MULTIPLE PERIODICITIES IN THE WHITE DWARF
HL TAU-76

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SUMMARY

Power spectrum analysis applied to the light curve of HL Tau-76 given by Warner and Nather has revealed at least three independent periodicities which entirely account for the phase deviations in pulse arrival times noted hitherto.

Photometric observations of the fifteenth magnitude white dwarf star HL Tau-76 have been presented in a series of papers by Warner & Nather (1), (2), (3). They found that the star has quasi-periodic outbursts at intervals of about 12.44 min which vary in amplitude and are complicated by a considerable phase jitter. Their data from runs on three nights were presented in Fig. 1 of paper (3). The strong phase variations imposed on the primary periodicity, together with the amplitude modulation, suggested that more than one regular period might be present, and a power spectrum analysis has therefore been carried out.

The photometric plots presented by Warner & Nather (3) were smoothed and sampled every 0.2 inch along the time axis which corresponds to intervals of approximately 100 s. The observations of run 1091 yielded 175 points and runs 1112 and 1115 each provided 208 points. Individual power spectra of the three runs were computed using the Cooley–Tukey algorithm and the average power spectrum obtained by combining the results is shown in Fig. 1. In addition to the prominent feature $f_1$ which corresponds to the period of 12.4 min given by Warner and Nather, other discrete frequencies $f_2, f_3$ and $3/2 f_1$ were found. The remaining maxima are probably harmonic combinations of these. The power scale of the figure is arbitrary but the peak at $f_1$ corresponds to a sinusoid with mean amplitude 280 counts per second. The components at $f_1$ and $2 f_1$ were present at about the same intensity on the three individual spectra whereas $f_2$ and $f_3$, while remaining roughly equal, appeared at about half intensity on run 1115 compared to the previous two runs. The peak at $3/2 f_1$ also appears to be variable.

Since the pulses are markedly non-sinusoidal, harmonics of the individual frequency components are to be expected but the presence of peaks at $f_1 + f_2$, $f_1 + f_3$ etc., indicates that some kind of modulation process is involved. Inspection of the light curves obtained by Warner and Nather indicates a tendency for large pulses to occur in groups of 3 or 4 at intervals of about $8 P_1$, where $P_1$ is the fundamental period of 12.4 min. This suggests that strong emission takes place only when $f_1, f_2$ and $f_3$ are suitably aligned in phase. If all three components are in phase at some instant, this condition will repeat at intervals of $16 P_1$, while for $f_1$ and $f_3$ alone the repeats will be at intervals of $8 P_1$.

The peaks in the spectrum at $f_2, f_3$ appear to be quite as sharp as $f_1$ and all are unresolved in the present analysis; this implies $Q > 40$. More precise values were found by interpolation between the computed elements of the spectrum. This was
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Fig. 1. Mean power spectrum of three runs of data from HL Tau-76; the vertical scale is arbitrary.
done for each run giving mean periods of 748.5 ± 28, 665 ± 28 and 628 ± 28. The computer program gave the phases as well as the powers of the components and these were used to combine runs 1112 and 1115 with only a small probability of ambiguity in the cycle count. The corrected periods then became 746.0 ± 0.58, 663 ± 18 and 626 ± 18. The value 746.0s = 12.435 min agrees well with corresponding values found by Warner & Nather (1) and by Landolt (4). It would be interesting to determine the secondary periods on other occasions to see whether they are sufficiently stable to enable a cycle count to be maintained over a considerably longer time.

The spectrum in Fig. 1 is similar to the multiple periodicities observed in F 548 (212.86s, 273.8s) and in G 44–32 (163.8s, 822s, 600s) by Lasker & Hesser (5) although for these white dwarfs the intensity variations were weaker. No simple explanation is apparent but a model along the lines proposed by Warner & Nather (6) for U Geminorum may be relevant. If the radiation is emitted from a localized region on a nebular ring surrounding the star, and if differential rotation takes place between the star and the nebula, some of the observed features might be reproduced.

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REFERENCES
