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NEW PHOTOMETRY OF THE HYADES δ SCUTI STAR V777 Tau (71 Tau)

71 Tauri (= BS 1394 = vB 141 = V777 Tau) is a rapidly rotating, F0 IV–V member of the Hyades cluster. It is the second brightest X-ray source in the cluster, after V471 Tauri, and an intensely bright coronal EUV source (Stern *et al.* 1995). It is a lunar occultation binary, but the secondary star (estimated by Peterson *et al.* 1981 to be a G4 V star in possibly a 53 day orbit) has never been seen directly. As pointed out by Stern *et al.*, the tremendous X-ray luminosity of 71 Tau, $L_x = 10^{30}$ erg s^{-1}, is not the result of a flare. It is not easily explained as the coronal emission of an individual star, or even as the combination of emission from several stars, considering that most F–M Hyades stars are detected at levels of only $L_x \sim$ few $\times 10^{29}$ erg s^{-1} (or in some cases, much less). The X-ray properties of 71 Tau are more in line with those of a very much younger star, but would still be considered remarkable even for a coronally active star in the $\approx$80 Myr old Pleiades cluster (Stauffer *et al.* 1994). 71 Tau has been observed a number of times by IUE and has been shown to be variable by as much as 30 % at ultraviolet wavelengths near 1700–2000Å (Simon and Landsman, in preparation).

Horan (1979) discovered that 71 Tau was a δ Scuti star with an amplitude of 0.01 to 0.02 mag. To our knowledge no other optical photometry of 71 Tau has ever been published. Horan gives a principal period of 3.9 hours (f = 6.15 d^{-1}) and suggests that 71 Tau may be excited in more than one mode. However, his conclusions are based on only 38 points obtained on two nights which were two months apart. From Horan's Figure 5 it seems much more likely that the principal period is near 4.4 hours if the decline in brightness occurs at the same rate as the increase of brightness.

We have obtained new photometry of 71 Tau, observed differentially with respect to BS 1422, amounting to 58 points on 5 nights during a 7 night run with the 0.6-m telescope at Mauna Kea. Observations of BS 1432 (the check star) vs. BS 1422 indicated that both were constant, so any variations in the differential magnitude of 71 Tau vs. BS 1422 may be attributed to 71 Tau. The individual data points can be obtained by requesting file 307E from IAU Commission 27, Archives of Unpublished Photometry (see Breger *et al.* 1990).

Figure 1 shows a power spectrum of the photometry of 71 Tau vs. BS 1422, using the Lomb-Scargle algorithm as presented by Press and Teukolsky (1988). Clearly, many aliases are present. On the basis of Horan's Figure 5 and folded plots of our data we believe the frequency near 5.5 cycles per day is more likely to be the true principal frequency, not its one-day alias at 6.5 d^{-1}. (Note that the frequency corresponding to Horan's period is between these two values.) Having settled on a principal period of 0.1823 day, we subtracted a properly phased least-squares sinusoid with that period from the data to see if other frequencies are present. That power spectrum is shown in Figure 2. We note that if $f_1 \approx 6.5$, essentially the same power spectrum of residuals results.

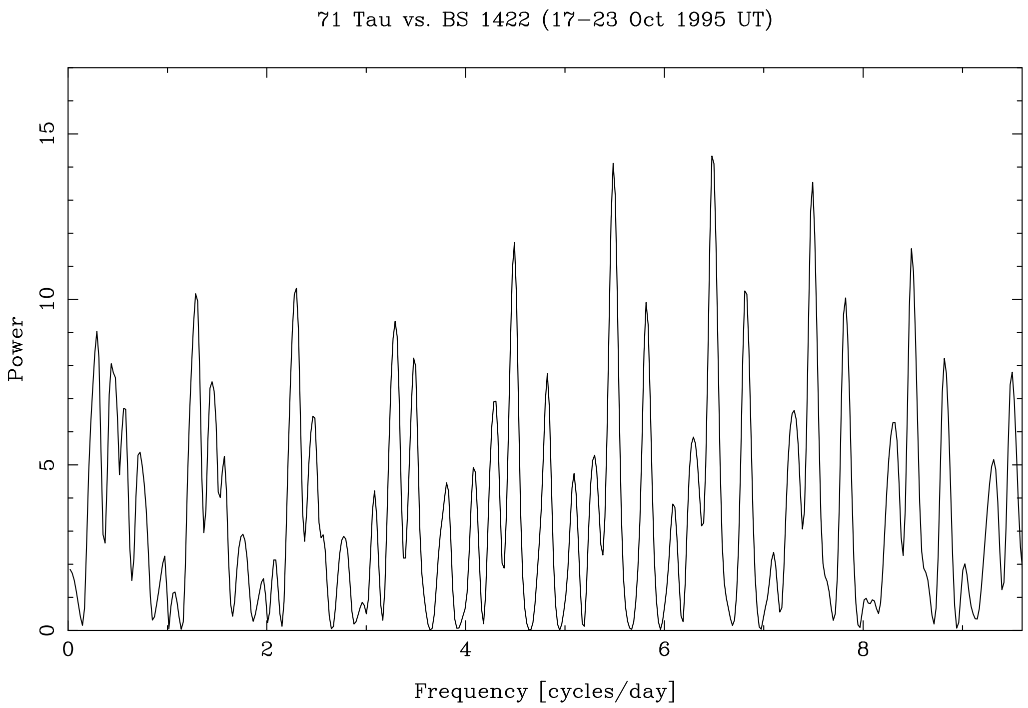

Figure 1 – Power spectrum of V-band differential photometry of 71 Tau vs. BS 1422.

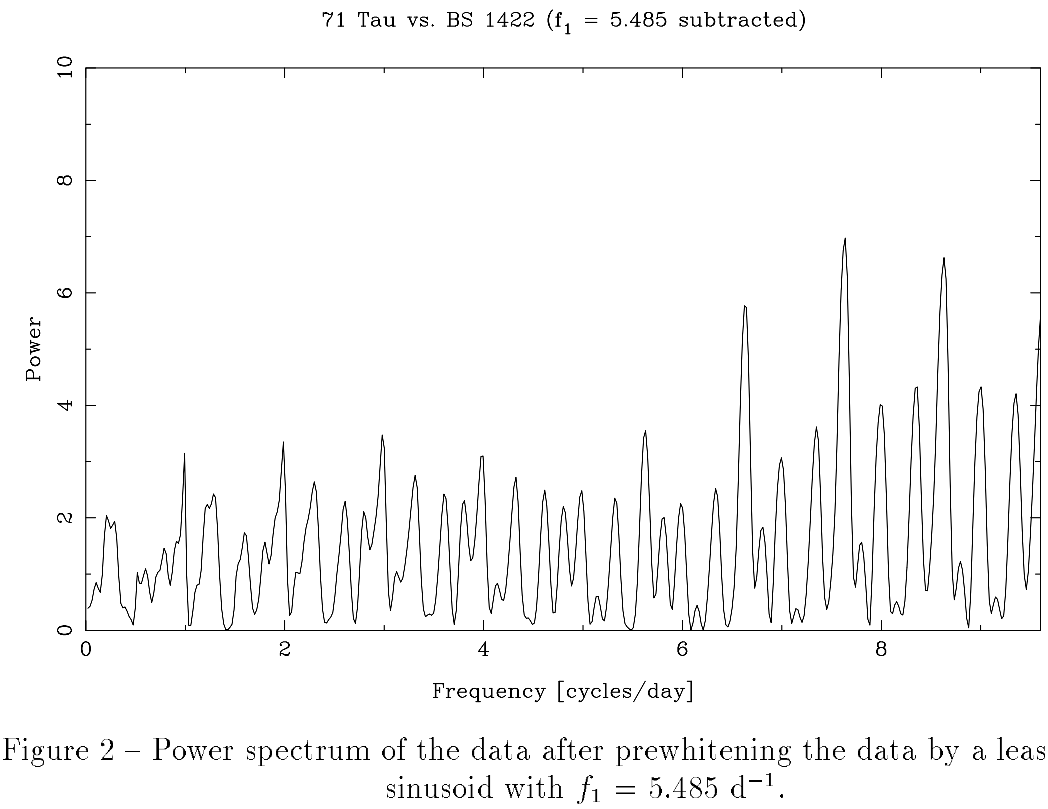

Figure 2 – Power spectrum of the data after prewhitening the data by a least-squares sinusoid with $f_1 = 5.485$ d^{-1}.

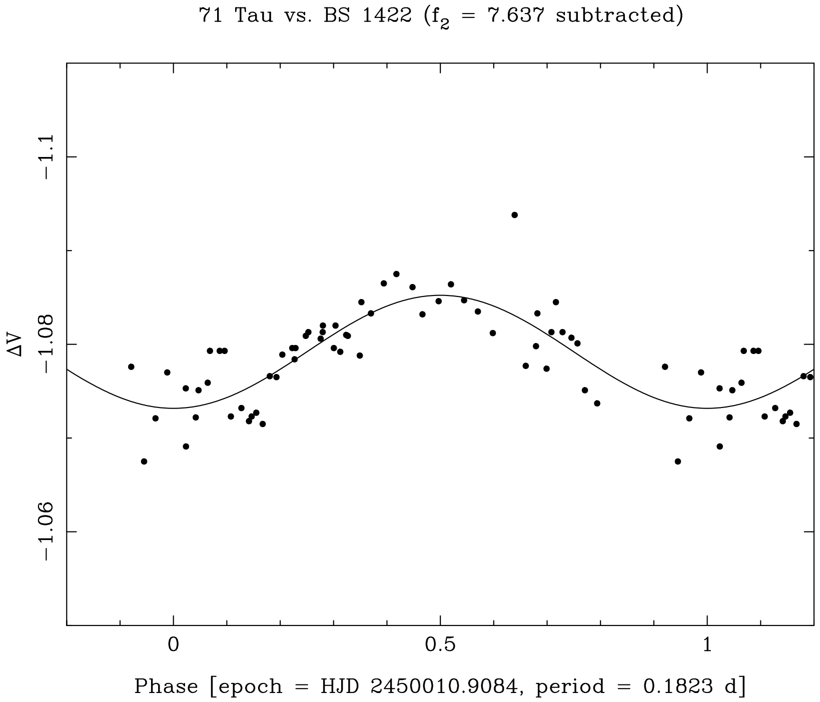

Figure 3 – Folded light curve of 71 Tau vs. BS 1422 V-band data, after prewhitening by the secondary sinusoid with $f_2 = 7.637$ d^{-1}.

One might assume that one of the peaks in Figure 1 represents pulsation in the fundamental radial mode, while one of the peaks in Figure 2 represents the first overtone radial mode. However, the period ratio of first overtone to fundamental should be close to the observed value of 0.773 (Breger 1993) – essentially equal to the theoretical value of 0.772 (Guzik and Bradley 1995). The closest we can come is $1/8.63 \div 1/6.49 \approx 0.752$. But given the small number of data points, we do not feel that this is the best method for choosing which peaks in the power spectrum are true and which are aliases.

Using an epoch of HJD 245 0000, we believe the following is the best two-frequency fit to the data: $f_1 = 5.485$ d^{-1}, amplitude = 6.0 ± 0.7 mmag, phase = 0.171 ± 0.016; $f_2 = 7.637$ d^{-1}, amplitude = 3.4 ± 0.7 mmag, phase = -0.439 ± 0.030. Thus, we find a principal period of 0.1823 days (4.38 hours), and a secondary period of 0.1309 days (3.14 hours). The ratio of the latter to the former is 0.718. Given the amplitudes of the two frequencies, we can account for a range in brightness up to 0.02 mag in V, and we can also account for the differing amplitudes observed by Horan on the two nights he measured the star.

Figure 3 shows our data folded by the principal period after the data have been prewhitened by the secondary frequency.

A definitive solution to the photometric behavior of 71 Tau could only be obtained from a more extensive data set than ours. In light of the unusual properties of this star at X-ray and ultraviolet wavelengths, such further study seems amply warranted.

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