Radial and Nonradial Pulsations as Probes of Stellar Physics
ASP Conference Series, Vol. 259, 2002
C. Aerts, T.R. Bedding, & J. Christensen-Dalsgaard, eds.

Irregular Behavior in the Light Variations of 29 Cyg

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Abstract. The phase space and FFT tools are applied to investigate the irregular behavior of the existing light curves of the λ Boo star 29 Cyg.

1. Introduction

λ Boo stars are non-magnetic stars which are chemically peculiar. The peculiarity of 29 Cyg was discovered by Slettebak (1952). This star has a metal deficiency of about 50 compared with the Sun (Paunzen, 1997). The first detection of pulsations in the λ Boo star 29 Cyg was announced by Gies & Percy (1977). This star lies on the main sequence near the instability strip, where δ Scuti variables are found. For this reason, 29 Cygni is considered as a δ Scuti variable by many authors (see e.g. Cooper & Walker, 1989). δ Scuti stars are short period (30 min<P<8 hr) pulsating variables located around the region where the instability strip crosses the main sequence. They have masses in the range $1.5M_\odot < M < 2.5M_\odot$.

2. Frequency domain and phase space analyses

The light curves used in our analysis were taken from Cooper & Walker (1989) and Kusakin & Mkrtichian (1996). Cooper and Walker's data were obtained in July 1983, while those of Kusakin and Mkrtichian were obtained in July–September 1995.

Free hand, smooth curves were first drawn in order to eliminate observational noise from the data. From these smooth curves, 2^n equal-time-interval data were extracted as a time series suitable for Fast Fourier Transform (FFT) analysis. A few prominent peaks were observed in each power spectrum. Kusakin & Mkrtichian (1996) detected 7 frequencies in their power spectrum. They tried to model the light curves using a Fourier combination of these 7 frequencies. However, their composite model did not produce a satisfactory fit to the observational data, even for a short time interval which includes 10 pulsations or so. They also re-analyzed Gies & Percy's (1977) data and detected 5 frequencies. Although 3 of these frequencies are near to those from their own data, even the primary frequency shows differences, and the corresponding amplitudes are also certainly different.

In order to explore the phase space behavior, $\delta m(t)$ smooth curves were differentiated numerically and the $\delta\dot{m}$ versus δm are plotted for each data set.

https://doi.org/10.1017/S0252921100016481 Published online by Cambridge University Press

3. Conclusion

At the first sight, the Fourier spectra show a few dominant peaks, similar to the behavior of a multi-periodic system. The periods corresponding to each data set, however, did not repeat themselves in other samples. Even the primary periods seem to be different for each observation. For example, the average primary period is 45±1 minutes for the Cooper & Walker (1989) data and 39±1 minutes for those of Kusakin & Mkrtichian (1996).

The phase space behavior is also interesting. Trajectories seem to be confined to an ellipse-like figure. Calculated points are scattered almost uniformly within this boundary ellipse, except – in most cases – for a small region around the origin ($\delta\dot{m}$=0, and δm=0).

Nonlinear oscillators usually exhibit a well-defined correlation between the period and amplitude. The most familiar example is the period-amplitude of a pendulum for large deflection angles. In order to search for such a possible correlation, we examined the amplitude-period graph for the Cooper & Walker light curves. It was seen that such a correlation hardly existed and a linear fit yielded

$$\text{Period} = A \times \text{Amplitude} + B,$$

with $(A = 5.7 \pm 3.2) \times 10^{-4}$ mag/min.

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https://doi.org/10.1017/S0252921100016481 Published online by Cambridge University Press