UNUSUAL PHOTOSPHERIC ACTIVITY IN STARS OF SPECTRAL TYPE F0–F5

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ABSTRACT. Photometry of two early F-type stars HD 224638 and HD 224945, found to be variable by chance suggested the presence of a new kind of variability "on" the cold border of the instability strip. They indeed show an unusual photospheric behaviour, also reported for a few other stars in the same spectral region: the whole sample plot a common behaviour still to be deepened and understood. We report in this contribution further observation and analyses on the two stars.

1. Introduction

The two early F-type stars HD 224638 and HD 224945 were discovered to show photometric variability while used as comparison stars in various campaigns devoted to the δ Sct star HD 224639.

In order to investigate the nature of this variability we collected in September, October 1991 in La Silla, 1000 and 988 differential photometric measurements respectively in the Johnson B band and we measured the Strömgren color indices.

Power spectral analyses performed on these data by means of various techniques provided evidence of a pseudoperiodic behaviour with time-scales of the order of one day.

A small group of stars with very similar colours and showing the same kind of unusual variability was found among literature (Abt et al 1983, Antonello and Mantegazza 1986, Krisciunas et al 1991, Cousins 1992). These stars, regarded as a group, have been compared with various models (Mantegazza et al. 1993), among which at least the followings can equally explain the present data in our possession: i) spots carried through the visible disk by rotation (a dynamo may be active in their thin convection layers), ii) non-radial g-modes pulsation (they lie "on" the border of the instability strip), iii) close binarity (variability induced by gravitational effects).

2. Further observations and discussion

The aim of the work now in progress is to select which of the above models really describes the ongoing process in these stars.
A spot model can be figured out if spectroscopic and photometric determinations of the spin rate are in agreement. In addition, considered that for certain values of the inclination $i$, a fraction of the visible disk is always visible in spite of rotation, sufficiently high $i$ values are required for a spot model to hold.

Therefore in November 1992 we collected for HD 224638 and HD 224945 some high resolution spectra (ESO CAT, 4489-4526 Å, 0.09 Å FWHM) in order to evaluate the $v\sin i$ values for the two stars. We computed rotation either by classical FWHM method and also through the position of the minima in Fourier transform of the line profiles (Carrol 1933, Gray 1988). We found good agreement of the spectroscopic and photometric determination of the rotational velocities, providing values of the inclination $i$ compatible with a spot model. The fraction of photosphere always pointing toward the observer is for these values sufficiently small.

Moreover, it is known that various photospheric phenomena, including pulsation and the presence of spots, may produce time dependent emission features in the absorption lines. For HD 224638 a small feature of this kind is visible in various absorption lines, suggesting a time–dependent changeable profile. A number of new spectra, with the same passband and resolution, collected serendipitously in September 1993 (fig. 2) in a campaign devoted to other objects, confirm the line profile variation. After the correction for Earth’s motion a residual difference in radial velocity of a few km/s was found in the two set of spectra. This small difference, if not due to instrumental effects, could suggest an intrinsic variation in radial velocity.

Spectroscopy, through $v\sin i$ determination and emission features in the absorption lines, could confirm the spotted structure suggested by photometry, but no new experimental evidences are reported to rule out models based on pulsation or binarity. The emission feature, if moving through the line profile periodically, can be also interpreted...


\begin{table}
\centering
\begin{tabular}{|c|c|c|c|c|}
\hline
Star & $v \sin i$ & $\nu_{ph}$ & $i$ & $\Delta(\%)$ \\
\hline
HD 224638 & 24 km/s & .67 c/d & 22° & 40 % \\
HD 224945 & 60 km/s & .75 c/d & 51° & 5 % \\
\hline
\end{tabular}
\caption{Comparison between photometric and spectroscopic determination of the spin-rate for HD 224638, and HD 224945. The last column indicates the fraction of the photosphere always pointing toward the observer.}
\end{table}

Fig. 2. Spectra of HD 224638: a small feature suggesting a changeable line profile is visible.

*Mem. S.A.I., 1994*
as due to pulsation, while the possible variable radial velocity can be either a sign of pulsation or binarity.

3. Conclusions

While the presence of an unusual kind of variability among early F-type star is confirmed by the new observations reported in this communication, a conclusive understanding of the underlying phenomena is still to be achieved.

Either g-modes pulsation or binarity or spot can be expected under the theoretical point of view in these spectral region. Plotting the true scenario for this variability is therefore a matter of dedicated and crucial observations.

Among these observations high resolution spectroscopy is needed in order to obtain radial velocity curves and line profile mapping; multisite photometric campaigns are also needed to achieve a better understanding of the light curves.

References

Cousins, A.W.J.: 1992, The Observatory., 112, 53