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TITLE LIGHT AND VELOCITY CURVES OF BUMP CEPHEIDS

AUTHOR(S) Arthur N. Cox, T-6
Charles R. Proffett, University of Washington

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LIGHT AND VELOCITY CURVES OF BUMP CEPHEIDS

Charles R. Proffitt
University of Washington
and Arthur N. Cox
Los Alamos National Laboratory

We present light and velocity curves for eight hydrodynamic bump Cepheid models. All of the models were converged to the fundamental mode solution using a relaxation technique developed by Stellingwerf (1974). Our use of this method assures that the time behavior repeats each period to better than one part in a thousand. The motivation for this work was to help Buchler, at the University of Florida, to develop his theory of modal interactions in pulsating stars.

Normal solar composition for the pulsating envelopes were used. The convection, which certainly occurs in these yellow giants, was ignored here, both in the model structure and in the nonlinear pulsation calculations. These models have a luminosity of 5681 solar luminosities and a mass of 4 suns. Effective temperatures range from 6050K to 5400K, giving fundamental mode pulsation periods of 7.3 to 11.1 days. Period ratios for the second overtone to fundamental mode, which seem to be a key factor in the light and velocity curve shapes, range from 0.531 to 0.493.

Calculations have been made of the Fourier components of both the light and velocity curves by Geza Kovacs from the University of Florida. We here compare them to observations of velocity curve Fourier components tabulated by Simon and Teays (1983) and the light curves tabulated by Simon and Moffett (1985). The fits are made to the expression $A+\Sigma B_j \sin(i\omega t + \Phi_j)$.

Figures 1 and 2 show the velocity and light curves of the full amplitude solution for the 5700K model with a period of 9.07 days. The "bump" on falling light and on falling radial velocity (relative to the stellar center) can be seen as observed for classical bump Cepheids.

Figures 3, 4 and 5 show the ratio of the amplitudes for the first and second harmonics, the phase difference $\Phi_2-2\Phi_1$, and the other phase difference $\Phi_3-3\Phi_1$ for the velocity curves. Both our data points and those observed for Cepheids and indicated. As found by other authors such as Simon and Davis (1983), the agreement is good but not perfect. Improvements in the theoretical models are needed.

Figures 6, 7 and 8 show the same relative Fourier components for the light curves. Again there is at least qualitative agreement.

Our improvement over earlier limiting amplitude calculations is in the use of a method that gets exactly a periodic solution. Any residual modal contamination, which is probably small anyway in initial value calculations, cannot occur for our results. However, if there is not enough spatial resolution in the mass zoning, our solutions will not agree with observations. Such a difficulty probably occurs in our results.

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Simon, N. R. and Moffett, T. J 1985, Ap. J., preprint.
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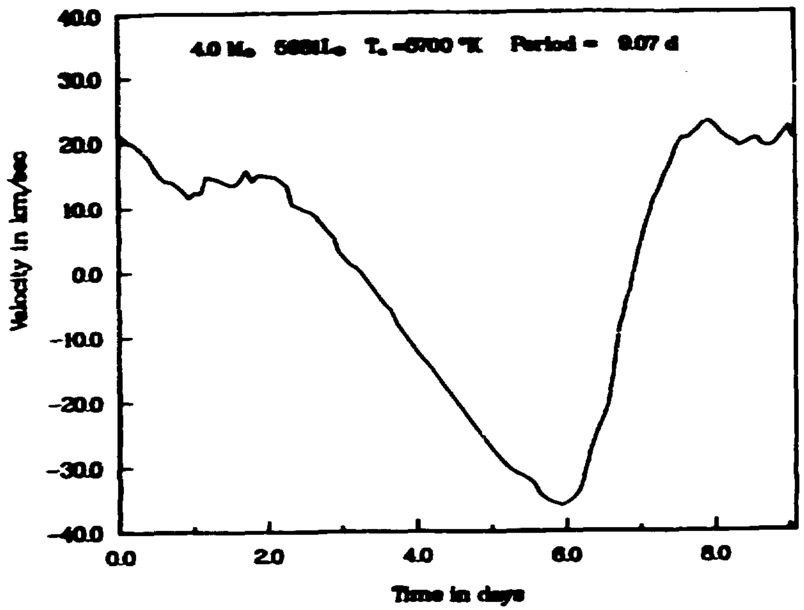

Figure 1. The velocity curve for the 9.07 day Cepheid model.

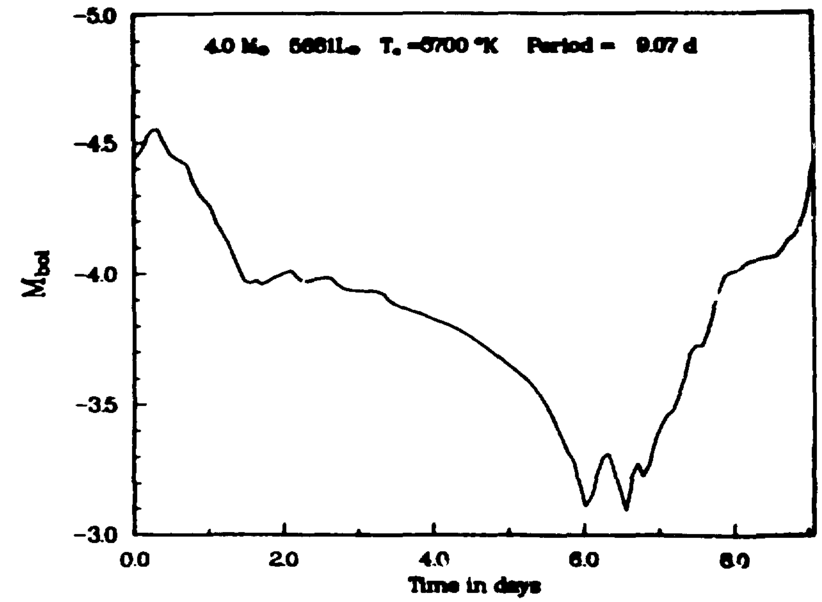

Figure 2. The light curve for the 9.07 day Cepheid model.

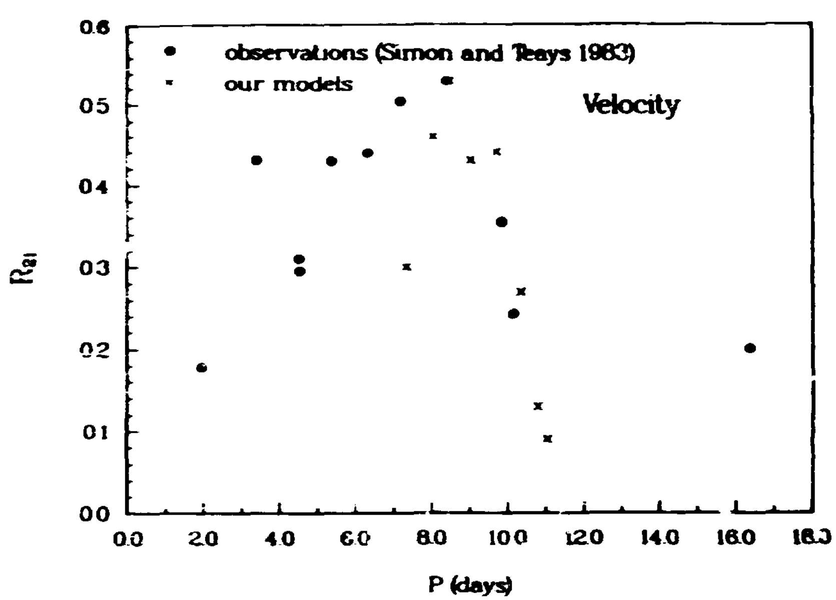

Figure 3. The ratio R_{21} between the Fourier amplitudes for the second and first harmonics of the velocity curve analytic fit.

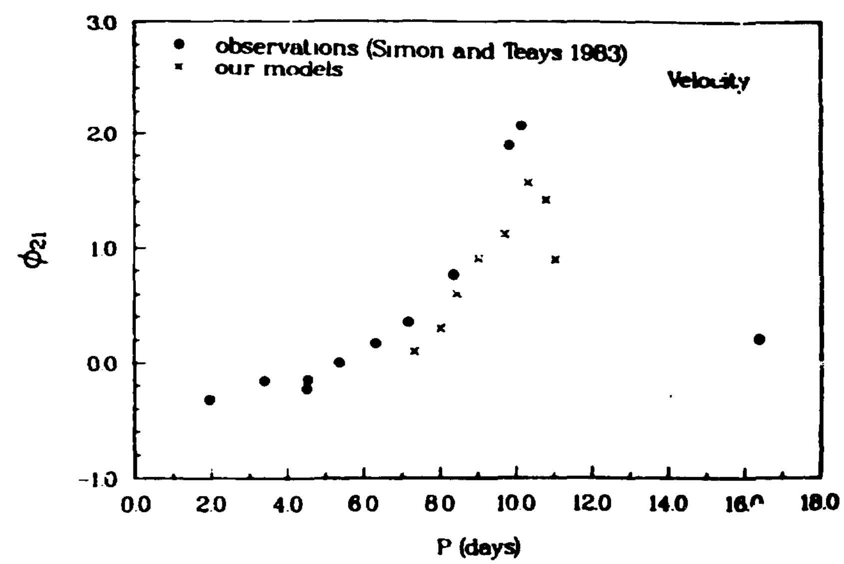

Figure 4. The difference between the phases for the second and first harmonic Fourier terms for the velocity curve analytic fit.

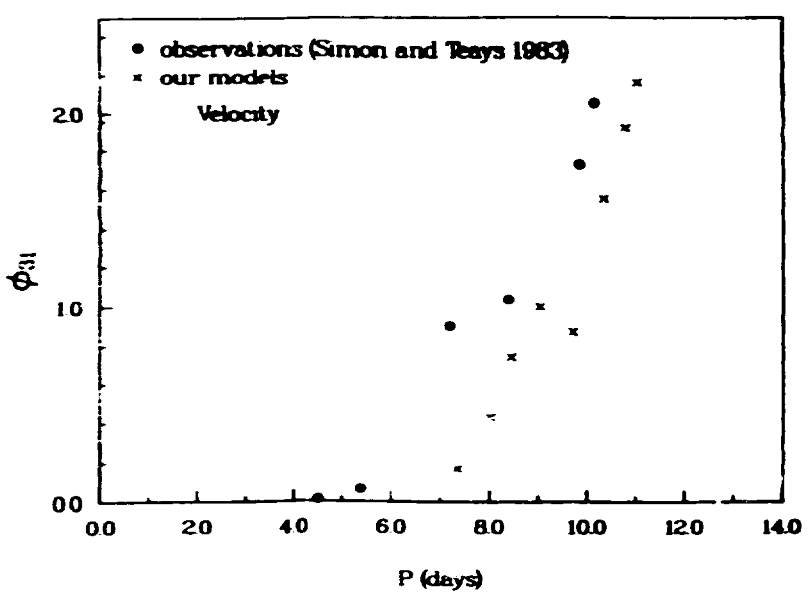

Figure 5. The difference between the phases for the third and first harmonic Fourier terms for the velocity curve analytic fit.

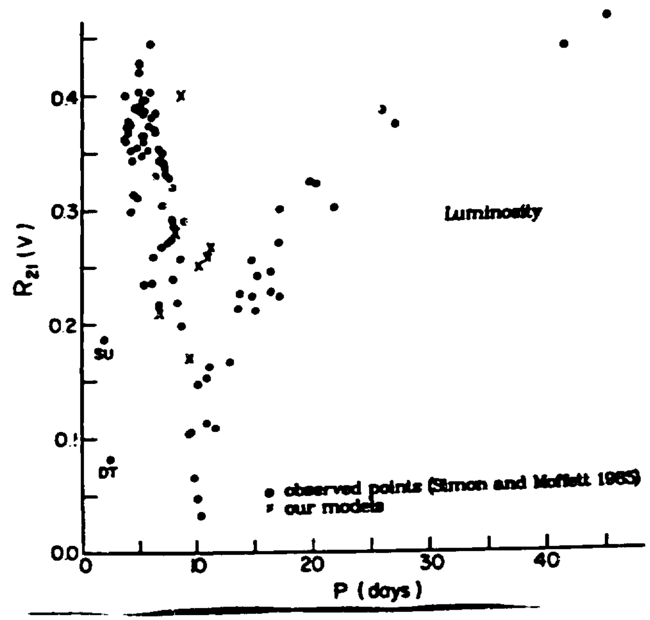

Figure 6. The ratio R_{21} between the Fourier amplitudes for the second and first harmonics of the light curve analytic fit.

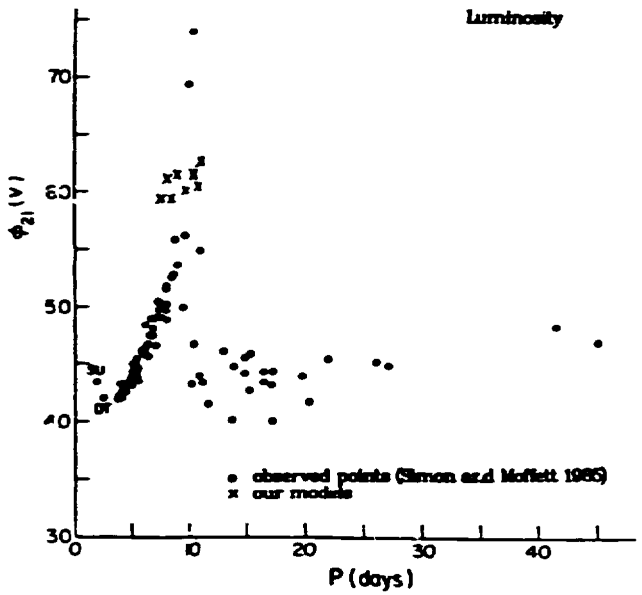

Figure 7. The difference between the phases for the second and first harmonic Fourier terms for the light curve analytic fit.

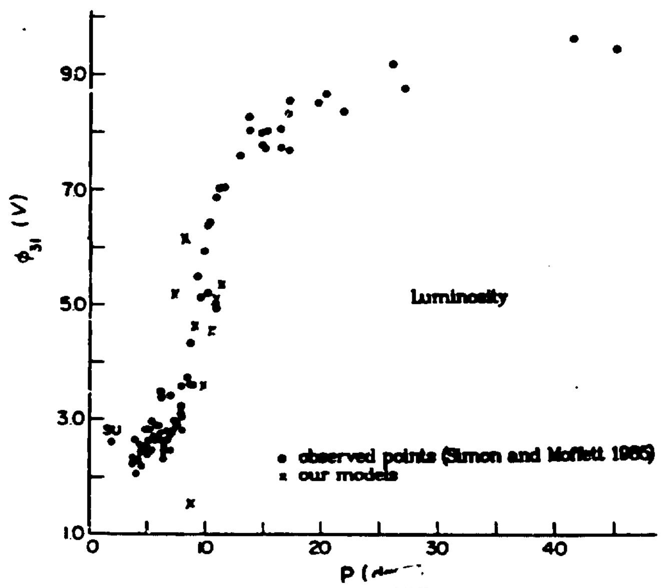

Figure 8. The difference between the phases for the third and first harmonic Fourier terms for the light curve analytic fit.