Activity, Colour Anomalies and Temperature Determination in Solar-type Stars

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1. Introduction

The presence of photometric anomalies in broad band colours produced by chromospheric activity was first suggested by Campbell (1984). He defined the colour anomaly $\delta(B-V)_{V-K}$ as the deviation from the mean relation $(B-V)-(V-K)$ for Hyades dwarfs, and found this anomaly correlated well with several activity indicators.

Since the work of Campbell, several authors have discussed the relation between activity and colour anomalies, obtaining diverging results. This discussion is relevant because long baseline photometric colours are the most reliable temperature indicators, and the presence of such anomalies implies that no consistent temperature scales can be obtained for stars with different activity levels. These topics have been recently reviewed by Soderblom (1989).

For this work we have obtained JHKL values for 18 main sequence solar-type stars with well determined activity levels, which spread over a wider range than the Hyades stars used by Campbell, and we aim to reproduce his discussion and check his results with the same kind of data.

2. Discussion

Observations were made during three runs in December 1987, March 1988 and June 1988 in the 1.5 m Sánchez Magro Telescope at the Observatorio del Teide (Tenerife, Spain). The $(V-K)$ indices have been obtained from our K data and the V values in Nicolet (1978). We have also adopted the $(B-V)$ values of this reference. The colour anomaly $\delta(B-V)_{V-K}$ has been computed in the same way as in Campbell (1984). $\delta(B-V)_{V-K}$ is the difference between the $(B-V)$ obtained from $(V-K)$ by means of the Carney (1983) mean relation for the Hyades, and the observed value.

In Fig. 1 we have plotted the colour anomaly against two activity indicators related to the chromospheric emission in the CaII H and K lines. R'_{HK} is the

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flux in the lines normalized to the bolometric flux and corrected for photospheric contribution, as defined by Noyes *et al.* (1984). The values used have been taken from this reference. ΔF_{CaII} is the chromospheric H and K flux density, in erg cm^{-2} s^{-1}, taken from Rutten (1987). As can be seen, no correlation between colour anomaly and CaII emission level is present.

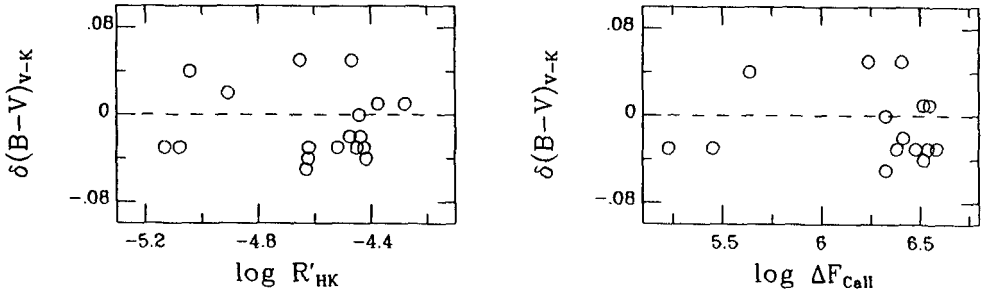

Fig. 1. The colour anomaly $\delta(B-V)_{V-K}$ against the activity indicators R'_{HK} and ΔF_{CaII}

In order to obtain further evidence of the independence of the (V−K) colour with activity, and its reliability for determining a consistent temperature scale for solar type stars, we have computed temperatures for the stars in our sample from the (V−K) values, using the calibration of Cayrel *et al.* (1985). We have also computed temperatures from the uvbyβ photometry published by Fabregat and Reglero (1990). For stars with $\beta > 2.595$ (T > 5800 K) we have derived the temperature from the β index, using the calibration of Saxner and Hammarbäck (1985). For the rest we have employed the calibration of Olsen (1984) in terms of the (b−y) colour. β is known to be not affected by chromospheric activity (Giampapa *et al.*, 1979; Fabregat, 1989), while (b−y) is not expected to be significantly affected. We have also considered temperatures determined by spectroscopic methods, taken from the catalogue of Cayrel de Strobel *et al.* (1985). We have computed mean differences for active and inactive stars, following the Soderblom (1985) criterion of considering as active stars those with log $R'_{HK} > -4.5$ and inactive those with $R'_{HK} < -4.7$. The mean differences between the (V−K) scale and the others are comparable for active and inactive stars, and hence we can conclude that no activity effects are present in the temperature determination from the (V−K) colour. We have also made plots of temperature differences against the activity indicators discussed before, finding no correlation in any case. It is noticeable, however, that temperatures determined with the (V−K) calibration are systematically higher than the others by some 100 K.

We can conclude that broad band photometric colours are not affected by different levels of magnetic activity, and hence can be used as reliable temperature indicators. Our results agree with those of Soderblom (1989) and with the theoretical discussion of Spruit and Weiss (1986).

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