Variable Stars in the Local Group
ASP Conference Series, Vol. 310, 2004
Donald W. Kurtz & Karen R. Pollard, eds.

Mode Selection Mechanism in B-Type Pulsators: Observational Clues

Mikołaj Jerzykiewicz

Wrocław University Observatory, ul. Kopernika 11, 51-622 Wrocław, Poland

Abstract. Linear nonadiabatic calculations for models of B-type pulsators predict many more unstable modes than actually observed, therefore a mode selection mechanism must operate in these stars. To investigate this problem quantitatively, available data for singly-periodic and multi-periodic β Cephei variables are compared. No clear-cut differences are found. The slight difference in [m/H], noted recently by Daszyńska et al. (2003), may indicate the solution.

1. Introduction

For models of B-type pulsators, linear nonadiabatic calculations predict many more unstable modes than actually observed. An example of this is given in Fig. 1 for a multiperiodic β Cep star 16 (EN) Lac. Thus, a mode selection mechanism must operate in these stars. Identifying an observed feature or parameter which is correlated with the number of modes observed in a star may provide a clue to the nature of the mechanism. A somewhat less demanding approach consists of finding a difference (other than the number of observed modes) between the singly-periodic variables and the multiperiodic ones. This is what we attempt here.

2. The Data

The singly-periodic β Cephei variables are listed in Table 1. The table is divided into three parts. The upper part contains stars with stable light-curves. The middle part contains stars which have unstable light-curves; in case of EW CMa and V986 Oph this may be connected with their fast rotation. In the last row of the table there is the large-amplitude variable BW Vul, unique in several respects. Among Slowly Pulsating B stars, singly-periodic variables may also exist (Molenda-Żakowicz 2000). However, their census is uncertain at present. In the following we shall limit ourselves to the five singly-periodic β Cep stars with stable light-curves.

3. Discussion

The five singly-periodic variables with stable light-curves (upper part of Table 1) do not differ from other β Cep stars in (1) their periods, (2) their effective

https://doi.org/10.1017/S0252921100010769 Published online by Cambridge University Press

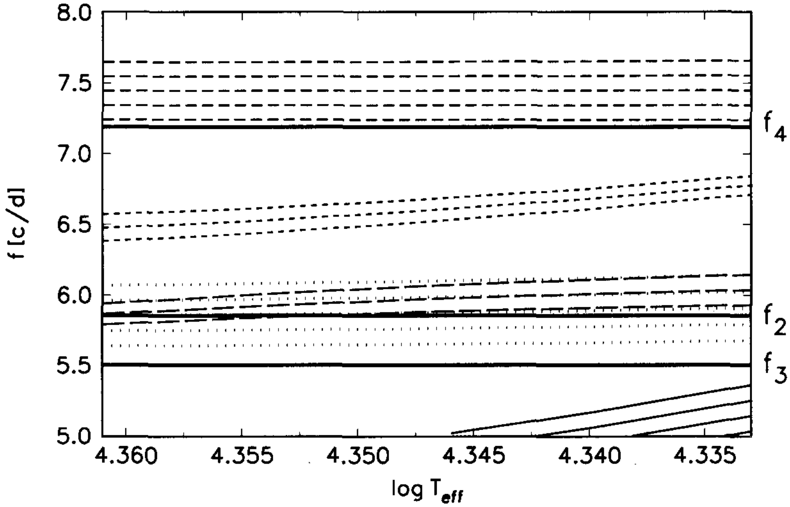

Figure 1. Frequencies of modes with $\ell = 1$ (short- and long-dashed lines) and $\ell = 2$ (medium-dashed, dotted and thin-solid lines) for models in the 9 to $10\,M_\odot$ mass range plotted as a function of effective temperature. The rotational frequency splitting was calculated assuming $v_{\rm rot} = 40$ km s-1. The three horizontal solid lines represent the observed frequencies f_2, f_3, and f_4 for 16 Lac. The model parameters were interpolated so that the fundamental radial mode frequency is exactly equal to the observed frequency, $f_1 = 5.9112\,\mathrm{d}^{-1}$ (not shown). From Dziembowski & Jerzykiewicz (1996).

temperatures (as measured by c_0), and (3) their luminosities (as indicated by β). Thus, their position in the HR diagram is not a clue to the mode selection mechanism.

All five stars except for V2052 Oph have small $v_{\rm rot} \sin i$. V2052 Oph is the only star in Table 1 that has been observed to have a (dipole) magnetic field (Neiner et al. 2002). However, among multiperiodic β Cep stars slow rotators also occur; ν Eri is an example. Moreover, a dipole magnetic field has been discovered in β Cep itself, which is multiperiodic.

Except for τ^1 Lup, the singly-periodic variables with stable light curves are *radial pulsators*. However, a *radial mode is dominant in several multiperiodic* variables; ν Eri is again an example.

Finally, the singly-periodic variables all have a negative $[m/H]$, while for multiperiodic β Cep variables the mean value of $[m/H]$ amounts to 0.0. This has already been noted by Daszyńska et al. (2003).

Table 1. The singly-periodic β Cephei stars

Name	m_V	MK	P d	c_0	β	$v_{\rm rot}\sin i$ km s^{-1}	ℓ	[m/H]
γ Peg	2.8	B2 IV	0.15175	0.117	2.626	10	0	-0.1
δ Cet	4.1	B2 IV	0.16114	0.092	2.619	12	0	-0.2
ξ^1 CMa	4.3	B1 III	0.20958	-0.028	2.588	10	0	-0.3
τ^1 Lup	4.6	B2 IV	0.17735	0.122	2.622	20	1	-0.2
V2052 Oph	5.8	B2 IV-V	0.13989	0.089	2.630	85	0	-0.2
15 EY CMa	4.8	B1 III	0.18456	-0.022	2.594	40	1	0.1
27 EW CMa	4.7	B3 IIIp	0.0918	0.157	2.569	155	?	0.0
V986 Oph	6.1	B0 IIIn	0.303	-0.170	2.565	295	?	0.1
BW Vul	6.4	B2 III	0.20104	0.006	2.611	38	0	0.1

Note to Table 1: The sources of the data are: The visual magnitude, m_V, the MK type, the period, P, and the Strömgren indices, c_0 and β, are from Sterken & Jerzykiewicz (1993); the projected velocity of rotation, $v_{\rm rot}\sin i$, is from Głębocki & Stawikowski (2000) for all stars except V2052 Oph, for this star the $v_{\rm rot}\sin i$ is from Neiner et al. (2002); the spherical harmonic degree, ℓ, is from Cugier et al. (1994); and the metallicity parameter, $[m/H]$, is from Daszyńska et al. (2003).

4. Conclusions

A β Cephei star's position in the HR diagram is not a clue to the mode selection mechanism. The singly-periodic β Cephei variables have lower photospheric metallicity than the multiperiodic ones. This may be a promising clue to the mode-selection mechanism provided that metallicity in the driving region is correlated with the photospheric metallicity. In addition, the singly-periodic variables are predominantly radial pulsators and all but one have small $v_{\rm rot}\sin i$. The significance of these facts is not clear.

Acknowledgments. This research was supported by KBN grant 5 P03D 014 20.

References

Daszyńska, J., Niemczura, E., Cugier, H. 2003, Adv. Space Res., 31, 387

Dziembowski, W.A., Jerzykiewicz, M. 1996, A&A, 306, 436

Głębocki, R., Stawikowski, A. 2000, AcA, 50, 509

Molenda-Żakowicz, J. 2000, in ASP Conf. Ser., Vol. 203, The Impact of Large-Scale Surveys on Pulsating Star Research, eds L. Szabados & D.W. Kurtz (San Francisco: ASP), 434

Neiner, C., Henrichs, H.F., Tijani, A., Geers, V., Nichols, J.S. 2002, in ASP Conf. Ser., Vol. 259, Radial and Nonradial Pulsations as Probes of

Stellar Physics, eds C. Aerts, T.R. Bedding & J. Christensen-Dalsgaard (San Francisco: ASP), 210

Sterken, C., Jerzykiewicz, M. 1993, Space Sci.Rev., 62, 95

Mike and Christina Jerzykiewicz

https://doi.org/10.1017/S0252921100010769 Published online by Cambridge University Press