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Nature of Emission-Line Stars in the Outer Orion Region

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Abstract. Near-infrared photometry is reported for 76 emission-line stars in outer regions of the Orion molecular cloud complex. Most of our program stars are selected from the Hα emission-line star catalog of the large-scale Kiso Schmidt survey of the Orion region. We confirm that most of the emission-line stars with strong emission detected in the Kiso survey are typical T Tauri stars with masses in the range 0.5 to 2 $M_{\odot}$. Low mass stars have therefore continued to form in the outer parts of the Orion region, away from present day massive molecular clouds, until at least as recently as a few million year ago.

1. Introduction

Recently, Wiramihardja et al. (1989), Kogure et al. (1989), and Wiramihardja et al. (1991) have made a large-scale Schmidt survey in search of Hα emission stars in the whole Orion region. They have surveyed 125 square degrees using the Kiso Schmidt telescope, and have detected as many as 1000 Hα emission-line stars. About half of these are new detections. Although the nature of emission-line objects far removed from known dark clouds is uncertain and cannot be determined from the objective-prism spectra alone, their V magnitude distribution suggests that they are mostly T Tauri stars. Spectroscopic observations of these emission-line stars in the Ori OBIb region has been reported by Kogure et al. (1992). They confirmed that most of these stars are highly probably T Tauri stars.

We obtained JHK photometry of 76 emission-line stars in the outer Orion region with the ANU 2.3m telescope at Siding Spring Observatory. 74 stars are selected from the Kiso survey, and 70 % of them have medium or strong Hα emission. We have identified infrared excess objects and obtained a better understanding of the nature and evolutionary states of these Hα emission-line stars.

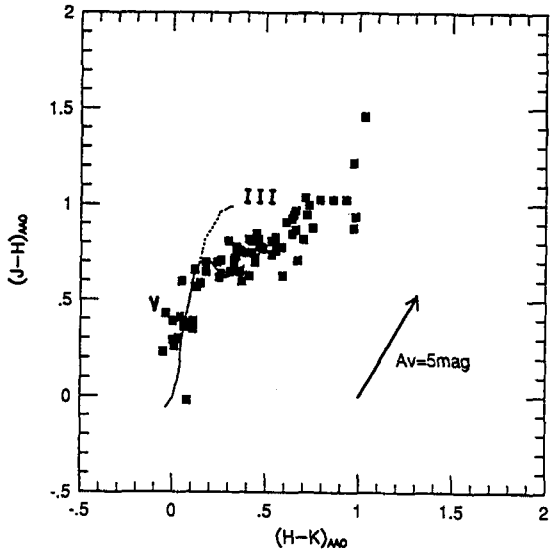

Figure 1. $(J\text{-}H)$ - $(H\text{-}K)$ diagram for our photometric sample. The solid and dashed curves are the loci of unreddened main sequence and giant stars. The arrow in the lower right-hand portion of the figure indicates the reddening line corresponding to $A_V = 5$ mag.

2. Results

Fig. 1 presents the data for our photometric sample of emission-line stars plotted in the near-infrared two colour diagram $(J\text{-}H,H\text{-}K)$. We distinguish two groups of stars in Fig. 1. One is the group of stars with the colours of G-type main sequence stars, and the other is the group extending from ($J\text{-}H \sim 0.6$, $H\text{-}K \sim 0.1$) along a sequence to redder colours. The locations of our stars mainly outside of the Ori A and Ori B molecular clouds (Maddalena et al. 1986) and the small dispersion of the observed colours in the direction of the interstellar reddening vector in Fig. 1 both suggest that the interstellar reddening to our objects is low. The locations of our stars in Fig. 1 therefore fairly accurately reflect their intrinsic colours. The sequence of stars extending to red colours is typical of a population of pre-main sequence stars with circumstellar dust envelopes, as we expect for the bulk of our sample. Furthermore, 22 stars of our sample had been observed spectroscopically by Kogure et al. (1992). All of them except one star belong to the group of redder stars. Their spectral behaviors are consistent with our results that they are pre-main sequence stars.

In the $(K,J\text{-}K)$ near-infrared colour-magnitude diagram, we identify three groups of stars. All stars in the G-type clump in Fig. 1 lie below the Orion main sequence locus, suggesting that they are background emission-line stars. Five stars lie on the Orion main sequence, suggesting they have masses of ~ 0.7 $M_\odot$ and ages of $\sim 3 \times 10^7$ yr. The remaining stars lie above the main sequence in locations typical of pre-main sequence stars.

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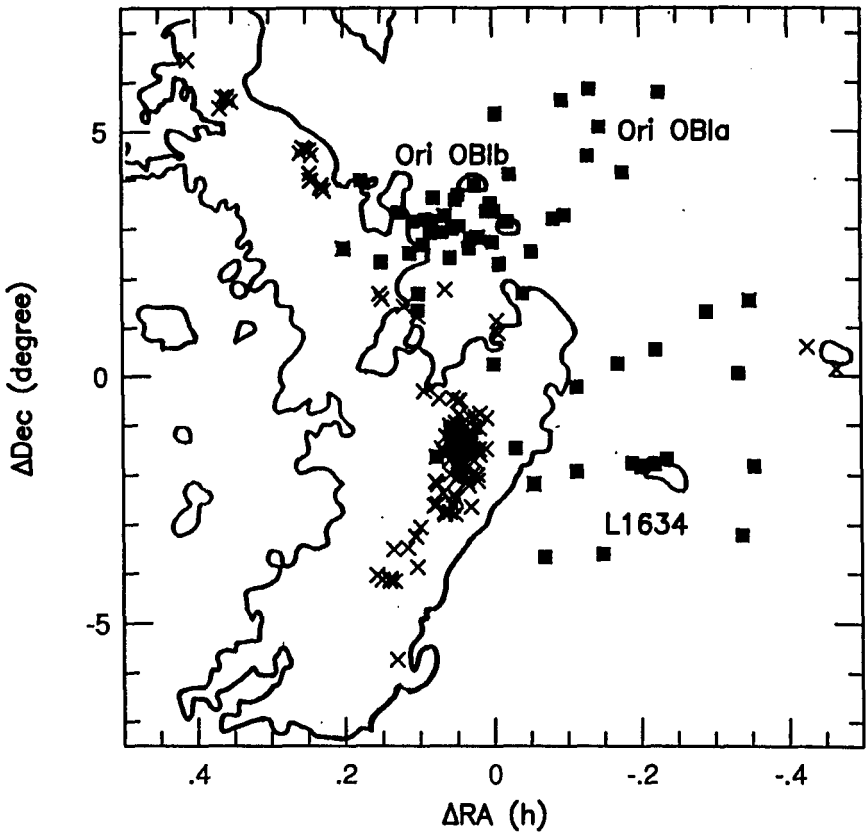

Figure 2. Spatial distribution of the pre-main sequence star candidates in our sample (filled squares) superposed on the lowest contour of integrated CO intensity taken from Fig. 2 of Maddalena et al. (1986). Known T Tauri stars (Herbig & Bell 1988) are also plotted as crosses. The offsets for RA and Dec are with respect to the position RA=5^h30^m Dec=$-4°$ in hours and degrees, respectively.

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Of the full sample, about 80 % have near-infrared colours typical of low mass pre-main sequence stars and so are most likely members of the Orion association. All the emission-line stars in our sample classed as having strong (class 4) or very strong (class 5) Hα emission in the Kiso survey belong to this group (Fig. 2).

3. Discussion

It is possible that the isolated Hα emission-line stars have moved out of clouds due to stellar interactions. Another possibility is that they have formed in small dark clouds which are remnants of molecular material which coalesced to form the Orion molecular clouds. They may be compressed by energetic events like supernovae and/or stellar winds from massive stars in the Ori OB association as suggested by Cowie et al. (1979). The near-infrared excess stars near the Orion OBIb association can be interpreted as being formed in the compressed layer built up by the interaction of the stellar winds from OB stars with the interstellar medium.

Many of the emission-line stars in the Ori OBIb association lie along an arc which closely matches the H I shell (Chromey et al. 1989) swept up by an outflow originating from the vicinity of σ Ori. It is well correlated with the ring-like structure seen in the IRAS 100 μm Skyflux image (Bally et al. 1991). The interaction of massive stars with the interstellar medium may be responsible for inducing much of the star formation still occurring in the relatively low density outer parts of the region.

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