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AN ANALYSIS OF THE LIGHT CURVE OF THE ZZ CETI STAR G117-B15A

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RESUMEN: Se muestran los resultados del análisis de observaciones fotométricas obtenidas durante los últimos quince años. Los resultados sugieren que hay efectos no lineales en la curva de luz de esta estrella.

ABSTRACT: We show the results of the analysis of photometric observations obtained along the last fifteen years. The results suggest that nonlinear effects are present in the light curve of this star.

Key words: **STARS-LIGHT CURVE – STARS-VARIABLE**

I. INTRODUCTION

G117-B15A is a hydrogen rich pulsating white dwarf (DAV). It was identified as a proper motion star by Giclas, Burnham and Thomas in 1971 and found to be a variable white dwarf star by McGraw and Robinson (1976). For a review on pulsating white dwarfs see Kepler (1989). In 1982, Kepler *et al.* deciphered the light curve of this star as being composed of six pulsations, three of them with amplitudes larger than 0.11 magnitudes and periods of 215.2s, 271.0s, and 304.4s. It called the attention of the astronomers that time the intriguing fact that the largest amplitude pulsation, at 215.2s, had its strength constant while the two other peaks, at 271.0s and 304.4s, varied in the Fourier transform even by a factor of five in amplitude. We are interested in understanding how and why the amplitude of the two other pulsations change in time while, within our errors, the amplitude of the largest oscillation is constant during the fifteen years observed.

II. ANALYSIS

We have analyzed high speed photometric data on G117-B15A obtained from 1974 till 1989 in a total of 54 nights (Kepler *et al.*, 1989) , summing 195 hours of observation. Each run has a minimum length of one hour and the longest one is seven hours long.

In our analysis, we normalized the value of the amplitude of the 215.2s oscillation to 1 and computed the amplitude of the two other pulsations relative to it. We found amplitude ratios ranging from 0.10 to 0.55 for both periods.

After subtracting the 215.2s oscillation from the light curve and using a technique of least squares fitting of sinusoidals to the data, we determined the amplitude of these pulsations in every run, obtaining a curve of amplitude versus time, for both. In Table 1 we show the times of maxima and amplitudes for each pulsation, in Figures 1 and 2 we plot, for the two periods, the amplitude for the epoch we have the best coverage, four consecutive nights. It is possible to see that the variations are appreciable in 24 hours.

1. CNPq-Brazil fellow.

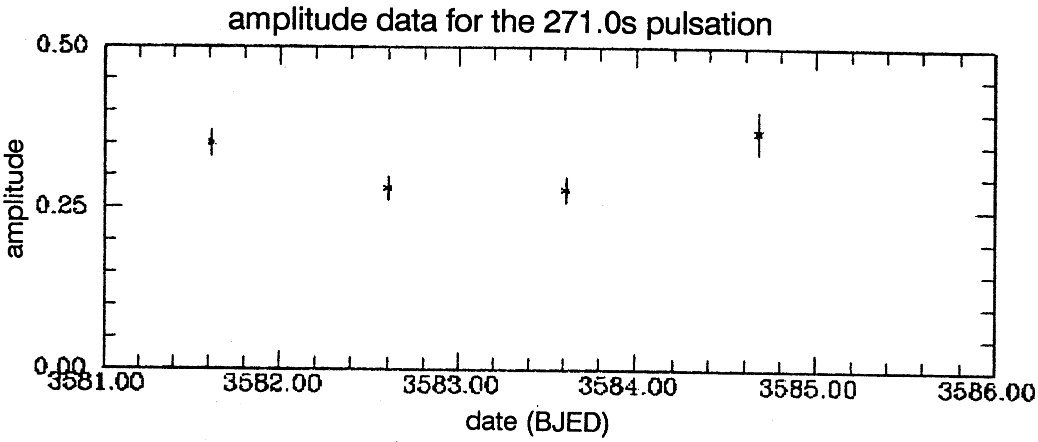


Fig. 1. Amplitude versus time (in Baricentric Julian Dynamical Date) for the 271.0s pulsation. The error bars are 2σ large.

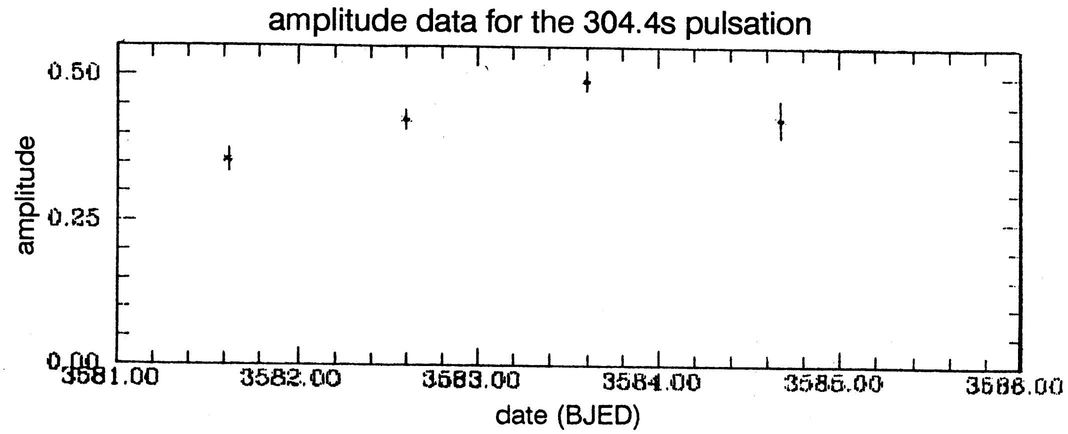
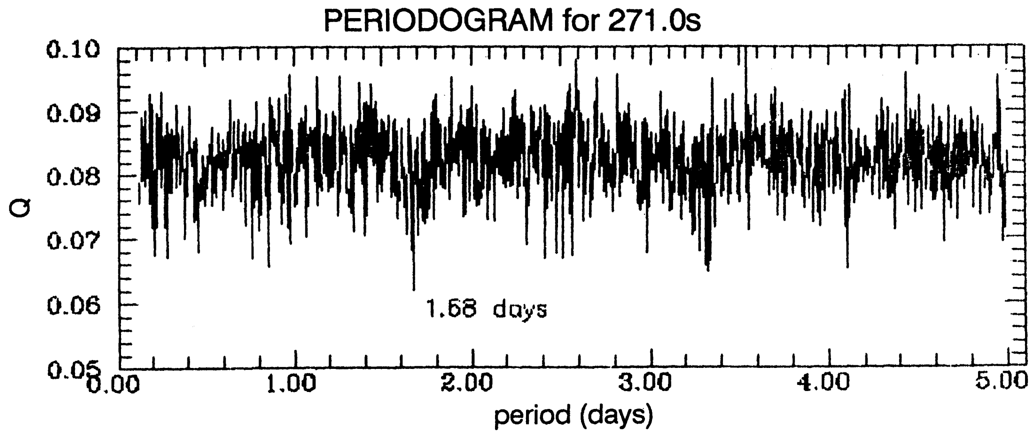


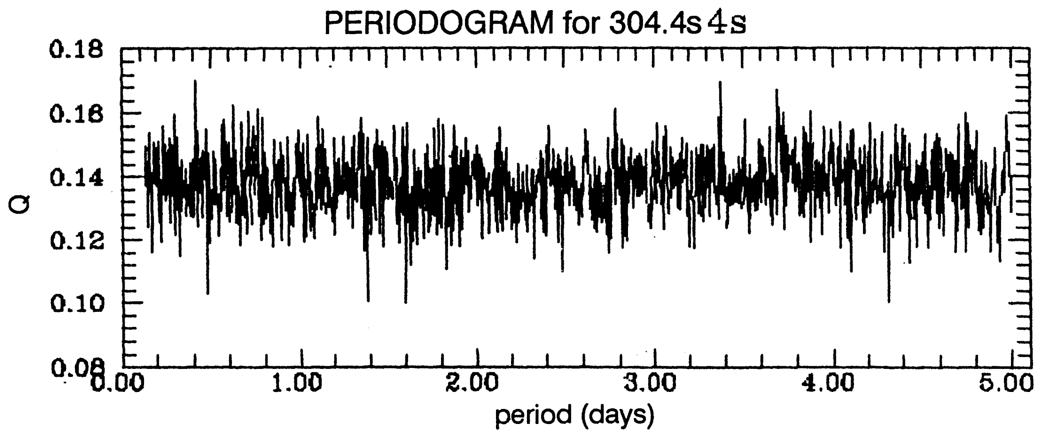
Fig. 2. The same as Figure 1 for the 304.4s pulsation.

Using periodograms we searched for any periodicity in the amplitude variations, and found none. In Figures 3 and 4 we show the periodograms for the 271.0s and 304.4s pulsations.

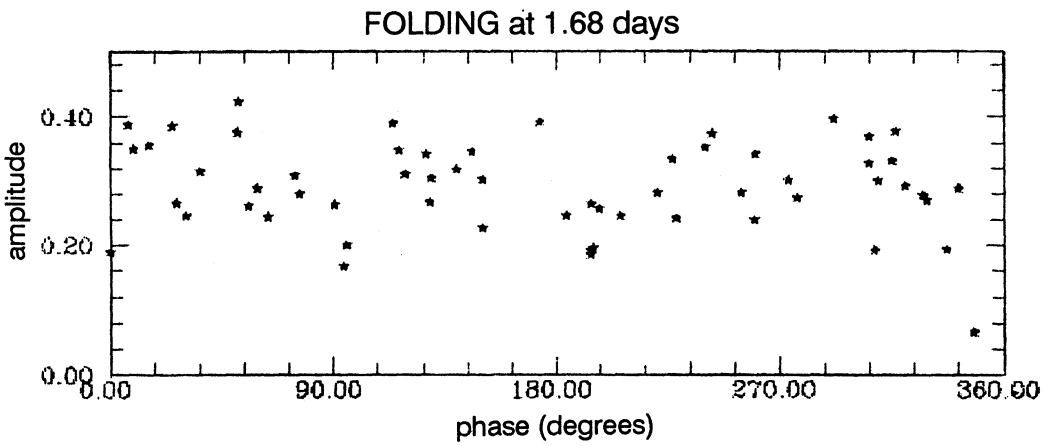
A periodogram is a technique used for period search. Its advantage with respect to Fourier transform is that it works with any curve independent of its form, so it is optimum for searching nonsinusoidal variations. In our period analysis we chose a period range of from 4 hours to 5 days and a period step of 0.004875 days. At each trial period we transform the time of maximum to period phase, setting the phase to zero at the first point. The next step is to reoder the data in crescent phase. The last step is to sum up the squares of the differences between adjacent points; it was conventioned to call this sum Q. Finally we compare the summations for all trial periods, the minimum Q being the most probable value for a periodic variation, In Figure 5 we show the amplitude data for the 271.0s pulsation ordered in phase for a 1.68 days trial period which gaves the minimum in the periodogram. If there were a variation in the amplitude with this period there would be a distribution over a curve instead of a scatter diagram. We looked for all the local minima in both periodograms and no one shows a smooth curve. We expect a periodic behaviour for the amplitude if its variations are caused by beating among close frequencies (e.g., Kepler *et al.*, 1983) , but this variation could be nonsinusoidal.



ʒ. 3. Periodogram for the 271.0s pulsation. The point for minimum Q (1.68 days) is marked. In Figure 5 are the amplitudes for this pulsation ɔwn as function of phase for the 1.68 days trial period.



ʒ. 4. Periodogram for the 304.4s pulsation.



ʒ. 5. The amplitudes for the 271.0s shown in function of phase for the trial period which gives the minimum for Q in the periodogram, 1.68 ys. From the high dispersion of the data we conclude that the amplitude does not vary with this period.

The search for periods has been done in the period range from four hours to five days. Below four hou we are sure there is no beating among close frequencies because we calculated a Fourier transform of the entire dat set and there are no peaks separated from the central one of each pulsation able to produce the observed changes i amplitude. It is clear that there is no peak in this condition. We did not look for periods larger than five days becaus the amplitude variations occur in a timescale of one day, as can be seen in Figures 1 and 2 and Table 1.

III. CONCLUSION

The interpretation that there are no closely spaced pulsations with beat period in the interval from fou hours to one day must be taken with caution because the coverage of the light curve in this range is not continuou since we observed the star from a single site. In order to extend our limits, we plan to observe this star in a multisi observation program next March, but we conclude that our data strongly suggest that the amplitude variations are n due to beating.

If the new observations confirm the result found here, we will have the first confirmation of amplituc limiting effects in nonlinear pulsations in white dwarf stars, which seems to be the way to explain how th nonlinear effects could manifest themselves in the small amplitude pulsations instead of manifesting in the large on (Dziembowski 1982).

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