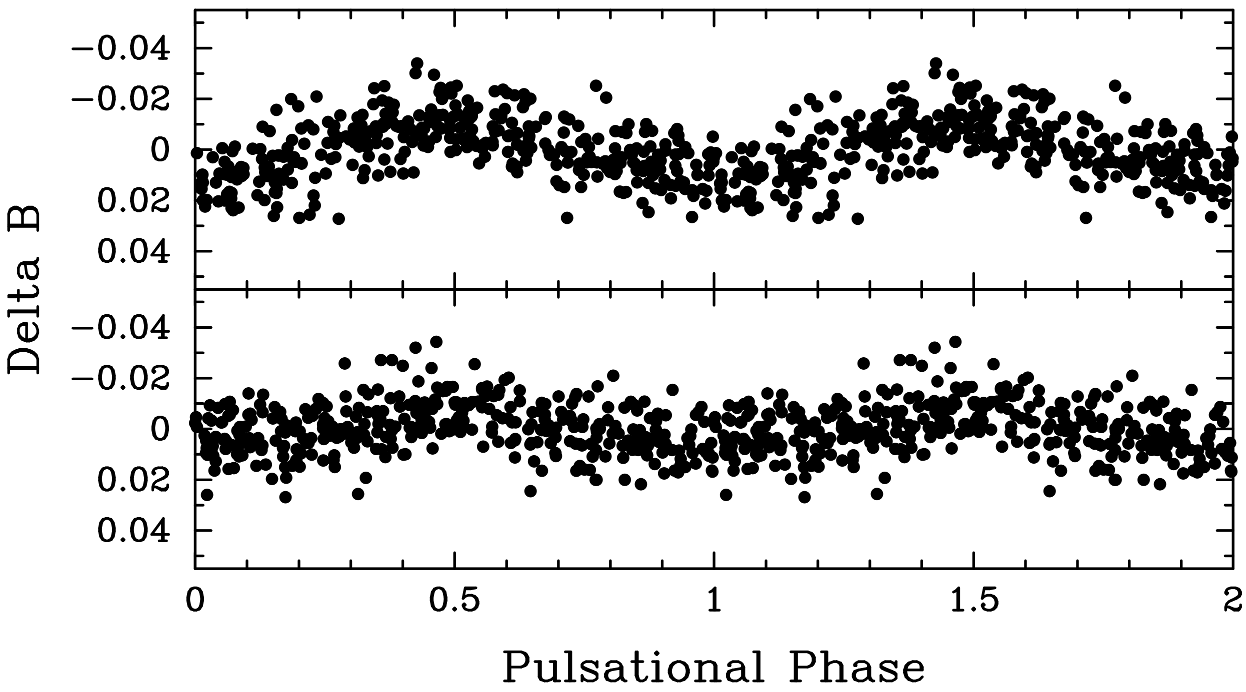

Figure 2. The Johnson B photometry phased with the two detected periods and times of minimum from Table 1. The observations are phased with the 0.088474-day period in the top panel and with the 0.096380-day period in the bottom panel. In each case, the data have been prewhitened to remove the other period.

The majority of known δ Scuti variables are Population I objects pulsating with low amplitudes in nonradial p modes (Breger 2000). The catalog of Rodríguez et al. (2000) shows that nearly 30% of the 636 known δ Scuti stars have amplitudes smaller than 0.02 mag, which implies that many more low-amplitude variables are yet to be discovered. The high-amplitude δ Scuti stars (HADS) and the Population II SX Phe subgroups have much higher photometric amplitudes of 0.3 mag or more (Breger 2000). As seen in Figure 5 of Rodríguez et al. (2000), the high-amplitude stars have low rotational velocities ($v \sin i < 20$ km sec^{-1}), while the low-amplitude stars rotate much more rapidly. HD 67852 clearly belongs to the more common low-amplitude, rapidly-rotating subgroup of δ Scuti variables.

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