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12. SPECTROSCOPY OF SCORPI-CENTAURUS ASSOCIATION

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Abstract

Rotational velocities and intensities of hydrogen and helium lines for over 40 members of the Scorpio Centaurus association are presented. From the measured equivalent width of $H\gamma$ and $H\delta$ some evidence is found for the age difference between the upper Scorpius and upper Centaurus sub-groups.

Scorpio Centaurus is the nearest of the B star associations and, therefore, has been studied in greater detail than the others for the calibration of luminosity criteria and distance scale of the galaxy. A review of the work on this association can be found in the articles by Blaauw (1964, a, b). The membership down to spectral type F0 has been extended by Garrison (1967). UVby and $H\beta$ photometry of the association members has been recently published by Glaspey (1971). The rotational velocities of stars north of $-40°$ declination of the Scorpio Centaurus stars is due to Slettebak (1968).

Spectra of the brighter members of the association have been obtained at Kodaikanal with the 51cm reflector at a dispersion of 45Å/mm on IIa-0 plates. Microphotometric tracings of the spectra at a magnification of 80 for the hydrogen lines and at a magnification of 160 for the HeI 4026Å, and 4471Å lines were utilised to obtain the line intensities. In Table 1 the hydrogen line intensities are listed and Table 2 gives the intensities of the helium lines and the derived rotational velocities from the obsrved profiles of HeI 4026.

Rotational velocities were derived by the graphical method first suggested by Shajn and Struve (1929). We took as initial contour, the observed profile in the non-rotating star τ Scorpii. Then the theoretical contours distorted by rotation for various values of V sin i were calculated and this is shown in Figure 1. By comparing the observed profile of the other objects with the constructed sequence of theoretical profiles, the rotational velocities are derived.

In Figure 2, we have plotted V sin i obtained by us against the visual estimates of Slettebak (1968), for the stars observed in common. Values below 50 km/sec are not plotted since at our dispersion, the instrumental profile corresponds to about V sin i=50 km/sec. The visual estimates by Slettebak with a spectrum comparator is in general good and, therefore, to obtain rotational velocities on a large scale, visual methods should suffice.

TABLE 1

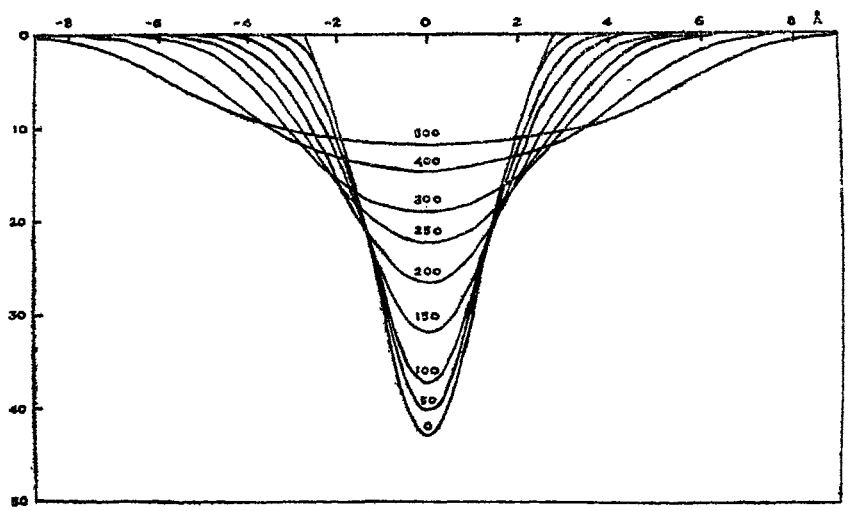
Hydrogen Lines

H.D. No.	Name	Sp. type	3770 Å	3797 Å	3835 Å	3889 Å	3970 Å	4101 Å	4340 Å
105382	HR 4618	B6 III	..	..	3.2	3.7	4.2	4.1	4.2
105435	δ Cen	B2 V Pe	1.6	2.3	1.7	2.6	2.7	2.5	0.9
105937	ρ Cen	B4 V	3.2	4.8	4.9	5.8	6.1	6.1	7.2
106490	δ Cru	B2 IV	2.1	3.0	2.6	3.2	4.4	3.2	3.6
108257	HR 4732	B4 IV	3.1	4.0	3.9	5.4	6.0	6.5	6.0
108483	σ Cen	B2 V	..	..	..	5.0	7.3	6.1	6.0
112092	μ^1 Cru	B3 IV	..	..	..	..	..	4.3	4.2
113703	HR 4940	B5 V	..	..	..	7.3	7.9	8.3	9.6
113791	ξ^2 Cru	B2 V	..	4.0	3.9	4.7	3.9	6.7	5.1
118716	ε Cen	B1 V	1.7	2.4	3.0	3.0	2.5	2.9	4.0
120307	ν Cen	B2 IV	..	..	..	..	..	4.4	5.8
120324	μ Cen	B2 Ve	2.8	5.0	4.0	4.0	4.1	4.5	4.8
121743	φ Cen	B2 IV	..	..	..	3.6	4.7	3.8	3.7
121790	ν^1 Cen	B2 V	..	..	3.4	3.6	3.3	3.9	4.4
127972	η Cen	B3 Ve	..	..	3.2	3.7	4.2	4.2	4.5
129056	α Lup	B2 II	2.7	3.6	3.5	2.3	3.1	2.8	3.8
129116	HR 5471	B2.5V	3.0	4.7	5.2	4.5	3.8	4.1	5.7
130807	ο Lup	B6 III	3.6	3.0	3.0	5.9	4.6	5.4	5.6
132058	β Lup	B2 IV	3.1	4.3	3.8	3.5	4.4	3.4	3.9
132200	K Cen	B2 V	..	..	..	..	..	5.0	4.8
133937	HR 5625	B7 V	..	..	3.4	3.9	3.1	3.3	4.6
136298	δ Lup	B2 IV	..	..	..	..	..	4.6	3.9
136664	ϕ^2 Lup	B3 V	..	5.7	4.1	3.4	4.5	6.2	5.7
138485	ξ Lip	B2 V	..	..	..	3.6	5.3	4.5	5.5
138690	ϰ Lup	B2 V	..	..	..	..	..	3.3	3.7
138764	HR 5780	B6 V	..	5.7	4.4	5.0	7.0	5.5	7.8
139365	τ Lib	B3 V	..	3.2	4.2	4.1	6.9	5.3	5.7
140008	ψ^2 Lup	B6 V	3.5	4.4	6.1	7.0	6.4	4.3	7.5
141637	1 Sco	B2 V	2.3	4.1	3.7	4.5	4.8	4.9	5.0
142184	HR 5907	B2.5V	..	..	..	3.4	4.4	4.8	5.5
142378	47 Lib	B3 V	..	..	..	5.5	5.7	5.8	8.4
142669	ρ Sco	B2 V	..	..	..	..	..	5.7	5.8
142983	48 Lib	B3 e	..	4.1	3.5	3.4	3.6	3.5	4.3
143118	η Lup	B2 V	..	..	..	..	..	4.4	4.7
143275	δ Sco	B0 V	..	..	..	..	..	4.1	3.1
144217	β^1 Sco	B0.5V	..	..	..	3.3	3.5	2.7	7.7
144218	β^2 Sco	B2 V	..	..	..	4.0	3.7	4.0	6.8
144470	ω^1 Sco	B1 V	..	..	6.2	6.6	7.2	8.6	4.7
145482	13 Sco	B2 V	4.1	3.6	3.5	4.2	4.4	5.6	5.5
147165	σ Sco	B1 III	..	..	2.8	3.7	3.3	3.4	4.7
149438	τ Sco	B0 V	..	..	..	..	..	3.0	3.5
151985	μ^2 Sco	B2 IV	2.2	2.8	4.1	3.4	3.7	4.7	4.5
157056	θ Oph	B2 IV	2.1	3.7	3.6	4.2	3.2	3.9	4.8

TABLE 2

Equivalent widths of helium lines and rotational velocities.

H.D. No.	Name	Helium 4026	Lines 4471	V Sin i	
				Present	Slettebak
105382	HR 4618 ..	1.0	0.6	150	..
105435	δ Cen ..	0.9	1.4	200	..
105937	ρ Cen ..	1.5	1.2	210	..
106490	δ Cru ..	1.0	0.8	120	..
108257	HR 4732 ..	1.0	0.6	150	..
108483	σ Cen ..	1.8	1.5	200	..
112092	μ Cru ..	1.4	1.6	160	..
113703	HR 4940 ..	1.3	1.1	160	..
113791	ξ^2 Cru ..	1.7	1.2	140	..
118716	ϵ Cen ..	0.8	1.1	80	..
120307	ν Cen ..	1.6	1.2	100	90
120324	μ Cen ..	2.2	1.7	210	190
121743	ϕ Cen ..	1.3	1.2	100	100
121790	ν^1 Cen ..	1.4	1.8	200	..
127972	η Cen ..	0.7	0.5	350	300
129056	$\propto$ Lup ..	1.2	1.2	$\geqslant$ 50	..
129116	HR 5471 ..	1.2	1.2	170	200
130807	o Lup ..	0.7	1.8	$\leqslant$ 50	$\leqslant$ 20
132058	β Lup ..	1.0	1.6	110	130
132200	κ Cen ..	1.2	1.1	$\leqslant$ 50	$\leqslant$ 20
133937	HR 5625 ..	0.3	0.5	230	350
136298	δ Lup ..	1.0	1.8	220	230
136664	ϕ^2 Lup ..	0.9	1.2	220	210
138485	ζ Lib ..	1.1	1.6	150	250
138690	$\varkappa$ Lup ..	1.0	0.8	230	270
138764	HR 5780 ..	0.8	0.4	$\leqslant$ 50	$\leqslant$ 20
139365	τ Lib ..	2.5	1.3	280	130
140008	ψ^2 Lup	0.8	1.0	70	50
141637	1 Sco ..	1.4	1.2	270	300
142184	HR 5907 ..	1.0	0.7	230	350
142378	47 Lib ..	0.8	1.0	110	240
142669	ρ Sco ..	0.9	1.0	120	140
142983	48 Lib ..	1.0	0.9	400	400
143118	η Lup ..	1.8	1.4	270	240
143275	δ Sco ..	1.4	1.6	190	180
144217	β^1 Sco ..	1.1	1.8	150	120
144218	β^2 Sco ..	0.9	1.1	60	80
144470	ω^1 Sco ..	2.6	3.5	260	140
145482	13 Sco ..	1.4	1.7	220	240
147165	σ Sco ..	1.1	2.1	$\leqslant$ 50	60
149438	τ Sco ..	1.1	1.8	$\leqslant$ 50	$\leqslant$ 20
151985	μ^2 Sco ..	0.7	1.4	$\leqslant$ 50	40
157056	θ Oph ..	1.1	1.8	$\leqslant$ 50	$\leqslant$ 20



HeI 4026 (τ Sco) Rotationally Broadened Profiles
Ordinate is Percentage of Absorption

Fig.1

FIGURE 1

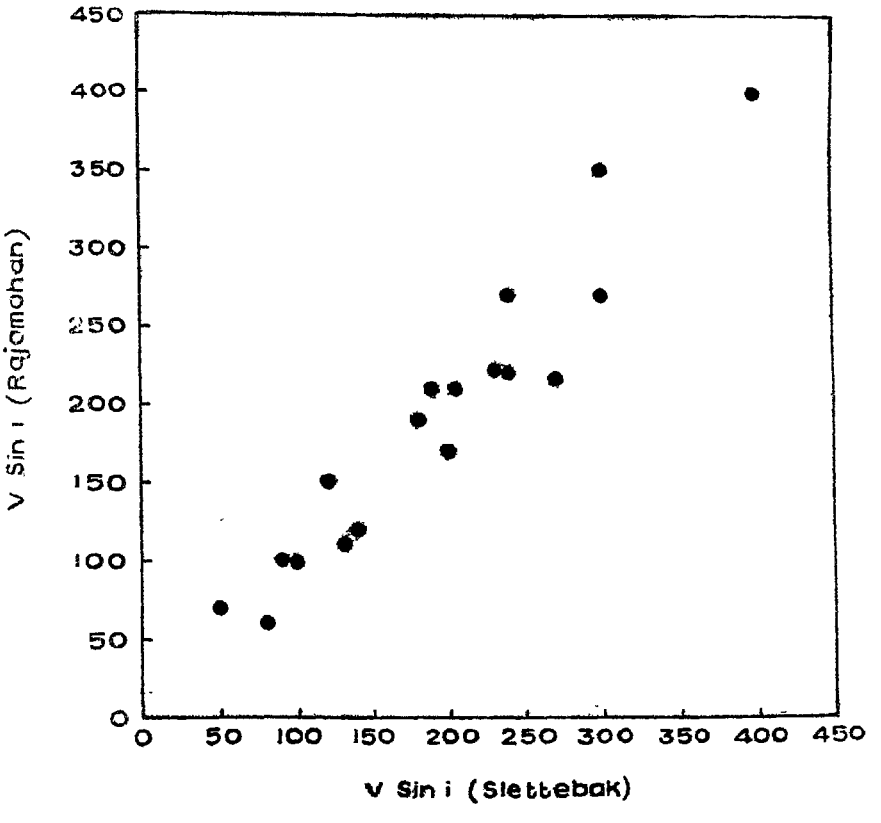

450
400
350
300
250
200
150
100
50
0
0
50
100
150
200
250
300
350
400
450
V Sin i (Rajamohan)
V Sin i (Slettebak)

Fig.2

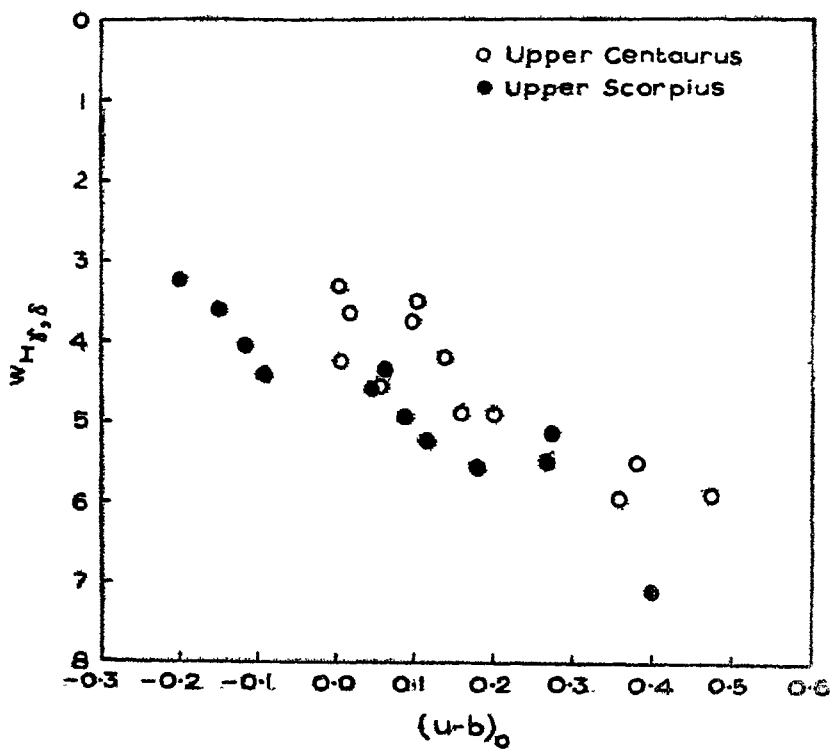

o Upper Centaurus
● Upper Scorpius
$W_{H\gamma,\delta}$
0
1
2
3
4
5
6
7
8
-0·3
-0·2
-0·1
0·0
0·1
0·2
0·3
0·4
0·5
0·6
$(u-b)_o$

Fig.3

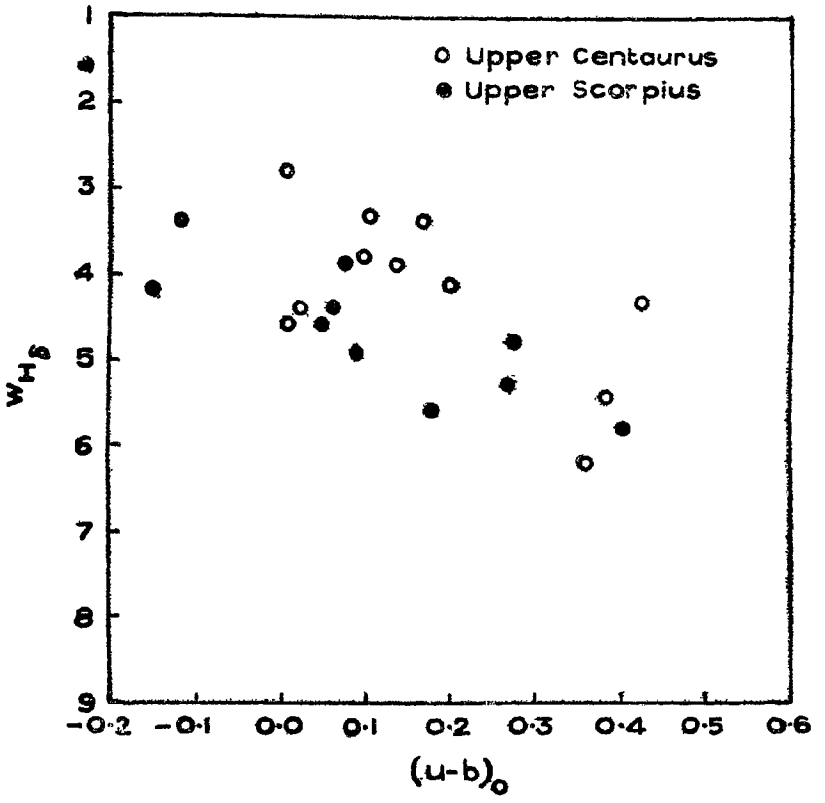

o Upper Centaurus
• Upper Scorpius
$W_{H\delta}$
1
2
3
4
5
6
7
8
9
−0·2
−0·1
0·0
0·1
0·2
0·3
0·4
0·5
0·6
$(u-b)_o$

FIGURE 4

In figures 3 and 4, we have plotted the averaged equivalent width of $H\gamma$ and $H\delta$, and $H\delta$ alone, respectively, against $(u-b)_o$ for all the members observed by us. The $(u—b)_o$ values were taken from Glaspey (1971). The Upper Centaurus members generally lie above the sequence defined by Upper Scorpius members. The same evolutionary effect was found by Glaspey in $H\beta$ index as well as in the C_o, M_o diagram. Spectroscopically, it should be possible to distinguish between different sub-groups in a cluster and thorough spectrographic analysis is lacking for this association. It is our object to obtain line intensities and rotational velocities for all the members. Spectrophotometric work will also be carried out to derive the emergent flux with a spectrum scanner. The derived tempratures, gravities and their dependence on rotation combined with line intensities should give us a better insight into the problem.

I wish to thank Dr. Bappu for his guidance and encouragement during the course of this work.

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Discussion

K. D. Abhyankar:

Do the rotational velocities show any evolutionary effect?

R. Rajmohan:

The age difference between the two sub groups is small and the sample studies is not large enough to decide this question. With the present sample no evolutionary effect is seen.