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Surveys for Hα Emission-Line Stars using the Bosscha Schmidt Telescope

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1. Introduction

According to McCarthy (1984) the objects detected in objective prism surveys for Hα emission line are a "most unnatural" group. Of course they consist of many natural groupings whose identities or other peculiarities could become apparent after observing them with higher dispersion and resolution spectroscopy. In some cases, however, their galactic locations and associations with other known populations, can provide a clue to their population types.

The aims of the objective prism surveys using the Bosscha Schmidt telescope can be broadly categorised as follows:

1. Searches for galactic planetary nebulae in the region $240° < l < 360°$; $|b| \leq 10°$, initiated by The (1968).
2. Searches for T-Tauri stars in some southern dark clouds (Shinohara, Ogura & Hidayat 1989).
3. Searches for variations in Hα intensities and luminous emission stars in some selected galactic regions, such as in the Puppis and Carina regions.

In almost all cases photometric studies are needed to determine population types. Due to the inherent character of the Bosscha Schmidt telescope, only $BVRI$ photometric studies can be carried out at Lembang. The U-band photometry must be obtained from elsewhere.

2. The Survey

The (1969) has described the main character of the telescope used in his study and some of the early results. Since that publication, the observational data for the galactic segment between 240° and 360°, and up to 10° on both sides of the galactic equator, have been secured. Some 80 per cent of the total areas have been observed in the $BVRI$ bands.

Whilst planning to compile a catalogue of emission line stars in the surveyed regions, to $I \sim 17^m$, special emphasis is given to regions of particular interest, such as the Puppis region ($240° < l < 247°$) and the Ara region ($342° < l < 346°$).

In these two fields, Hidayat et al. (1989) obtained 59 and 180 Hα emission line stars respectively. The results comprised all types of Hα emission line stars. The spatial distribution of the stars is interpreted in term of galactic structure and also in terms of interstellar absorption of the dark clouds in the respective areas.

The search for T-Tauri stars in the southern dark clouds started in 1986. This search is intended to provide answers to several questions concerning star formation in dark clouds. In order not to miss variable-line stars, the observations were carried out over several observing runs. For example, the R CrA region was observed in 1982. This area was also observed earlier by The (1963, unpublished). Some new emission-line stars revealed themselves in our new plates, but some stars which showed emission-lines in the older survey could not be detected by us. A detailed study of the area is now compared with the results obtained by Graham (1993).

Shinohara et al. (1989) gave preliminary results for the region in and around the Lynds 315 dark cloud complex, where an H II region, S37, and two reflection nebulae (vd Berg 118 and 119) are found. Within the complex 17 new emission-lines stars are found. Half of them are thought to be young objects. A study of the links between various young objects in this area is still underway.

The areas in our programme for T-Tauri type stars and for star forming activity are (i) Serpens Dark Clouds, (ii) Monoceros R2, (iii) Puppis and (iv) reflection nebula near NGC 5367

All the spectroscopic material consist of 103aE and IIIaF plates exposed behind a RG2 filter. We also secured spectroscopic plates in the blue-violet part of the spectrum. Kodak IIa-O emulsions, without filters, were exposed for this purpose. This wavelength coverage includes the Ca II H and K lines as well as the higher Balmer lines.

3. Some Results

Puppis region around NGC 2467

Two OB Associations are found in this area. Forty new and nineteen known Hα emission line stars were detected in this survey. They are shown in Fig. 1 together with the positions of the OB associations. The asymmetric distribution with respect to the galactic plane reflects the characteristic structure in that particular area, where many members of the OB associations are predominantly located south of the galactic plane.

The positions of the Hα emission stars in the $(U-B)$, $(B-V)$ diagram shown in Fig. 2, suggest that many of them are early-type emission-line stars. The frequency distribution of the magnitudes of the Hα emission stars shows a flat peak around $m_V \sim 12^m$–13^m. Using $E_{B-V} = 0.9$ (Hidayat & Djamaluddin 1987) and $M_V = -3.0$ for the early type emission line stars, we found that they are concentrated at $r \sim 2$ kpc.

The Ara regions

The (private communication) suggested that the Ara regions should be studied in detail. Fig. 3 shows the area searched which includes dark clouds of various

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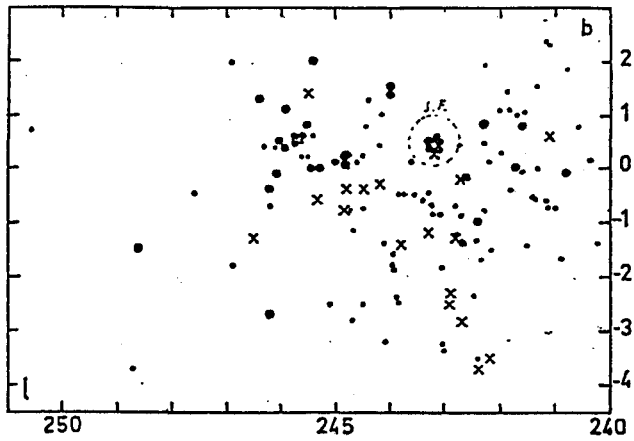

Figure 1. Distribution of Hα emission-line stars in Puppis (small filled circles); Puppis OB2 (large filled circles) and Puppis OB1 stars (crosses).

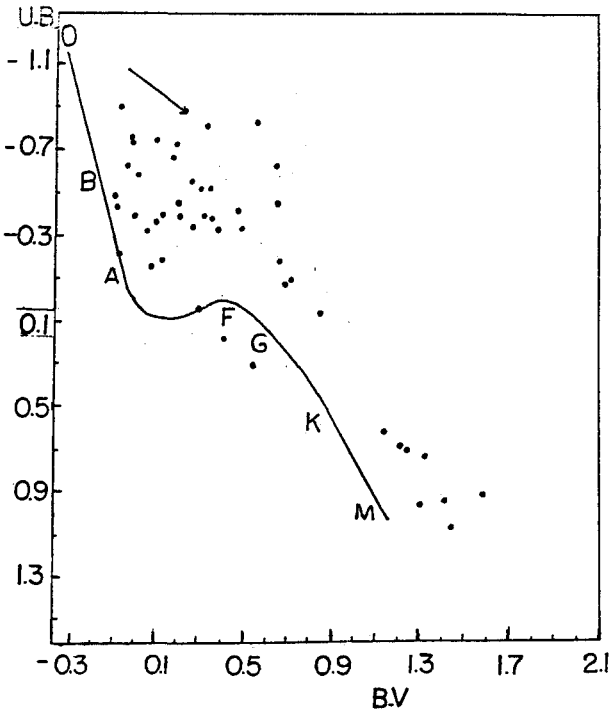

Figure 2. The positions of Hα emisison-line stars in the two colour diagram.

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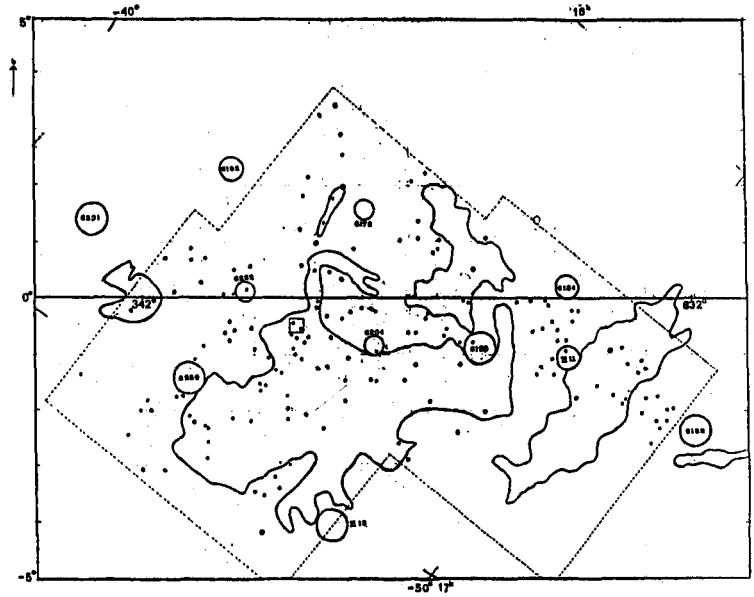

Figure 3. Distribution of Hα emission stars in Ara, superposed on the Ara dark clouds.

types and several HII regions. Altogether 180 Hα emission stars were detected in our survey, of which 80 were already known.

The surface distribution of the stars is shown in Fig. 3 (dots). The apparently asymmetric distribution of stars may be caused by the lack of survey material in the north of the galactic plane. 147 Hα emission line stars are found south of the plane. We note. however, that although the plate material reached V $\sim$ 16^m–17^m, the peak distribution of the Hα emission stars is found at V $\sim$ 13^m. The decline at V $\sim$ 14^m may be real. Feitzinger and Struwe (1986) have classified the form and opacity of the dark clouds. Further studies to interpret the distribution of stars in terms of the dark clouds, the IRAS point sources and energetic events in the area, are now underway.

Lynds 315

This is an interesting area, located south of the M17-SW giant molecular cloud. Shinohara & Ogura (1987) have found some Hα emission stars. Table 1 lists

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the Hα emission stars found in Lynds 315. Four of these stars are identified with IRAS point sources. In view of their coincidence within 30″ with the tabulated IRAS sources, it is estimated that half of the objects may be young stars associated with the cloud complex.

Table 1: The coordinates of the Hα emission stars

No.	α (1950.0)	δ	Comments
1	$18^h12^m21.8^s$	−19°32′54″	*
2	$18^h12^m24.5^s$	−19°32′41″	*
3	$18^h12^m35.4^s$	−19°45′14″	
4	$18^h13^m17.4^s$	−19°26′48″	IRAS
5	$18^h13^m36.8^s$	−19°35′03″	*
6	$18^h14^m33.3^s$	−19°29′43″	*
7	$18^h15^m30.2^s$	−18°56′30″	* IRAS
8	$18^h15^m32.0^s$	−19°13′05″	IRAS
9	$18^h15^m41.3^s$	−19°32′29″	
10	$18^h16^m02.4^s$	−18°50′55″	
11	$18^h16^m02.6^s$	−19°23′46″	*
12	$18^h16^m11.3^s$	−20°48′16″	* IRAS, nebulous
13	$18^h16^m24.1^s$	−20°55′38″	
14	$18^h17^m21.2^s$	−20°42′46″	
15	$18^h17^m44.3^s$	−18°58′34″	*
16	$18^h19^m25.1^s$	−19°36′46″	
17	$18^h20^m22.5^s$	−20°29′45″	*

Serpens dark clouds and NGC 5367

In these areas some IRAS point sources are found to coincide with cometary-shaped reflection sources. Some of the sources show the typical infrared colour of protostars. Preliminary results of our survey in the Serpens area ($18^h16^m < \alpha < 18^h40^m$; $25° < \delta < -4.5°$) reveal 50 Hα emission line stars. They are distributed near the periphery of dark clouds. The nature of the stars, and whether they are pre-main sequence objects are still to be determined.

4. Conclusions

The study aims to present, through the surveys of Hα-emission line objects combined with data from the IRAS point source catalogue, CO surveys; Southern Dark Clouds (see Hartley et al. 1986) and $(U)BVRI$ photometry:

1. The spatial distribution of the early-type emission-line stars in order to study complicated galactic regions. Results for the Puppis and Ara regions show that if the Hα emission line stars are members of the surrounding

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OB-association, then we are dealing with the natural subgroup of B0-B2 emission stars. These stars are tracers of spiral structure.

2. The number of pre-main sequence stars and of classical T-Tauri type stars. The mass and spatial distribution of these stars can give important clues in understanding the processes of star formation in dark clouds. The Herbig & Bell (1988) catalogue gives 800 pre-main sequence stars. Results in Lynds 315 (present study), in Bok globules (Ogura & Hidayat 1985) and in L1228 (Ogura & Sato 1990) show that searches for new T-Tauri type stars are still warranted. Our preliminary study of variable Hα emission in R CrA also supports this view.

3. Searches for faint planetary nebulae. Although the discovery of southern planetary nebulae carried out with the present survey mode has become dwindlingly small, the coverage of up to 10° on each side of the galactic equator, in particular in the zone 350°–360°, could reveal several more planetary nebulae. Ratag (1993) suggested that in this general direction the IRAS point sources could serve as a guide for discovering compact planetary nebulae.

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