EFFECTS OF ROTATION ON COLOURS AND LINE INDICES OF STARS

III. *Binary and Peculiar Stars*

R. RAJAMOHAN and ANNAMMA MATHEW*

Indian Institute of Astrophysics, Bangalore, India

(Received 3 July, 1989)

Abstract. We have analysed the broad-band *UBV* colours and the intermediate band *uvby* colours of α Persei, Pleiades, and the Scorpio-Centaurus association for rotation effects. An attempt was made to see if we can discriminate normal single stars from that of binary and peculiar stars after taking the observed rotation effects into account. It is found that the spread in the observed colours does not allow in general such a discrimination except that the objects with large reddening are double-lined binaries, peculiar stars or emission-lined objects. The few normal stars in these three clusters with such large reddening are listed as they are likely to belong to one of the above classes.

1. Introduction

The need for determining the effects of rotation on the colours and line indices of stars and the methodology we adopted were discussed in some detail in Paper I of this series (Rajamohan and Mathew, 1988). At about the same time, the work of Gray and Garrison (1987) appeared which shows that rotation effects on colours is no more a subject of controversy and that stars with higher $V \sin i$ are systematically redder than stars with low $V \sin i$ at a given spectral type. We have now completed the analysis of published data of α Persei, Pleiades, and the Scorpio-Centaurus association (Mathew and Rajamohan, 1989; Paper II) for the intermediate band *uvby* and Hβ colours and the broad-band *UBV* colours.

In this paper a specific attempt is made to find whether we can discriminate the binaries, emission-lined objects, and the peculiar stars from their observed colours taking into account the effects of stellar rotation.

2. Data Analysis and Results

For the α Persei cluster the u, v, b, y, and Hβ are taken from Crawford and Barnes (1974) and broad-band *UBV* colours from Mitchell (1960). The $V \sin i$ data for α Persei are taken from Kraft (1967). For the Pleiades the *uvby* and Hβ indices are taken from Crawford and Perry (1976) and *UBV* colours from Johnson and Mitchell (1958). The

* On leave of absence from Assumption College, Changanacherry, Kerala.

Astrophysics and Space Science **164**: 107–112, 1990.

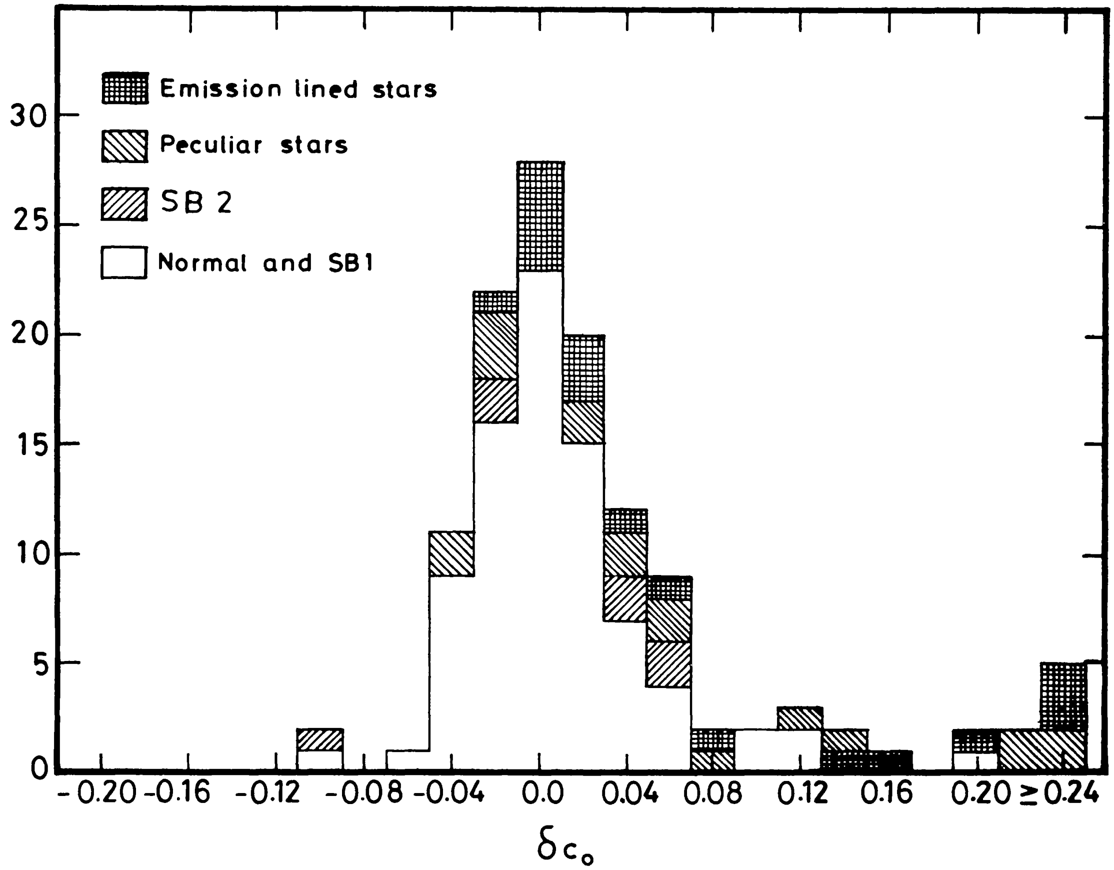

Fig. 1. Histogram showing the frequency distribution of the excess δc_0 from the mean relationship between Δc_0 and $V \sin i$ for B stars in α Persei, Pleiades, and Scorpio-Centaurus association.

TABLE I

Normal stars with large colour excesses

Cluster	HD or BD No.	$V \sin i$	Cluster	HD or BD No.	$V \sin i$
Pleiades	23288	260	Upper-Sco	139094	180
	23387	15		142315	250
	23631	10		142669	120
	23873	90		142990	150
	23964	15		143699	180
	24076	155		144661	50
				145792	50
Sco-Cen				146029	250
Lower-Cen	93163	15		146284	200
	93194	295		151985	50
	109026	180		170465	50
	115823	160		170523	30
Upper-Cen	120908	180		180885	205
	124367	270	α Persei	48°862	20
	124771	240		47°817	25
	125238	235			
	134687	40			

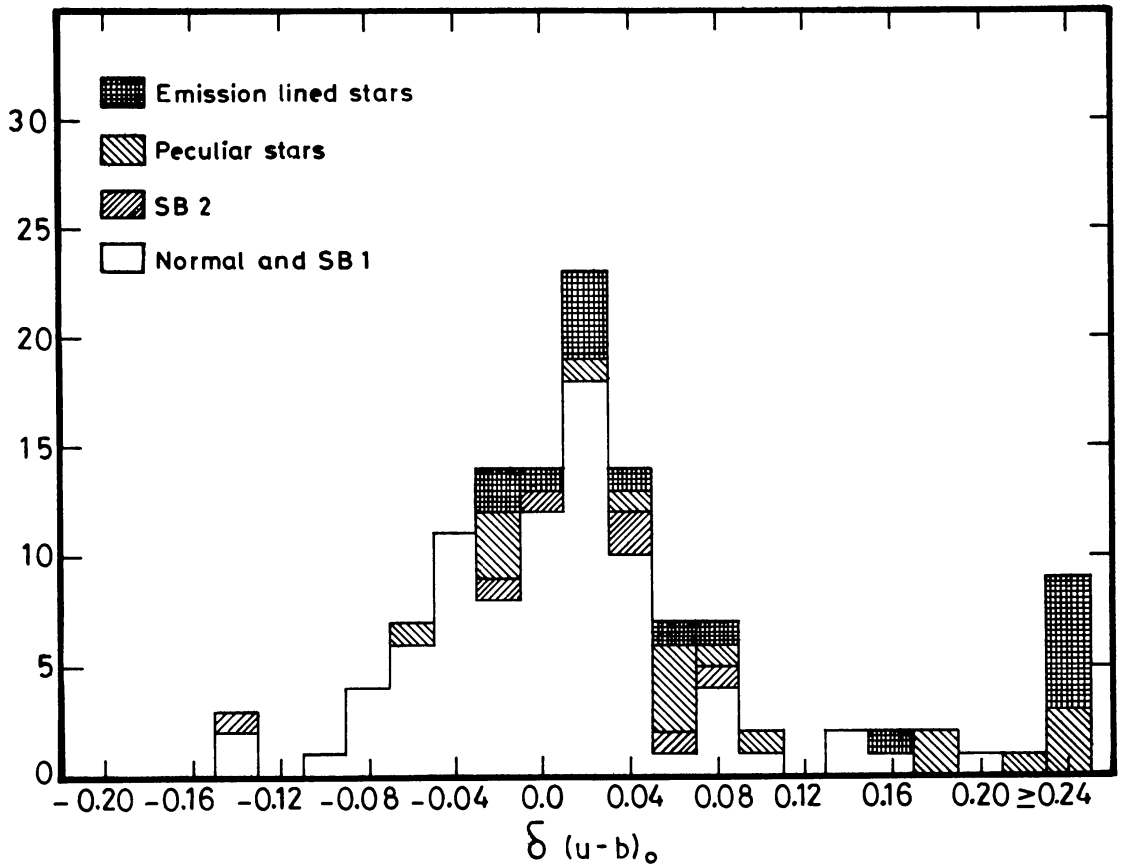

Fig. 2. Histogram showing the frequency distribution of the excess $\delta(u-b)_0$ from the mean relationship between $\Delta(u-b)_0$ and $V \sin i$ for B stars in α Persei, Pleiades, and Scorpio-Centaurus association.

rotational velocities are taken from Anderson *et al.* (1966). For the Scorpio-Centaurus association the u, v, b, y, and Hβ indices are taken from Glaspey (1971) and the broad-band *UBV* colours from Moreno and Moreno (1968). The rotational velocities used are taken from Rajamohan (1976) and Slettebak (1968). For objects not found in these two lists, the rotational velocities were taken from Uesugi and Fukuda (1982).

The colours were de-reddened following the usual procedures before analysing for reddening effects due to rotation. Procedures similar to that given in Paper I of this series were followed.

For each cluster the deviations from the mean relationship between β and c_0, β and $(u-b)_0$, β and $(U-B)_0$, β and $(B-V)_0$ for apparently single stars were determined and plotted against $V \sin i$ of the stars. These deviations define the effect of rotation on these colour indices (Rajamohan and Mathew, 1988; Mathew and Rajamohan, 1989). These colour excesses are represented by the symbol Δc_0, $\Delta(u-b)_0$, etc. In general it was found that normal single stars define a good relationship between these quantities and the rotational velocities of the stars (e.g., Figures 2, 3, and 5 of Paper I). However, the binaries, emission-lined objects, and peculiar stars behave differently in the colour excess (due to rotation) and the $V \sin i$ diagram. The excess δc_0, $\delta(u-b)_0$, $\delta(U-B)_0$,

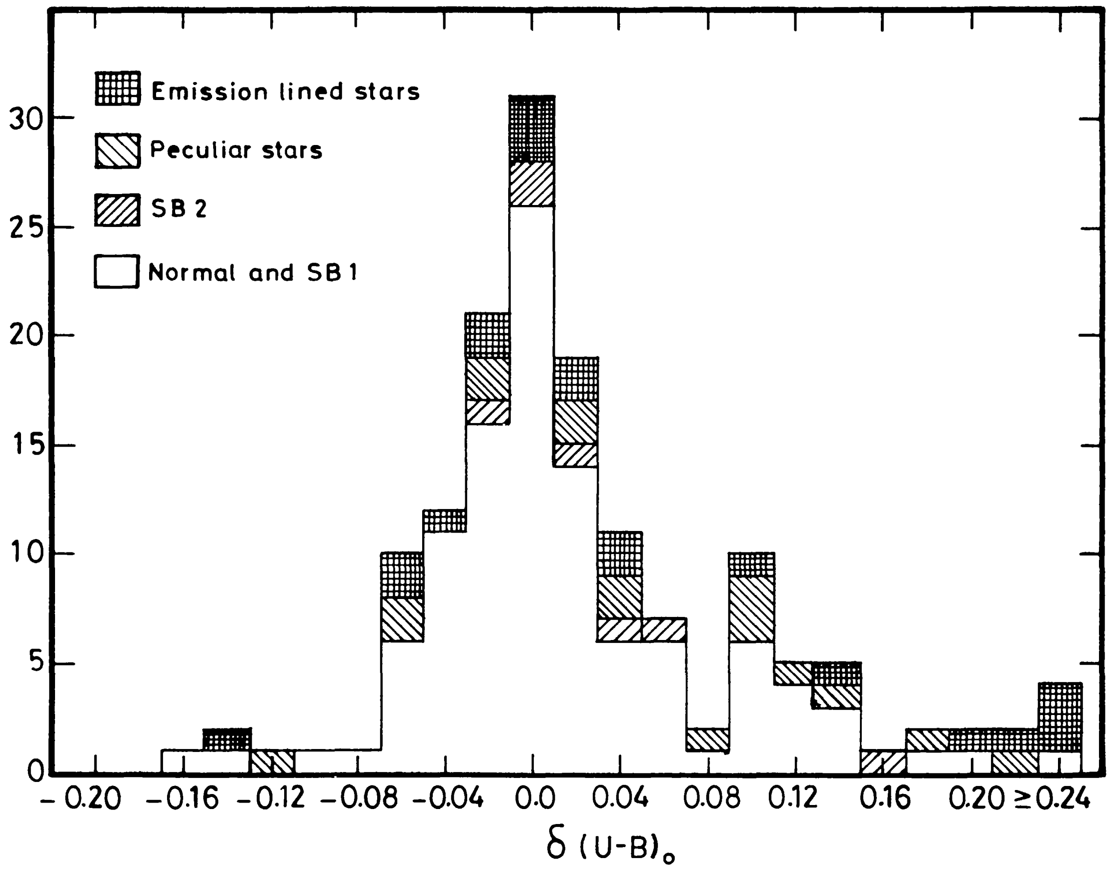

Fig. 3. Histogram showing the frequency distribution of the excess $\delta(U-B)_0$ from the mean relationship between $\Delta(U-B)_0$ and $V \sin i$ for B stars is α Persei, Pleiades, and Scorpio-Centaurus association.

$\delta(B-V)_0$ from the mean relationship between Δc_0, $\Delta(u-b)_0$, etc., and $V \sin i$ for each star was determined from such diagrams.

Figures 1, 2, 3, and 4 are the histograms of such deviations for all three clusters combined together. Only B-type stars were considered. Normal single stars and single-lined spectroscopic binaries were clubbed together as it was found that for SB1, the presence of a secondary is not found to have affected their observed colours. In Scorpio-Centaurus associations, many close visual doubles were omitted from the analysis for obvious reasons. Close pairs with Δm greater than two magnitudes are included. The histograms indicate that probably not all sources that affect the colours have been taken into account.

The following broad trends can be noted. Objects with δc_0, $\delta(u-b)_0$, $\delta(U-B)_0$ larger than +0.05 mag are in general either SB2's, spectroscopically peculiar or emission-lined objects. Some normal stars and SB1's which also occupy this region are listed in Table I. Similarly objects with $\delta(B-V)_0$ larger than about 0.02 mag are in general SB2's peculiars or emission-lined objects.

Table I lists those stars that were considered as normal but have colour excesses that cannot be accounted by rotation alone. In general we expect that objects in Table I with

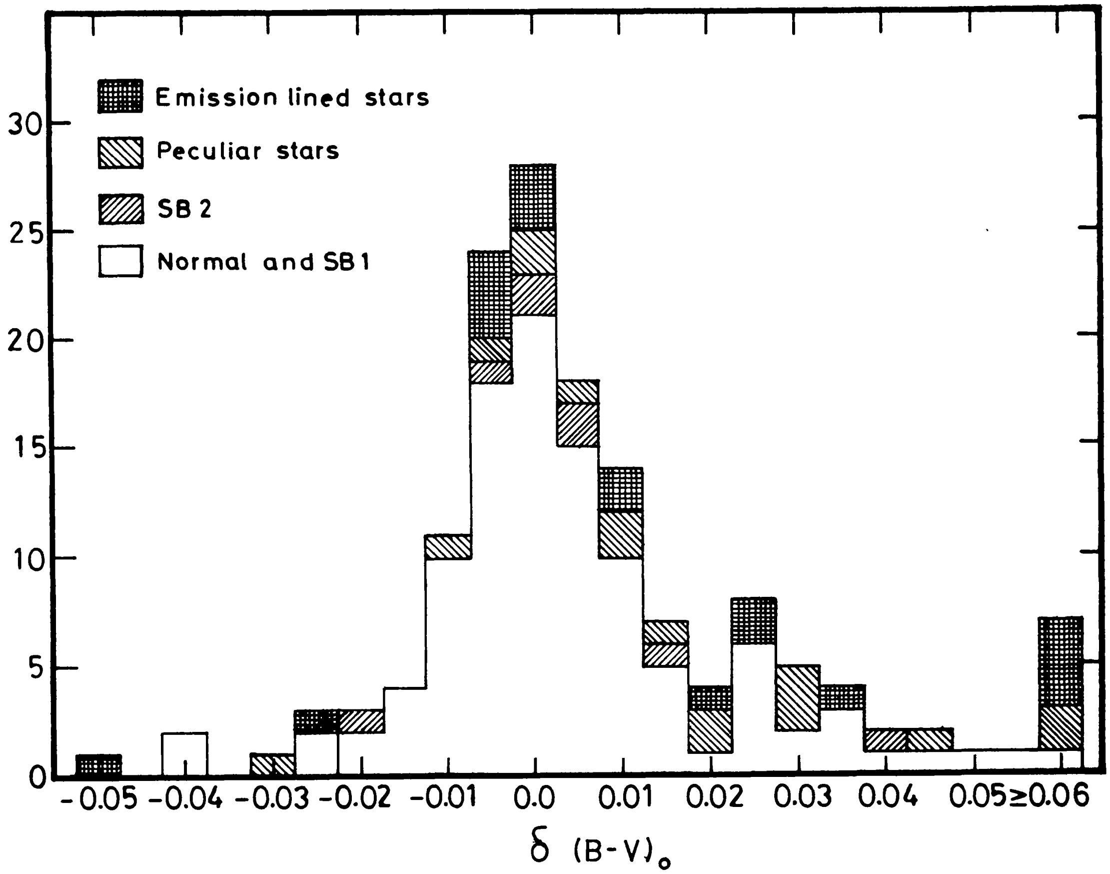

Fig. 4. Histogram showing the frequency distribution of the excess $\delta(B - V)_0$ from the mean relationship between $\Delta(B - V)_0$ and $V \sin i$ for B stars in α Persei, Pleiades, and Scorpio-Centaurus association.

low rotational velocities are likely to be spectroscopically peculiar while those with large values of $V \sin i$ were prone to show emission at the time when these objects were observed.

3. Conclusions

An attempt was made to discriminate between normal single stars from binaries, peculiar stars, and emission-lined objects after taking into account the effect of rotation on the observed colour indices. It is found that some of the double-lined binaries, emission objects and peculiar stars can be discriminated from single-lined binaries and normal single stars. Those which show large colour excesses over and above that accounted for by rotation effects are likely to belong to one of these classes of objects. A list of normal stars with such large observed colour excesses in the three clusters analysed is given. We also find that the cosmic spread in the observed colour indices of stars on the Main Sequence cannot be completely accounted for by rotation effects.

References

Anderson, C. M., Stoeckly, R., and Kraft, R. P.: 1966, *Astrophys. J.* **143**, 299.
Crawford, D. L. and Barnes, J. V.: 1974, *Astron. J.* **69**, 687.
Crawford, D. L. and Perry, C. L.: 1976, *Astron. J.* **81**, 419.
Glaspey, J. W.: 1971, *Astron. J.* **76**, 1041.
Gray, R. O. and Garrison, R. F.: 1987, *Astrophys. J. Suppl.* **65**, 581.
Johnson, H. L. and Mitchell, R. I.: 1958, *Astrophys. J.* **128**, 31.
Kraft, R. P.: 1967, *Astrophys. J.* **148**, 129.
Mathew, A. and Rajamohan, R.: 1989, (in prep.).
Mitchell, R. I.: 1960, *Astrophys. J.* **132**, 68.
Moreno, A. G. and Moreno, H.: 1968, *Astrophys. J. Suppl.* **15**, 459.
Rajamohan, R.: 1976, *Pramana* **7**, 160.
Rajamohan, R. and Mathew, A.: 1988, *J. Astrophys. Astron.* **9**, 107.
Slettebak, A.: 1968, *Astrophys. J.* **151**, 1043.
Uesugi, A. and Fukuda, I.: 1982, *Revised Catalogue of Stellar Rotational Velocities,* C.D.S. Strasbourg.