A GALLERY OF NEGLECTED NEARBY
STAR FORMING REGIONS

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Abstract
This paper reports on a search for pre-main sequence stars in the nearby molecular clouds L 1228, L 1241, L 1251, L 1333, as well as in the region of the reflection nebula IC 2118. These low-mass star forming regions are at distances 180–300 pc from us, just a little farther than Taurus, Chamaeleon and Ophiuchus. Studying their star forming histories therefore may be important for understanding star forming processes in our galactic environment.

1. Introduction

Physical processes governing the formation and evolution of molecular clouds can be inferred from the observed patterns of star formation in them. Efficiency of star formation, initial mass function, duration of star formation in a cloud, and propagation speed of the process across interstellar medium are regulated by large-scale interstellar processes. In order to test theories of star formation these quantities have to be find and compared for several star forming regions. Though such data sets are essential for understanding star formation at the scales of star forming regions, the number of well-studied star forming regions in our galactic environment is small. Conclusions on their global properties probably suffer from uncertainties due to the statistics of small numbers.

The target clouds of the present study have already been mapped in $^{12}$CO or/and $^{13}$CO. Their distances from us are well determined, and most of them have shown evidence for low-mass star formation: embedded IRAS sources, H$_2$O masers, outflows are associated with them, indicating protostellar accretion. These clouds certainly contain a less conspicuous population of young pre-main sequence stars. Our aim is
to assess the number of these pre-main sequence stars, as well as to establish their mass and age distribution.

2. Methods

I have been searching for pre-main sequence star candidates using objective prism spectra taken with the 60/90/180 cm Schmidt telescope of Konkoly Observatory (see e.g. Kun 1998). The dispersion of the objective prism is about 2000 Å/mm at Hα. Figure 1 shows examples of the objective prism spectra obtained with a CCD camera installed on the Schmidt telescope. The wavelength scale of the very low dispersion spectra was established in possession of the geometric and optical properties of the prism and camera, and using the atmospheric A-band as reference wavelength. Quality of such a low dispersion slitless spectrum highly depends on the atmospheric conditions.

This method is suitable for finding classical T Tauri stars, as they show strong Hα emission (EW(Hα) ≥10 Å). The real nature of the selected stars have to be established by medium-resolution spectroscopic follow-up observations. I performed spectroscopic observations of a few regions studied earlier with objective prism using the instruments CAFOS on the 2.2 m telescope of Calar Alto Observatory, as well as ALFOSC on the Nordic Optical Telescope. Though several candidates proved to be field stars without Hα emission, a number of classical T Tauri stars were found in molecular clouds where no pre-main sequence stars have been known earlier. This poster demonstrates some preliminary results.

3. Results

LDN 1333 is a small molecular cloud in Cassiopeia, at a distance of 180 pc from the Sun. Its total mass, revealed by molecular observations, is about 100 M⊙ (Obayashi et al. 1998). 13CO and C18O observations have shown L 1333 to be a part of a 30 pc long filamentary cloud complex. Star formation is indicated by the protostar-like IRAS source IRAS 02086+7600. Spectroscopic study of L 1333 revealed four classical T Tauri stars in the region of L 1333 (Kun et al. 2003a). Together with the protostellar-like object IRAS 02086+7600 these stars constitute the L 1333 association. Their positions mark two star-forming knots along the filamentary cloud complex, separated from each other by some 6 pc.

Figure 2 shows the distribution of cold dust associated with L 1333 obtained from IRAS data. ∆I100 = I100 - I60/0.21 (Laureijns et al. 1988) values are displayed, together with the positions of low mass pre-main sequence stars.
IC 2118 is a reflection nebula at high galactic latitudes, illuminated by β Orionis. It is situated at a distance of 210 pc from the Sun, and is associated by several small molecular clouds (Kun et al. 2001), among others MBM 21 and 22 (Magnani et al. 1985). Two YSO-like IRAS sources, IRAS 04591−0856 and IRAS 05050−0614 are indicative of ongoing low-mass star formation in this region. Our spectroscopic observations revealed five classical T Tauri stars in the region of IC 2118 (Kun et al. 2003b).

Figure 3 shows the distribution of the YSOs projected on the IRAS 100µm image of the region. Circle marks the Class I infrared source IRAS 04591−0856, and plusses are classical T Tauri stars.

The IC 2118 association contains five classical T Tauri stars and an accreting protostar. The 2MASS $K_s$ image shows several faint stars around IRAS 05050−0614. Among them probable fainter members of the association can be found.
3.1 Clouds in the Cepheus Flare region

In the Cepheus flare region at $100^\circ < l < 120^\circ$, $10^\circ < b < 20^\circ$ three large cloud complexes have been found, at distances 200, 300 and 450 pc from the Sun (Kun 1998). $\Delta I_{100}$ image of a part of the region, containing the molecular clouds L 1228, L 1241, and L 1251 is shown in Fig. 4. Numerous H$\alpha$ emission objects of this region, selected as candidate pre-main sequence stars, wait for spectroscopic follow-up observations.

LDN 1228 is situated at a distance of 200 pc from the Sun. Several signposts of low-mass star formation have been observed in the cloud (e.g. Bally et al. 1995). A large number of H$\alpha$ emission stars were found in and around L 1228 by Ogura & Sato (1990). Objective prism spectra of a few stars are shown in Fig. 1. Spectroscopic follow-up observations are needed to establish the pre-main sequence nature of these stars.

LDN 1251 at a distance of 300 pc from us is associated with two protostars, driving optical jets and molecular outflows. The spectacular cometary shape of L1251 and presence of a supernova bubble in its neighbourhood suggest that star formation in L1251 was triggered by a supernova shock. Grenier et al. (1989) proposed that the bubble was...
created by a Type I supernova some $4 \times 10^4$ ago. Our results have shown that star formation in L1251 was initiated long before this explosion. We found eight pre-main sequence stars in L1251. According to their positions in the HRD these stars are at least $10^6$ years old (Eredics & Kun 2003).

**LDN 1241: The Northern Coalsack?** Next to L1251 in the Cepheus flare region, and at the same distance from us, lies the large molecular cloud L1241. It occupies an area of some $2^o \times 2^o$. Its mass, determined from $^{13}$CO observations (Yonekura et al. 1997) is about 1500 M$_\odot$. Neither IRAS sources nor other star formation signposts have been found in the cloud area. Apparently L1241 is similar in nature to the Coalsack, the most famous massive, nearby cloud which does not form stars, but, located at the galactic latitude of $+17^o$, is much less conspicuous than Coalsack.
Figure 4. IRAS $\Delta I_{100}$ image of L1228, L1241 and L1251 in the Cepheus flare region. Pre-main sequence and candidate pre-main sequence stars are marked by crosses.

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References

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