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Proceedings of the Workshop on the Hydrodynamic Study of Accretion Disks and Pulsating Stars

The Pulsation Properties of AC Her

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1. Irregular variability of RV Tauri stars has been investigated based on nonlinear dynamics which is developed in this few years. Saitou et al. (1989) draw the return maps of a few typical RV Tauri stars to compare with their one-zone stellar models. Kollath (1990, 1992) studied carefully R Sct, one of RV Tauri stars, with smoothed luminosity data. He succeeded in showing its low dimensional feature by the reconstruction method and estimated the correlation dimension. Lebre and Gillet (1991) also discussed the motion of the photosphere of R Sct based on high resolution spectroscopic observations.

Recently Gillet (1992) presents the results of photometric study on AC Her, an RV Tau type variable stars. He gives the smoothed light curve between 1983 and 1988 based on observational data of AAVSO. Sixty five peaks and minima are recognized during the period. Tanaka and Kuwamoto (1992) use the data and plot them in a return map. The return map of the light maxima shows random pattern, while the map of the light minima has rather systematic pattern.

We can see the feature of chaotic oscillation in a three-dimensional deterministic system. In this note, we will briefly report their results on the return maps for AC Her and discuss the properties of irregular pulsation.

2. A kind of return maps for variable stars could be obtained as the maxima or minima of the light curve versus the preceding ones. The return maps in the $(n, n+1)$ plane for AC Her are plotted according to the Gillet's smoothed maxima and minima. The map for the maxima shows a complex feature. However, it seems that two bifurcation types coexists. One is the type that high and low peaks alternate, which appear as incomplete squares in the map. And spiral patterns are seen, which mean the increase of visual magnitude of successive two peaks. The other is the tangent bifurcation which can be seen as increasing steps above the diagonal line. But the channel of intermittency is not so narrow.

In contrast to light maxima, the feature of light minima in $(n, n+1)$ plane is rather simple. All is composed of the incomplete squares, which mean deep and shallow minima appear alternatively. The alternative feature is more apparent if we draw the $(n, n+2)$ return map. The alternative minima are separated in the plane. The shallow (brighter) minima and deep ones show the similar behaviors. The $(n, n+2)$ map for deep minima seems to be more complicated than shallow ones.

3. The one-zone model with a simple damping term (Takeuti and Tanaka, 1991) may also show the similar feature to the light curve of the RV Tauri stars as pointed out by Kollath (1991) who used the Rössler's equation. However, more realistic models should be used to analyze the observational data, if possible. The study of hydrodynamical stellar models shows that the light minima correspond to the contracting phase, and the light maxima are observed at the expanding phase. At the contracting phase, matter flows down until the strong repulsion by the quasi-adiabatic region occurs. At the expansion phase, the matter maybe blows up with strong turbulence just after the strong shock. This picture can explain the regular return map of the light minima, and the random nature at the light maxima. Recently Takeuti and Tanaka (1993) illustrate a hydrodynamical model of RV Tauri stars and show orbits in the phase diagram. The behavior of the model suggests that the repulsion at the contracting phase is also complex as well as the blowup at the expansion. This may cause the complex return map for deep minima. It should be noted that further studies of hydrodynamic models of the irregular stellar pulsation.

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