HYDRODYNAMIC MODELS OF POPULATION II CEPHEIDS

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This is a short report on hydrodynamic modelling for BL Her and W Vir pulsating variables. We present only a qualitative summary of the results obtained, whereas detailed paper will appear soon.

We studied radial self-exciting stellar oscillations with convection ignored. The Massevitch I mixture (X=0.7, Z=0.004) was assumed for calculating the opacity coefficient. All models have a mass $M=0.6M_\odot$, but their absolute magnitudes are in the range from -0.5 to -3 mag. The study covers the period range from 1.3 to 20 days. The models under investigation revealed the following properties:

Increase of the luminosity is accompanied with increasing nonadiabaticity of stellar pulsation. This leads to both increase of the growth rate while pulsations are exciting and increase of the oscillation amplitude of the limit cycle. The relative oscillatory moment of inertia of the radiative damping region was found to decrease with increasing luminosity. As a result, in the models with $L\gtrsim 800L_\odot$ amplitude growth ceases due to strong dissipation of the mechanical energy by shocks in the stellar atmosphere. The relative amplitude of oscillations in photospheric layers of such stars is $\Delta R/R\gtrsim 0.5$.

Within the period range from 1.3 to 3 days the theoretical light curves have a bump the phase of which depends on the pulsation period. Detailed analysis of the non-linear models confirmed a dualistic pulse-reasonance approach proposed by Whitney (1983) to interpretation of the Hertzsprung progression. The main conclusions are as follows: at maximum compression two pulses are generated at the antinode of the second overtone. One of the pulses moves inward and exactly after a half of the period reflects off the stellar core. The pulse arrives at the antinode exactly one period after its generation. The other pulse propagating outwards arrives at the photosphere δt after its generation. It is the dependence of the time delay δt on the pulsation period that is responsible for the existence of the Hertzsprung progression. The reflection coefficient of the photosphere for the outward pulse does not exceed 0.1, so that the pulse goes on to propagate through the stellar atmosphere as a shock. The pulse reflected off the photosphere is very weak but arrives at the antinode together with that reflected off the stellar core. The time delays estimated for the pulses obey to pulse-reasonance condition (Aikawa & Whitney 1983). Thus, the mechanism of propagating pulses and that of modal resonance are complementary.

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For long-period models we tried to find a connection between W Vir and RV Tau pulsating variables. Estimates of adiabatic periods showed that the resonance condition $P_1/P_0=1/2$ begins to be fulfilled when the period of the fundamental mode $P_0=10$ days. Non-linear analysis of the model with the pulsation period 10 days revealed alternation of deep and shallow minima on the radial temporal dependences of the layers lying near the antinode of the first overtone. However, the amplitude of first overtone at the photosphere is not perceptible and the photospheric layers do not show the alternation. The depth of the shallow minimum increases with increasing pulsation period and the model having P=20 days reveals slight alternation on the temporal dependence of the photospheric radius. Thus, our non-linear calculations confirm the assumption proposed by Takeuti & Petersen (1983) about the resonance between the fundamental mode and first overtone in RV Tau pulsating variables.

The Population II Cepheids are known to have a degenerate carbon-oxygen core surrounded by a double shell source. Fadeyev (1982) proposed the period-luminosity relation for stars with degenerate cores and showed that this relation predicts the observer period increase for FG Sge. Expressing the pulsation constant Q as a function of the ratio M/R we used this dependence to determine the luminosities of the Population II Cepheids having known effective temperatures. We found that within errors of observations the theoretical period-luminosity relation is in good agreement with the observable one.

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