ARE THERE DIFFERENT TYPES OF VARIABILITY AMONG B STARS ?

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1. INSTABILITY BOX AND DETECTION SURVEYS.

Almost every survey for β Cephei detection has been restricted to the small area of the HR diagram that contained the 15-20 first discovered . (Table 1). Of course, every new short period pulsating star found in such an a priori limited region has strengthened the impression that an instability box could be derived from the study of the statistics of β Cep variables. That conclusion could have led to the discovery of a β Cep pulsation mechanism related to a particular mass - age internal structure status. On the contrary if the phenomenon is due to a mechanism acting in a wider extension of the HR diagram (and so probably better related to envelope properties) one still has to explain why its detection seems to be easier in the B_0-B_2 zone. Moreover, even within the "instability box" some classical β Cep could be either in core hydrogen burning phase or others in shell hydrogen burning phase, i.e. with quite different internal structures.

Most of the recently found variables, whatever detected by light or spectral variations, that lay around the "instability strip" have been listed as new types of B variables (while the rapid rotating variables found by Shobbrook and Lomb (1972) have been accepted among the slow-rotating β Cep because they were within the strip!).

These "new types" of variables are the variables detected by Hill (1967); 53 Per variables (Petrie, Pearce 1962; Percy 1970, Smith 1977); ultrashort period and slow period variables (Jakate 1979).

Using the PMR Catalogue (Philip et al. 1976), we have plotted in figure 1 all these B variables for which available observing methods and reduction procedures provide support for the variability claimed by the authors. Unfortunately many a B variable lacks in the PMR Catalogue, so our figure 1 is far from exhaustive. However it shows that the variability domain of B stars widely expands from c_o = - 0.2 to c_o = + 0.5, and includes the small area where the classical β Cephei are located.

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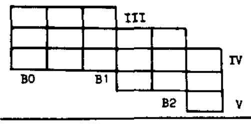
TABLE 1 - DETECTION SURVEYS FOR β CEP VARIABLES

AUTHOR(S)	YEAR	SURVEY AREA	DEFINITION
LYNDS	1959	B0 - B2.5 II - IV	"Among stars that occupy roughly the same region as do the β CMa"
HILL	1967	B	Among the members of the nearest associations and galactic clusters.
JERZYKIEWICZ STERKEN	1977	B0 - B2.5 III - IV	
BALONA	1977	B suspected variables	in a list of Cape photometry (mostly B giants, with emphasis on B intermediates, to spread the instability strip).
JAKATE	1978	B0.5 - B2 III - V	Stars that belong to Shaw's (1975) strip.
SHOBBROOK	1978	close to previously known β Cep.	among stars close to the β CMa in a β / [c_1] diagram (Shobbrook, 1974, IAU Symposium n° 59), i.e. "in or close to the instability strip".
JAKATE	1979	B0 - B3	within 500 pc. of the sun

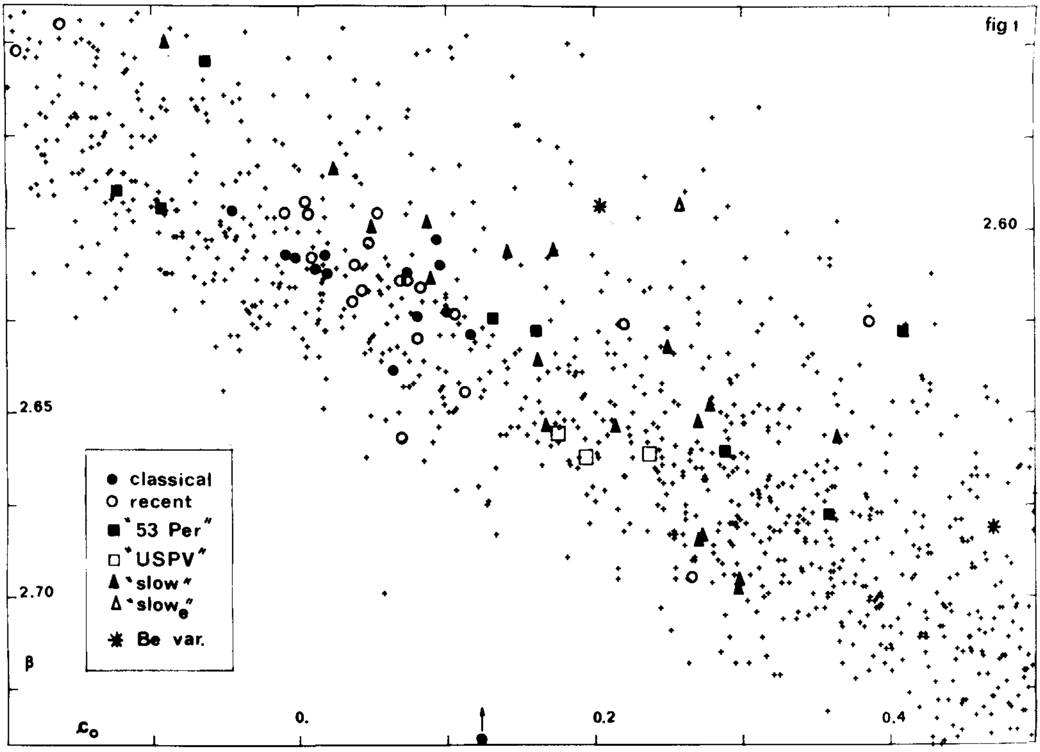
This raises several questions:

- Have we different types of variables ? (Are there different mechanisms for the B variables ?). Or are we selecting different groups of variables from observing bias, bias more or less related to the actual physics of a given group of stars ?
- Do the main criteria from which the selection has been made between the different groups imply a single determination of group membership?

a. Variables detected by Hill (1967).

The detection has been carried out in the UBV system. There is no restriction on the observational characteristics of the variability. Some of Hill's variables have been confirmed to be β Cep, either by spectrographic or photoelectric observations: most of them are not listed in the PMR, but they principally lie outside the classical β Cep domain; the periods are in agreement with those of the β Cep. Among them we find HD 43818 (Le Contel et al., 1970), but according to Jerzykiewicz (1980, private communication) this star shows only night to night variations; HR 2670 (Balona 1977); HD 149881 (Hill et al., 1976; Lane and Percy, 1979); HR 6747 (Lynds 1959; Jerzykiewicz 1975); HD 13745 (Le Contel et al., 1970).

So we think there is no reason to define a "Hill type" variable as sometimes found in the literature and no reason to discard his suspected variables as specific objects.



B versus c_o diagram (1016 stars).

- crosses: non variables; "USPV" and "slow" : Jakate's ultra short period and slow variables.
- "$slow_e$": slow variables also classified as Be; Be var: variable Be stars.

b. "53 Per" variables.

Smith (1979, IAU Meeting in Montreal) wrote that all 53 Per variables show continuous line width changes. This is also the case for every classical β Cep which has been studied with sufficient time and spectral resolution. Moreover, short period light variations have been found in 53 Per itself (Smith, 1978, Tucson Workshop). The period determination by profile fitting is dubious: for example, the same theoretical line shapes can be obtained from different physical effects, the observed line profiles are strongly related to time and spectral resolution (Huang and Struve, 1955; Le Contel, 1975). Detection of spectrum variables is limited to the smallest line widths.

c. "Ultra Short Period" and "Slow" variables.

Jakate (1979) introduced these two groups on the basis of a period length criterion, assuming that the periods of the β Cep variables "have to be" within the 3 to 6 hours range. But from different works (see Jerzykiewicz, IAU Meeting, Liège 1980) it appears that non radial modes could be excited in these stars. So a range of periods is possible which is larger than the one obtained from radial modes of stars having from 5 to 15 solar masses. For example 53 Psc has probably a 2 hours period (Sareyan et al., 1979) and is close to Jakate's "ultra short period" variables in the HR diagram. Apart from the period, other Jakate's criteria used for photometric detection of β Cep variables are excessively restrictive.

d. B_e variables.

In Figure 1, we have plotted some B_e stars detected in photometry with periods under one day. Their period range is that of the "slow variables", and also that of some "53 Per variables". 4 "Slow" variables are listed as B_e stars in Jakate (1979), so that no clear boundary seems to exist between those objects.

2. NEW OBSERVATIONS OF "CLASSICAL" β CEPHEI.

It seems that from the observational characteristics of the stars, there is no critical boundary between the different "types" of B variables. But some authors still have suspicion about type and variability of β Cep stars that are not located inside the historical "instability box". 53 Piscium is such a star: like classical β Cep it shows light, radial velocity and line profiles variations. Must we recall that line profile variations have been undetected for a long time in the β Cep stars γ Peg and β Cep itself ? In the same way, classical β Cep are still divided in single and multiple periodic variables (some have even "no strict periodicity" (Jerzykiewicz, 1975; Shobbrook, 1973)); the amplitudes may differ by a factor as large as 20 in RV and a factor 5 in light variations. So, from the properties of their variability, the β Cep stars form a non homogeneous group. Moreover, recent observations have shown that, - at least in some classical β Cep - the main oscillation behaviour is perturbated by different time scale phenomena.

a. Short time scale variations.

1) Fluctuations of 40-50 minutes have been pointed out in the visible continuum light curves of some single periodic β Cep like γ Peg. (Sareyan et al., 1976). They also appear in some of spectrographic observations of γ Peg. (Ducatel et al., 1980); especially around the RV minimum, and can be pointed out in other authors' previous observations (McNamara, 1953; ...). This time scale itself shows that these phenomena cannot be due to the pulsation of the whole star, but are probably related to strong atmospheric perturbations superimposed on it.

2) Emission and absorption components have been detected in Θ Oph (Van Hoof and Blaauw, 1958), γ Peg (Le Contel, 1980) and σ Sco (Smith, 1980) on Si III, Mg II and Ca II lines. The components appear and disappear

at very precise phases, but only on some cycles. (In γ Peg, they can be followed over less than 1/5th of the period when they exist).

b. Long time scale variations.

The amplitude of the variations of some classical β Cep has been found to vary with a time scale of years.

1) The RV amplitudes of δ Cet could have increased in the past 40 years (Ciurla T., 1979).

2) An amplitude decrease is being observed in 16 Lac (Jarzebowski et al. 1979; Le Contel et al., 1980), both in light and radial velocities, while a similar light amplitude decrease occured in α Vir (Lomb, 1978). For 16 Lac and α Vir, the amplitudes have been reduced by a factor two respectively in twelve and two years. Until now, we do not know whether a β Cep amplitude has ever increased after an observed decrease, or vice-versa. (This could be the case for α Vir, according to A.N. Cox, this conference). So we cannot know whether these phenomena are periodic or not. If they are reversible effects, it could mean that long period modes are being excited or that a relaxation phenomenon occurs in these stars.

Incidentally, as we still observe line profile variations in 16 Lac despite its now smaller amplitude, one could expect the line profile variables to be classical β Cep being observed near the minimum of a long time scale amplitude variation !

These long and short time scale variations show how careful one has to be before concluding from only a few nights of observation of a given star ! Moreover the above listed "discrepancies" occur among classical β Cep, for which one could think almost everything was already known !

3. CONCLUSION.

It now appears difficult to write that "the β Cephei stars occupy a well defined "instability strip" in the HR diagram (Lesh and Aizenman, 1978): the β Cep phenomenon - from any observational definition we could give - cannot be restricted to the small group of variables inside the box limited by the B 0.5 - B 2 spectral types and by the (II-III) - IV luminosity classes.

So the pulsation mechanism is probably not strictly related to a narrow evolutionary stage. From this point of view, a mechanism related to envelope properties could better allow for variability in a wider region of the HR diagram. Which should be the new boundaries for such a phenomenon ? Should we expect an "amplification" of the phenomenon towards the center of its HR domain ?

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DISCUSSION

A. COX: Percy told us that that BW Vul has not increased its radial velocity amplitude. You say it did. Who is correct?

SAREYAN: Underhill in Early Type Stars says that in 30 years BW Vul increased its amplitude at the rate of 0.7 km/s per year.

PERCY: Goldberg, et. al. conclude in a clear discussion how this is an instrumental effect. My contribution is to look at all the photometry back to the discovery of the variability. I found no amplitude variations greater than 5%; it actually seems to linearly decrease that much.

M. SMITH: I certainly agree with your conclusions about semi-periodicity and short time scale variations for γ Peg and others. I think I see it also. For δ Cet and BW Vul I agree with Percy. To get radial velocity extrema for 2K, line profiles either radial or nonradial can be quite asymmetric, and your instrumental resolution will really determine the radial velocity and 2K. Improved quality of instrumentation will naturally give an increase in 2K.

SIMON: Do the observers consider the behavior of these stars more upsetting than for the RR Lyrae stars? We think we understand them, but they change periods and amplitudes.

JERZYKIEWICZ: Light amplitudes are quite a bit smaller, and that is one of the problems. I'd like to understand the Blashko effect for RR Lyrae stars.

SAREYAN: RR Lyrae stars reproduce their cycle every time.

JERZYKIEWICZ: Oh, no. That's not true.

A. COX: I believe that all your stars vary because of an unstable μ gradient in the semiconvection zone.

SAREYAN: There was work done on that 10 years ago. Auré, in Astronomy and Astrophysics said it couldn't work.

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