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NONADIABATIC OBSERVABLES IN β CEPHEI STAR MODELS

H. CUGIER[1], W.A. DZIEMBOWSKI[2] and A.A. PAMYATNYKH[2,3]
[1]*Astronomical Institute, Wrocław University, Kopernika 11, 51-622 Wrocław, Poland*
[2]*N. Copernicus Astronomical Center, Bartycka 18, 00-716 Warsaw, Poland*
[3]*Institute of Astronomy, Pyatnitskaya 48, 109017 Moscow, Russia*

Results of the recent stability surveys (Dziembowski and Pamyatnykh 1993; Gautschy and Saio 1993) leave no doubts that the opacity mechanism is responsible for oscillations observed in β Cephei stars. The linear nonadiabatic analysis used to determine the instability domains in the HR diagram, yields also quantities that may be compared with observations. These nonadiabatic observables are evaluated from the complex eigenfunctions $y(r)$ and $f(r)$ describing variations of the radial displacement and the bolometric flux, respectively. Both y and f are very nearly constant within the stellar atmosphere. The eigenfunctions describing the horizontal displacement and variations of thermodynamical quantities may be expressed in terms of y and f. Since the linear eigenfunctions may be arbitrarily normalized, there are only two real independent observables. We may choose them to be $\tilde{f} = \mathrm{abs}(f/y)$ and $\psi = \arg(f/y)$. Using static atmosphere models, with the inertial term included in the effective gravity, we may evaluate amplitude ratios and phase differences for integrated changes in directly measured parameters (Dziembowski 1977, Stamford and Watson 1981, Watson 1988).

Balona and Stobie (1979) showed that the amplitude ratio *vs* phase difference diagrams for colors and luminosity are useful to identify the spherical harmonic degree, l, of an observed mode. We reexamined diagnostic value of such diagrams making use of $\tilde{f}$ and ψ for unstable low-l modes from the survey of Dziembowski and Pamyatnykh (1993). In Fig. 1a we show results of model calculations for the V and the 150 nm bands. Employing the satellite ultraviolet data turned out to be exceptionally revealing. An identification of the l value, with good photometric data should be unambiguous. In Fig. 1b we show that the radial velocity data combined with the UBV photometry may also be used for the same purpose. The model points corresponding to various spherical harmonic degrees occur in well separated domains. One may see that there is no ambiguity in assigning the l value to the observed modes.

Determination of the l-value is not the only use of the nonadiabatic observables. The plots in Fig. 1a clearly show that, especially in the case of radial pulsations, the data can be used to constraint mean stellar parameters. As well, that they may be used to distinguish between the fundamental and the first overtone pulsators. We believe that, in addition to precise fre-

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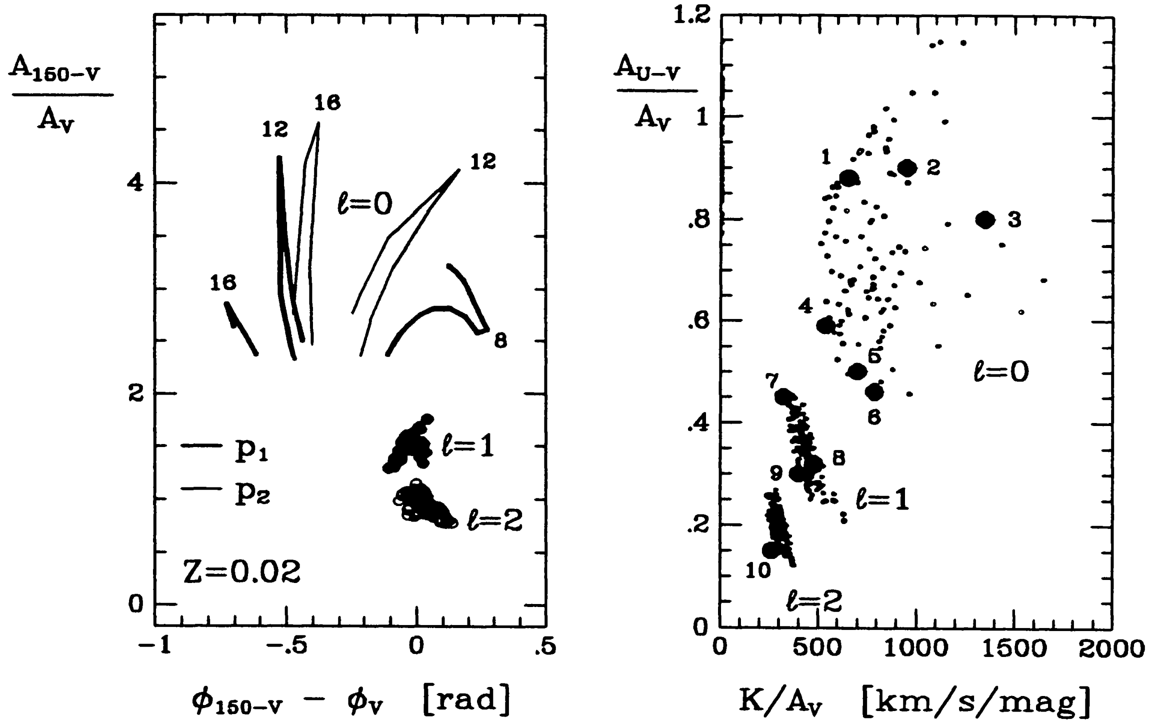

Fig. 1. (a) The ratio of color to light amplitudes is plotted against the phase difference for unstable modes in β Cephei models. For the case of radial pulsations, the plotted lines connect points, separately for p_1 (fundamental) and p_2 modes, corresponding to sequence of models, from the instability onset to the moment of hydrogen exhaustion in the core. The value of mass is given in $M_\odot$. Points plotted for the nonradial modes cover the same range of stellar models.

(b) The ratio of color to light amplitudes is plotted against the ratio of radial velocity to light amplitudes for the same models (small dots) and for β Cephei stars (big dots). The numbers from 1 to 10 correspond to the dominat mode of pulsation of the following stars: 16 Lac, ξ^1 CMa, BW Vul, γ Peg, β Cep, λ Sco, KP Per, 12 Lac, 15 CMa, and β Cru, respectively.

quency measurements, the nonadiabatic observables should be regarded as important data for asteroseismology. Thus, future efforts in this field should rely on *multicolor* photometry and/or employment of spectroscopic data.

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