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RADIAL PULSATIONS IN 63 HERCULIS

BÜLENT UYANIKER
Physics Department, Middle East Technical University
06531 Ankara, Turkey.

ABSTRACT Constructing a theoretical model of 1.88 $M_\odot$ pulsation properties of 63 Her have been analyzed. For the model, in question, pulsation periods in the fundamental mode and first two overtones have been derived by solving the linearized pulsation equations. The model has been found to be vibrationally stable.

INTRODUCTION

The variability of 63 Her (HR 6391) was first dicovered by Breger (1969). He announced it to pulsate with a period of $0^d.077$. Since then, it has been observed by other astronomers (Reed and Welch, 1988; Akan, 1991). Breger and Bregman (1975) reported that 63 Her oscillates in the radial fundamental mode with a period of $0^d.077$. Reed and Welch found that the star pulsates possibly in three distinct frequencies corresponding to $0^d.088$, $0^d.052$ and $0^d.130$. Akan obtained six frequencies which are 0.686, 1.383, 10.312, 18.588 and 19.870 c/d. In their analysis, Reed and Welch have concluded that $0^d.08$ corresponds to radial pulsation in the fundamental mode. They also analyzed the Breger's data and obtained $0^d.105$ and $0^d.051$ for the radial fundamental mode and for the second overtone, respectively. Belmonte and Michel (1991) gave, $0^d.250$, $0^d.157$, $0^d.130$, $0^d.080$, $0^d.077$, $0^d.050$ and $0^d.038$ of periods for 63 Her, while Manganey at. al. (1991) obtained six frequency solution due to their pulsation analysis.

In the present study, our intention is to investigate the pulsational properties of 63 Her in connection with stellar evolution so that we have constructed a theoretical model for 63 Her and evolved it until to satisfy the observed position in the H-R diagram. Then we solved the linerized pulsation equations for radial adiabatic oscillations.

THE MODEL AND PULSATION ANALYSIS

We have constructed a theoretical model using Ezer (1969)'s evolutionary code for a mass of 1.88 $M_\odot$. We have also chosen solar-type chemical composition of X=0.739, Z=0.021, and the value of ℓ/H=1.3 for mixing-length parameter. Basic properties of the model are given in Table I.

To obtain the linear set of equations governing the radial adibatic oscillations classical linear theory is applied (Ledoux and Walraven, 1958). Linearized equations are then solved uing a pulsation code (Uyanıker and Kırbıyık, 1992). Basic results of pulsation analysis are displayed in Table II.

In Table II. obtained periods as well as the corresponding frequencies are displayed. Last column of the table shows the ratio of surface to the center value of the eigenfunction σ'. Eigenfunctions for the fundamental mode and first two overtones are plotted in Figure 1. The vibrational stability coef-

Table I: Physical properties of the model

$M/M_\odot$	$R/R_\odot$	$L/L_\odot$	$\log T_e$	Age (yr)
1.88	2.45	19.2	3.89	1.112×10^9

T_c	ρ_c (gm/ cm^3)	ρ_{ph} (gm/ cm^3)	X_c	Y_c
2.45×10^7	101	7.91×10^{-9}	0.071	0.908

Table II: Pulsation properties of the model in question

Mode	P(day)	$\sigma^2 \times 10^{-7}$	ν (μhz)	$(\delta r/r)_s$ / $(\delta r/r)_c$
F	0.110	4.34	104.8	2.179×10^2
1 H	0.077	8.90	150.1	-9.590×10^2
2 H	0.061	14.40	191.0	1.065×10^3

ficient, σ', is computed as Boury et. al. (1975). In Figure 2, behaviour of σ' is given with respect to the radius fraction. Note that the dip taking place almost at the surface corresponds approximately 0.98 of the total radis. This irregularity of the σ' may be due to the effects of the medium belonging to that portion of the star. In that region the temperature is about 3.5×10^4 °K, so we conclude that at this portion of the star a hydrogen ionization zone exists.

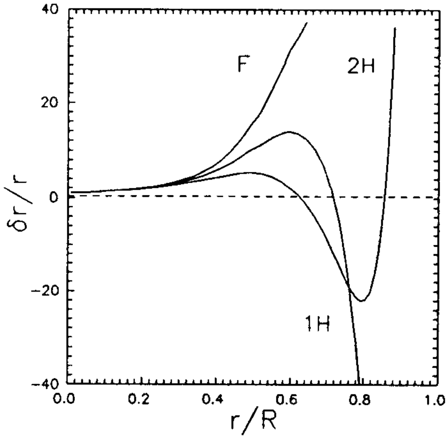

Figure 1: Change of $\delta r/r$ as a function of the fractional stellar radius.

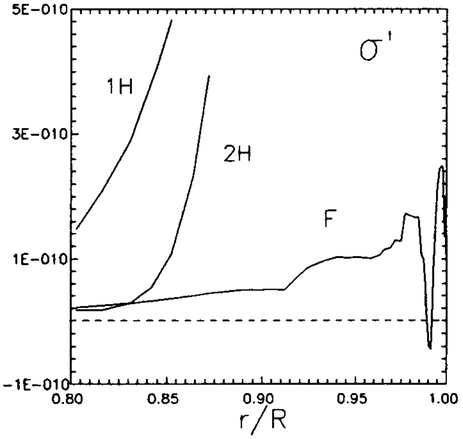

Figure 2: Change of vibrational stability coefficient with respect to r/R.

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DICSUSSION

We have found a period of $0^d.11$ for the fundamental mode. Furthermore, we obtained $0^d.077$ and $0^d.061$ for the first overtone and second overtone, respectively. Considering the Breger's data (analyzed by Reed and Welch) the period we found for the fundamental mode is compatible with the observations. It is interesting to note that $0^d.077$ we obtained for the first overtone is exactly the same with the reported observational fundamental periods (Breger, 1969; Baglin et.al., 1973). One possible explanation may be that, what they observe as the fundamental radial mode appears as the first overtone of the radial mode.

Periods obtained in the present study agree well with observations although there are differences in identifying with same modes. Oscillations checked for vibrational instability showed that all modes are vibrationally stable against radial pulsations. We have also found that the hydrogen ionization zone taking place almost at the surface is responsible from the generation of pulsations in 63 Her.

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