Inside the Stars, IAU Colloquium 137
ASP Conference Series, Vol. 40, 1993
Werner W. Weiss and Annie Baglin (eds.)

WAVELET ANALYSIS OF SOME PULSATING STARS

KÁROLY SZATMÁRY and JÁNOS GÁL
Dept. of Exp. Physics, JATE University
H-6720 Szeged, Dóm tér 9, Hungary

The detection of a variable period is very important as it gives information on the evolutionary state or on the binary nature of a pulsating star. If a pulsator is moving in a binary system, its light curve is frequency-modulated by the orbital period (light-time effect). Mode switching or chaos also may be the cause of the changes in the amplitude and period of the light variations.
The determination of period variability is difficult. Usually the conventional Fourier-spectrum cannot give any information about a possible period variation. The O-C diagram is useful to detect a variable period, but it does not give the amplitude and phase values.
The wavelet analysis (Grossmann et al. 1989), which is local both in time and frequency space seems well suited for pulsating stars, especially if one or more periods vary in time. For the application of this method is necessary a long and almost continuous observation. The shortest period variables (white dwarfs, see Goupil et al. 1990; and roAp stars) and the long period pulsators (SR and Mira stars) are the most suitable objects to the wavelet analysis.
The wavelet analysis is a new procedure in astrophysics therefore we have investigated how to use it for detecting of changes of the stellar pulsation. We have generated some test data series, which are connected with interesting phenomena (eg. frequency modulation, amplitude modulation, phase jump, mode switching). In these cases the conventional Fourier analysis of the whole data set cannot give required information. The wavelet maps of these tests suggest that the wavelet analysis is a useful method to determine of variable phenomena of stellar pulsation.
We demonstrate the difference between the Fourier-spectrum and the wavelet map in the case of the semiregular stars Y Lyn (Szatmáry and Vinkó 1992) and Z UMa.

DISCRETE FOURIER TRANSFORMATION

The power spectrum for the frequency f_k:

$$F(f_k) = \left(2/N\ C_{jk}\right)^2 + \left(2/N\ S_{jk}\right)^2,$$

where N is the number of data; $m(t_j)$ is the magnitude at the time t_j, and

$$C_{jk} = \sum_{j=1}^{N} m(t_j)\ cos(2\pi f_k t_j), \qquad S_{jk} = \sum_{j=1}^{N} m(t_j)\ sin(2\pi f_k t_j).$$

DISCRETE WAVELET TRANSFORMATION

The power spectrum for the frequency f_k:

$$W(f_k, \tau) = f_k \left(C^{\tau}_{jk}\right)^2 + f_k \left(S^{\tau}_{jk}\right)^2,$$

where τ is the time shift and

$$C^{\tau}_{jk} = \sum_{j=1}^{N} m(t_j)\ cos(2\pi f_k t_j)\ exp\left[-[(t_j - t_0 - \tau) f_k]^2/2\right],$$

$$S^{\tau}_{jk} = \sum_{j=1}^{N} m(t_j)\ sin(2\pi f_k t_j)\ exp\left[-[(t_j - t_0 - \tau) f_k]^2/2\right].$$

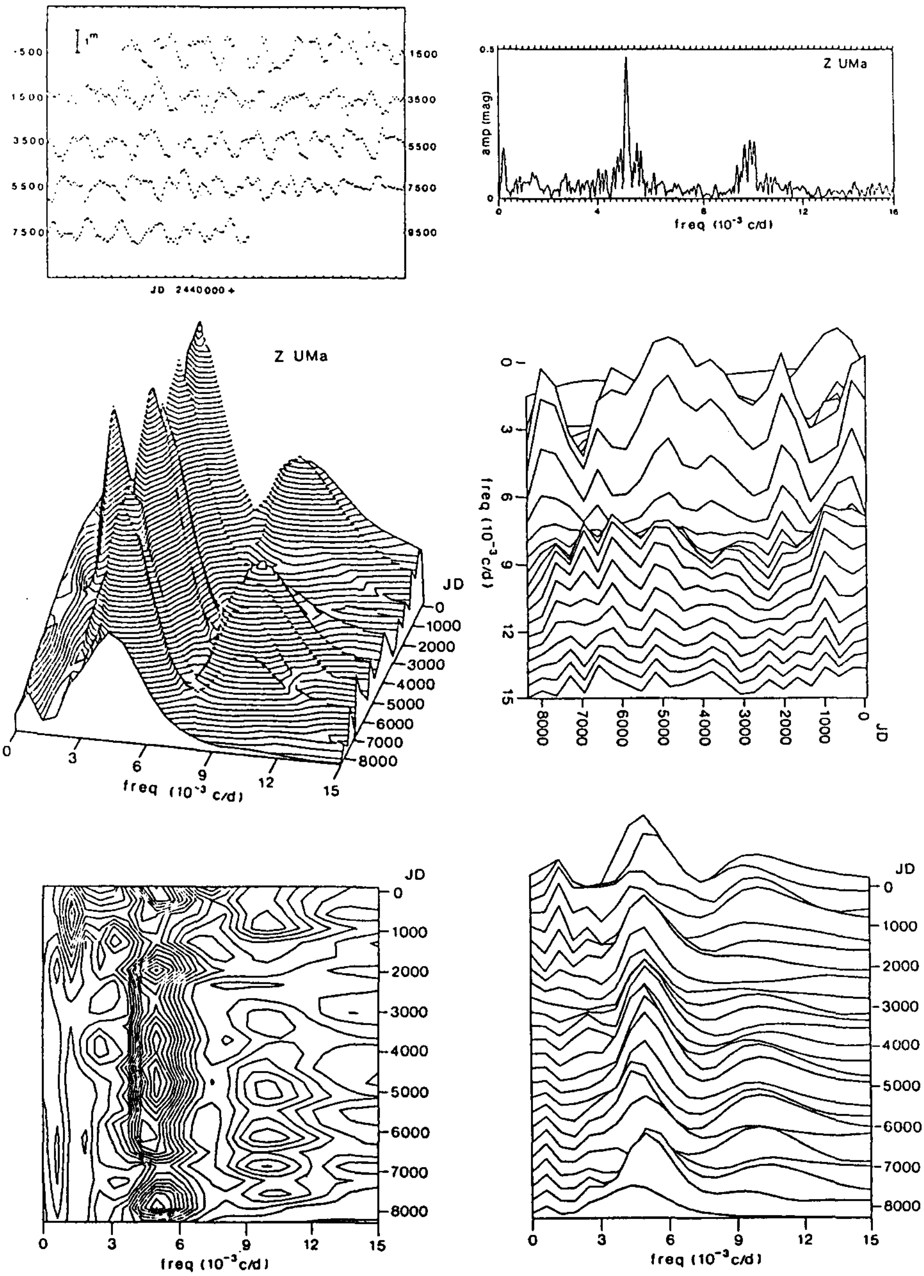
The window is a gaussian with a halfwidth of f_k and it is shifted with τ. t_0 is the first time of the observation.

REFERENCES

Goupil, M.J., Auvergne, M. and Baglin, A. 1990, in *Confrontation between Stellar Pulsation and Evolution*, ed. C. Cacciari and G. Clementini, Astron. Soc. of the Pacific, Conf. Series Vol. 11, p. 578.

Grossmann, A., Kronland-Martinet, R. and Morlet, J. 1989, in *Wavelets: Time-Frequency Methods and Phase Space*, ed. J.M. Combes, A. Grossmann and Tchamitchian Ph., Springer, p.2.

Szatmáry, K. and Vinkó, J. 1992, *MNRAS* (in press)



https://doi.org/10.1017/S0252921100018832 Published online by Cambridge University Press