SOME REMARKS ON THE UNIQUE CEPHEID HR 7308

N. R. Simon
Department of Physics and Astronomy
University of Nebraska-Lincoln, Lincoln, NE 68588-0111

HR 7308 is an apparently normal Pop. I Cepheid (Percy & Evans 1980; van Genderen 1981) with a constant period P = 1.49 days. However, its amplitude is variable with a range from about 5 to 20 km/sec in radial velocity and 0.05 to 0.30 in visual magnitude. The timescale for this variation is about 1200 days. According to Breger (1981) and Burki, et al. (1982; hereafter BMB), the star seems to be pulsating in a single modulated radial mode. Using published Q-values BMB identify this mode as a second or higher overtone. These authors also estimate a radius $R = 34 \pm 5\ R_{\odot}$ and, based in part upon the observations of van Genderen (1981), a temperature $\log T_e = 3.786 \pm 0.01$ and a gravity $\log g = 2.25 \pm 0.25$.

In the present investigation we have constructed linear nonadiabatic (LNA) pulsation models for HR 7308 using the Lagrangian code described by Aikawa & Simon (1983). These models assume the standard mass-luminosity relation for Pop. I stars, and fix the effective temperature at the value quoted above, namely T_e = 6110K. For masses appropriate to classical Cepheids we rule out fundamental or first overtone pulsation, in agreement with BMB. In addition, however, we are able to effectively discard the third and higher overtones which are linearly stable and thus not expected to exist at finite amplitude. Thus if HR 7308 is a normal Pop. I Cepheid with temperature as given by BMB, it must be pulsating in the second overtone.

To reproduce the period of HR 7308 we have constructed an LNA model with the following parameters: $M = 5\ M_{\odot}$, $L = 1000\ L_{\odot}$, T_e = 6110K, X = 0.70, Z = 0.02. The periods and growth rates (P,η) for the three lowest modes of this model are (2.40, 2.6E-3), (1.81, 1.8E-2) and (1.45, 3.4E-2). The higher modes (third overtone and up) are stable. One notes that the second overtone approximately matches the period of HR 7308 and has a growth rate which exceeds that of the fundamental by a factor 13 and that of the first overtone by a factor of nearly 2. While it is not possible to directly infer limit cycle characteristics from linear growth rates, experience indicates (e.g., King, et al. 1973) that the growth rates exhibited by the present model are at least not unfavorable for second overtone pulsation. In addition, this model has a gravity $\log g = 2.24$ and radius $R = 28\ R_{\odot}$, both reasonably consistent with the values estimated by BMB.

https://doi.org/10.1017/S0252921100109194 Published online by Cambridge University Press

In another part of their study, BMB Fourier decompose the radial velocities from a number of epochs of HR 7308 and publish the Fourier coefficients up to and including the second order quantities A_2 and ϕ_2. The zeroth order (static) velocity A_0 is found to vary from epoch to epoch with a relatively large range exceeding 1 km/sec. However, it is not clear to what extent this might be due to scattered phase coverage in the observations. The small second order quantities are subject to even greater distortion due to sparse coverage and are thus probably not well determined.

For one particular epoch BMB publish Fourier coefficients for both radial velocity and V magnitude. Using these we have calculated the first order phase shift between light and velocity, obtaining $(\Delta\phi)_1 = -0.24$. This value is normal for Pop. I Cepheids (Simon 1984) but may not confirm the overtone nature of the pulsations of HR 7308. A larger sample of very short period stars will be necessary to make further progress on this point.

Breger (1981) published 87 V magnitude observations of HR 7308 spread over about 3 years. We have selected for Fourier analysis 62 of these points all obtained within 3 months and thus corresponding to a given epoch of the 1200-day amplitude cycle. It was hoped to determine in this way the second-order Fourier quantities ϕ_{21} and R_{21} (Simon & Lee 1981) which have proven so useful in treating the classical pulsating stars. However, the oscillations of HR 7308 are so sinusoidal that the (very small) second order coefficients cannot be determined without extremely fine phase coverage which Breger's observations did not provide. Thus the calculation of ϕ_{21} and R_{21} must await a more extensive set of observed data.

References

Aikawa, T. & Simon, N. R. (1983). Ap. J., 273, 346.
Breger, M. (1981). Ap. J., 249, 666.
Burki, G., Mayor, M. & Benz, W. (1982). Astr. and Ap. 109, 258 (BMB).
King, D. S., Cox, J. P., Eilers, D. D. & Davey, W. R. (1973). Ap. J. 182, 859.
Percy, J. R. & Evans, N. R. (1980). A. J. 85, 1509.
Simon, N. R. (1984). Ap. J., in press.
Simon, N. R. & Lee, A. S. (1981). Ap. J., 248, 291.
van Genderen, A. M. (1981). Astr. and Ap. 99, 386.

https://doi.org/10.1017/S0252921100109194 Published online by Cambridge University Press