ADDITIONAL RED AND REDDENED STARS IN Cyg 0B2 ASSOCIATION

M. Parthasarathy and S. K. Jain
Indian Institute of Astrophysics
Bangalore 560 034, India

ABSTRACT

Several new red and reddened stars are detected in the most heavily reddened association Cyg OB2. About 47 IRAS sources are detected in Cyg OB2. Their flux distributions, and colours, suggest that they are young stellar objects embedded in dust envelopes or disks (some of them may be proto stars) and are most likely members of the Cyg OB2 association. The large values of the flux ratio L_{IR}/L_{VIS} suggests that the central objects are obscured because of very large extinction.

1. INTRODUCTION

The Cyg OB2 (VI Cygni) association consists of a group of luminous O-B stars some of which are extremely reddened ($A_V \sim 4$-10 mag). Cyg OB2 is the most heavily reddened association in the northern sky. The association is centered around $\alpha = 20^h\ 31^m\ 0.5$, $\delta = 41°\ 16'$ (1950) with an angular diameter of about 1°. Spectroscopic and photometric investigations of the Cyg OB2 association have been carried out by Johnson and Morgan (1953); Morgan et al. (1954); Schulte (1956a,b, and 1958); Reddish et al. (1967); Leitherer et al. (1982); and Voelcker (1975). The initial very low dispersion spectroscopic survey of Schulte (1956a,b, and 1958) revealed several heavily reddened bright O-B stars. We have carried out a very low dispersion spectroscopic survey similar to that made by Schulte (1956a,b) to detect fainter red and reddened stars in the region of Cyg OB2. Cyg OB2 is a heavily reddened young association. There can be several very young objects embedded in the dust. We have searched the IRAS point-source catalogue (Beichman et al., 1985) for infrared sources in the Cyg OB2 region. In this paper we present results of our very low dispersion spectroscopic survey and also an analysis of the IRAS data of the Cyg OB2 association.

2. OBSERVATIONS

The very low dispersion spectra of stars in the Cyg OB2 region were obtained with the f/2 Cassegrain slitless spectrograph with a 3° quartz prism at the Cassegrain focus of the 102-cm Ritchey Chretien reflector at Kavalur Observatory. The spectra are unwidened. Each exposure covers a field of 40 min of arc diameter. The exposure times ranged from 5 to 45 min with Eastman Kodak 103a-E emulsion. The 103a-E emulsion and quartz prism (3°) combination gives spectra from 350 to 6600 Å. The dip in the sensitivity of the 103a-E emulsion at 5200 Å enables us to distinguish the blue and red portions of the spectrum.

3. REDDENED STARS

The principal criterion for classification is the shape of the stellar spectrum and also the density in different portions of the image. Because of the very low dispersion, we reach fainter magnitudes in short exposure times, and also overlapping of the spectra is almost avoided. The spectral classification criteria and the method of detection of red and reddened stars have been described by Schulte (1956a,b), Bappu and Parthasarathy (1977) and Parthasarathy (1978). Employing the very low dispersion (10,000 Å/mm) technique, Schulte (1956a,b) found several reddened early-type stars in Cyg OB2 association. We have used the spectral types and colours of Schulte's (1958) (see also Leitherer et al., 1982) reddened O-B stars, and also other bright stars in the field to compare and calibrate our classification. We have detected a number of new red and reddened stars in Cyg OB2 association. A few are given in table 1 and are also shown in figure 1. Some of the red stars detected by us have UBV photometric observations made by Reddish et al. (1967) (see table 1). The UBV data of Reddish et al. and our micro spectra clearly suggest that these are reddened stars.

4. IRAS OBSERVATIONS

We found 47 IRAS sources in the region of the Cyg OB2 association. Some of the bright IRAS sources in the Cyg OB2 association region are given in table 2. The 12-μm, 25-μm, 60-μm, and 100-μm fluxes, total integrated fluxes, F_{IR}, and the dust temperatures T_d of 19 sources are given in table 2. All the IRAS sources in Cyg OB2 association show flux increasing with increasing wavelength, similar to that observed in young stellar objects (Lada, 1987). We identified the optical counterparts of some of these IRAS sources. Some of the IRAS sources in Cyg OB2 association appear to be associated with OB stars. Some of the IRAS sources in Cyg OB2 association show very high luminosities $L_{IR}/L_o \sim 2\times10^4$ (table 2) and also show very large values of the ratio L_{IR}/L_{VIS}. The flux distribution's location clearly suggests that these are young stellar objects embedded in thick circumstellar dust envelopes or disks and are most likely members of Cyg OB2 association. The large values of the flux ratio L_{IR}/L_{VIS} suggest that the central optical objects are obscured because of very large extinction.

5. CONCLUSIONS

We have detected several new red and reddened stars in Cyg OB2 association. We have found about 47 IRAS sources in the Cyg OB2 association. Their flux distributions and colours suggest that these are young stellar objects embedded in dust envelopes or disks.

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TABLE 1.– SOME OF THE REDDENED STARS WHOSE LOW DISPERSION SPECTRA ARE SHOWN IN FIGURE 1

Star no.	m_V	B-V	U-B	Comments
12	15.56	1.04	---	R1073
15	15.17	1.32	0.58	R 816
23	14.8	---	---	New
24	13.71	1.76	0.51	R 815
40	15.5	---	---	New
44	13.92	1.63	0.65	R 826
51	13.02	2.68	0.83	R 887
57	15.7	---	---	New
64	15.37	1.05	0.56	R 763
65	16.0	---	---	New
73	13.21	1.58	1.66	R 637
98	15.39	1.21	---	R 960
99	14.15	1.90	0.99	R 961
104	15.8	---	---	New
112	15.4	---	---	New
115	15.4	---	---	New
124	13.0	---	---	New
125	13.97	2.02	1.21	R 600
130	12.77	2.39	---	R 702
135	14.02	1.93	0.76	R 603
155	13.97	1.50	0.52	R 719
434	14.0	---	---	New
463	14.0	---	---	New
491	12.5	---	---	New
495	14.7	---	---	New
498	14.5	---	---	New
500	14.4	---	---	New
539	13.5	---	---	New
550	12.5	---	---	New

Note: The prefix "R" means the number refers to the catalogue number of Reddish et al.

TABLE 2.– SOME BRIGHT IRAS SOURCES IN Cyg OB ASSOCIATION

S. No.	Coordinates (1950)		IRAS FLUXES (Jy)				F_{IR}	T_d K	$L_{IR/L_\odot}$
	R.A.	Dec.	12-μm	25-μm	60-μm	100-μm	$\times 10^{-13} Wm^{-2}$		
1	$20^h28^m40.6^s$	+41°05'39"	12.91	91.9	789.89	1387.02	916.40	47	1.15×10^4
2	20 29 03	+40 52 15	0.58	5.62	65.67	136.29	76.93	43	9.62×10^2
3	20 29 32.9	+41 26 30	0.46	2.08	7.42	133.0	50.08	22	6.26×10^2
4	20 29 42	+40 52 42	1.3	2.8	34.1	150.6	69.10	32	8.64×10^2
5	20 30 2.2	+40 58 47	2.01	6.08	47.59	159.09	81.80	35	1.02×10^3
6	20 30 28.4	+40 59 00	4.21	10.29	179.8	800.2	360.10	32	4.50×10^3
7	20 31 28.1	+41 06 51	1.78	4.08	61.26	---	39.40	63	4.93×10^2
8	20 31 30.3	+40 48 39	1.48	4.26	49.71	142.2	74.90	38	9.37×10^2
9	20 32 8.0	+41 12 22	5.22	28.27	427.89	920.61	529.60	42	6.62×10^3
10	20 32 10.6	+41 46 10	1.58	2.52	44.38	88.72	52.98	36	6.63×10^2
11	20 32 26.3	+40 57 58	14.53	37.01	76.68	147.43	155.81	44	1.95×10^3
12	20 32 43.5	+41 20 22	11.56	17.54	286.67	631.4	363.90	38	4.55×10^3
13	20 32 46.0	+41 48 20	1.21	1.40	42.19	163.23	75.44	34	9.43×10^2
14	20 32 52.8	+40 42 32	3.63	8.73	76.3	---	53.80	71	6.73×10^2
15	20 33 12.3	+40 34 39	1.2	2.5	45.6	125.72	65.60	38	8.20×10^2
16	20 33 12.9	+41 24 24	11.44	77.46	909.21	1376.07	950.00	51	1.19×10^4
17	20 33 21.3	+41 02 53	22.85	74.88	1246.12	2477.62	1472.00	44	1.84×10^4
18	20 33 46.5	+41 04 56	4.42	7.8	192.37	542.43	277.00	38	3.46×10^3
19	20 34 19.5	+41 29 33	22.12	151.76	690.2	1035.34	822.00	17	1.03×10^4

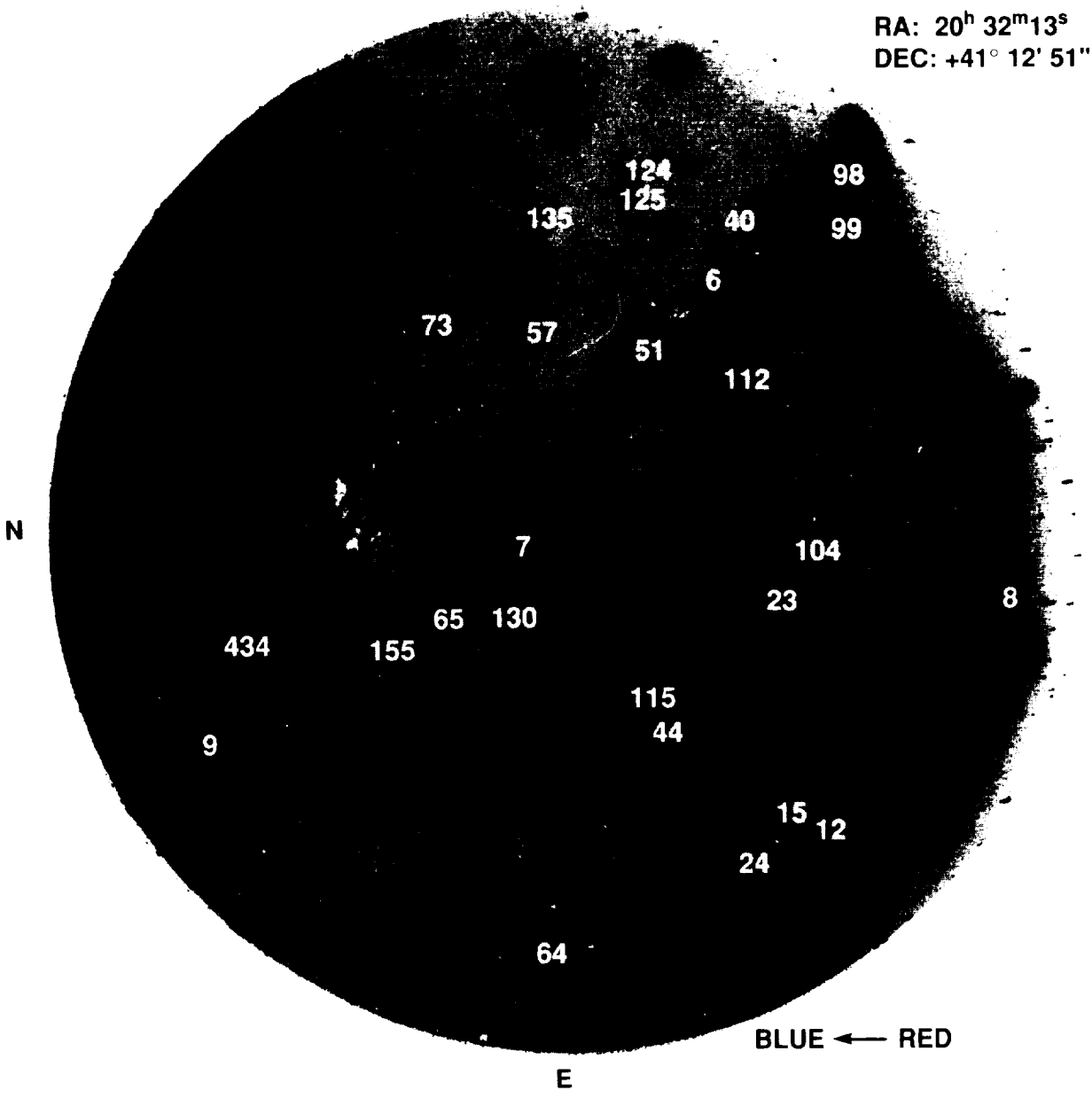

Plate 1: Low dispersion spectrograms of the Cyg OB2 association. Some of the red and reddened stars listed in table 1 are shown here. The encircled stars represent some of the IRAS sources listed in table 2.

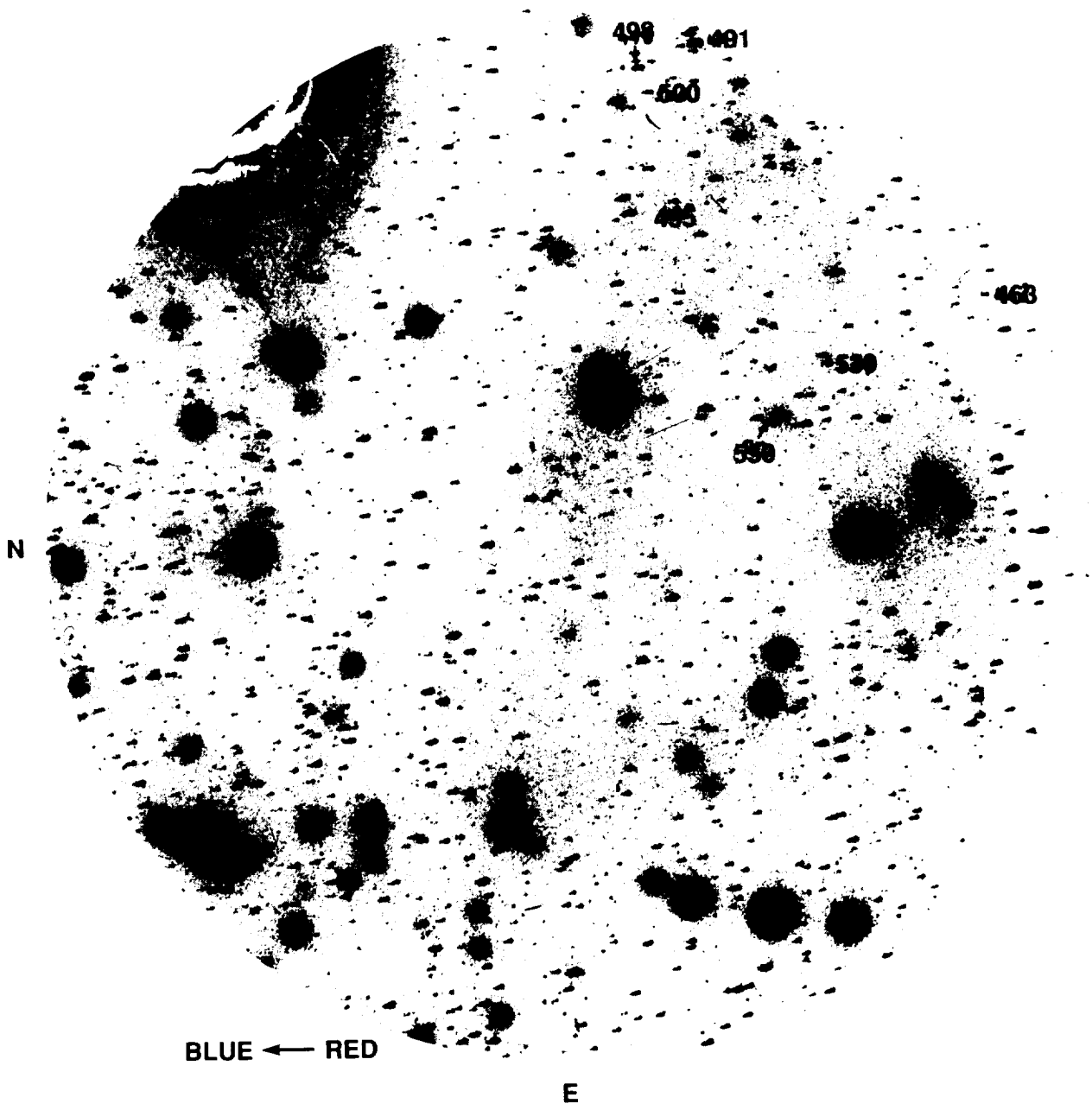

Plate 1: Concluded.