SEARCH FOR LONG-PERIOD RADIAL VELOCITY VARIATIONS IN SOME Be STARS

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INTRODUCTION

Some astronomers have suggested long period phenomena in the Be stars : Hubert (1971), Delplace and Hubert (1975), Feinstein (1975), Harmanec et al. (1976), Pustylnik (1976). In particular, Fracassini et al. (1977) have made a periodogram analysis of the radial velocities (RV) of the Be star o And from 1900 to 1976, to connect the shell appearance with eventual long-term RV variations. In the present study all the RV of seven Be stars, found in the literature from the beginning of the century up to now, have been assembled and analysed in the same way as o And, in order to find out long period phenomena (duplicity, variability, shell activity, etc...). A brief review on the studied stars may be found in Harmanec et al. (1980).

METHODS AND RESULTS

The long period analysis of the RV variations has been performed for EW Lac, 28 Tau, ζ Tau, KX And, CX Dra, 88 Her. Whenever possible, the hydrogen and metallic lines were considered separately and averaged for each spectrum and for each month. Therefore in this analysis we have averaged all the short period variations. The justifications of this procedure, already adopted in the previous work (Fracassini et al. 1977), are given in a more extensive paper to be published elsewhere. The reliability of our periodogram analysis was tested with a simulated RV curve. Only three stars have sufficient data, suitably spaced in the time, for a periodogram analysis. However, some useful indications were obtained also for two other stars.

The following conclusions have been drawn :

- EW Lac : the plot of the averaged RV vs date is shown in Fig. 1. In spite of the dispersion of the points, long-term variations of RV values are evident. The periodogram analysis gives a period of 40.3 years with

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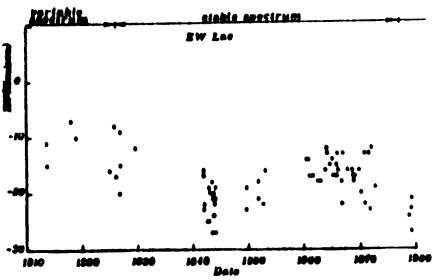

Fig. 1 Averaged RV vs date

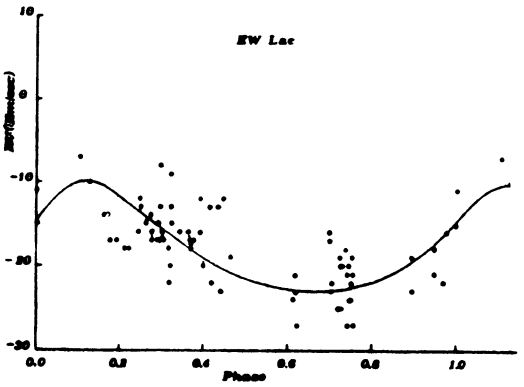

Fig. 2 RV vs phases (P=40.3 years).

a good confidence (Fig. 2). This period could be of dynamical nature since the envelope of the star seems to have been stable for fifty years, from 1926 to the end of 1977 (Hadrava et al. 1978 ; Harmanec et al. 1979). This hypothesis may be supported by a result of Scholz (1981) who suggests a possible existence of a cool companion. In the hypothesis of a binary system, from the RV curve, we have obtained the following elements :
$\omega = 345°$, e = 0.22, Epoch = 2421300.38, K = 6.6 Km/s
V_o = -18 km/s, a sin i = 8.68 A.U., f (m) = 0.4 $M_\odot$.
Hypothetical parameters : m = 18 $M_\odot$, $R_\star$ = 12 $R_\odot$ (allen, 1973)

- 28 Tau : the plot of RV vs date shows long period variations which could be periodical (Fig. 3). The lowest RV values (1951-54) are ascribed to the asymmetry of the line profiles (Gulliver, 1977). The periodogram analysis gives a period of about 45 years which does not seem correlated with the spectroscopic behaviour. In the hypothesis of a periodicity, another decrease of the RV would happen at the end of the century (probably in the years 1996-99).

- ζ Tau : Fig. 4 reports the plot of the RV of hydrogen lines from 1901 to 1976. Small variations of the averaged RV seem to occur in the interval 1901-51. In the years 1914-15 the RV are clearly higher than those of the subsequent years until 1958. We have suggested the occurrence of another activity phase during the interval 1905-21, since the RV, the V/R ratio and the appearance of the spectrum seem similar to those subsequent to the year 1951 (Hynek et al. , 1942 ; Hack, 1954). If the phases of shell activity should be recurrent, the interval between two of them would be of about 37 years. However the duration of the shell activity would have been shorter than the present one.

- KX And : we have remarked a decrease of the hydrogen RV after the year 1960 and RV variations larger than those of the preceding years. The lack of data does not allowns to ascertain a periodicity of this phenomenon.

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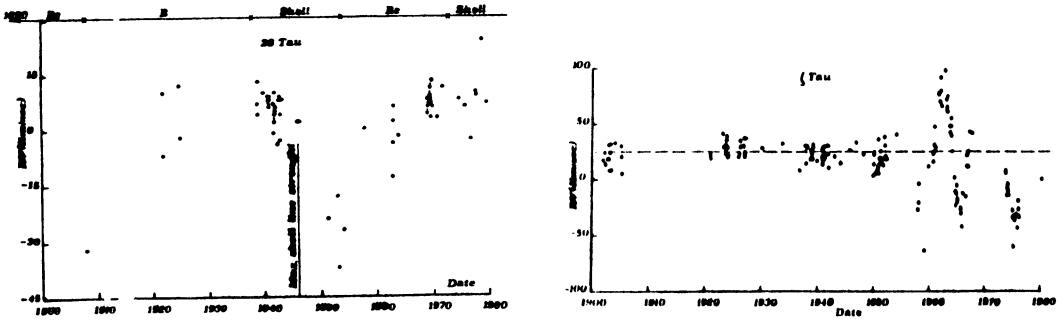

Fig. 3 Averaged RV vs date. Top of the figure : spectroscopic behaviour according to Hirata et al. (1976).
Fig. 4 Averaged RV of hydrogen lines vs date. The interrupted line is the mean RV value (+25 km/s) of the star.

- KY And : we have only two groups of RV values for the years 1928 and 1952-56 respectively. The RV ranges and the dispersions of the values are different in the two groups. The nature of this object being a spectroscopic binary and an unknown variable is uncertain.

For 88 Her and CX Dra we cannot attempt any long period analysis due to the lack of data.

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DISCUSSION

Snow: How many Be stars did you examine that did not show any radial velocity variations?

Pastori: Of course none.

Fehrenbach: In the case of ζ Tau you showed very rapid RV variations. Is it possible to reobserve the star to obtain new variations of this type?

Pastori: The variations are irregular.

Bolton: I think the procedure you have adopted is very dangerous and has a high probability of giving incorrect answers because of the inhomogenity of the data you are working with. I am not familiar with the spectra of your individual stars, but in general I think the systematic errors in radial velocity for broad lined and moderately broadened lined stars can approach a substantial fraction of the amplitudes you are finding. There are systematic errors in the older measures due to the use of different wavelengths for the lines, different measurers measuring different sets of lines, different lines having different velocities in the same spectrum, the personal equation for the measurer, unknown weightening of asymmetric line profiles when using microscope measuring engines, and systematic errors between spectrographs. The combination of these can easily exceed 10 km/s for many stars. Averaging bad data will not necessarily produce good data because the errors are systematic. In my opinion the only save approach is to borrow the plates and remeasure them on a modern measuring engine. You should also consider the measures of the radial velocity standard stars at the same time. Otherwise I will have great difficulty believing the results unless you have observed many cycles of variation or else have amplitudes of 50 km/s or more.

Harmanec: (reply to Bolton): We re-analyzed old RV of γ Peg from 1899 - 1903 using new wavelengths. The difference was about 2 km/s only and the β Cep variation with P = .1519 days and semi-amplitude of 3.5 km/s is clearly detectable. Thus, the situation is not so bad.

Pastori: Of course, we had already taken into account all your objections. In our work we have supported a global error (systematic errors of old measurements plus personal equation plus weightening of the asymmetries plus systematic instrumental errors) ≤ 15 km/s. Therefore we have discarded the possibility to find long period variations of this order of amplitude. However, the differences between our V_o and the corresponding RV in the catalogues are equal to 5 km/s (in the average) for all stars and less than 10 km/s for the single stars. Further, the data found in the literature are coming from about ten (in the average) different observers and instruments, for each star. Our declared purpose was to find long

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period and large amplitude RV variations. Indeed, our computations of the orbital elements are only tentative and qualitative ones. We believe that we have adopted a practical and realistic procedure to efface the preliminary approach to this problem. Similar, well known, procedures have been adopted for analogous problems which need the maximum number of historical informations: the rough determination of the solar cycle, of the earth's rotation, of the Hubble constant (by means of the ancient visual photometry of the old supernovae, etc. Qualitative and quantitative confirmations found by other A.A. sustain (and do not surprise) our efforts.

Harmanec: Your analysis may be sound for some cases but for KX And all RV can be reconceiled with a period of 38.9 days.

Pastori: We have looked only for long periodicities. We have not considered short period binarities or variations as we have averaged all the data over a month.

Koubsky: You mentioned CX Dra. Do you use RV obtained before 1975?

Pastori: Yes, we have found data for the interval 1919-1929.

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