A very extended area search for very low-mass stars and brown dwarfs in the Upper Scorpius association

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Abstract

Using the IJKs-band and the JHKs-band data from the Denis and 2MASS catalogs, respectively, we have performed a search for very low-mass stars and brown dwarfs covering an area of 168 deg^2 in the Upper Scorpius association (5Myr, 145pc). From I,I-J and I,I-Ks color-magnitude diagrams, we have selected 1257 candidates in the magnitude range I=13-18.5, following the photometric sequence of previously known member of the association with available Denis and 2MASS photometry. According to evolutionary theoretical models, they span a mass range from 0.15 to 0.020 M_{Sol} for an age of 5Myr, well within the substellar regime. We investigate the number of possible contaminants by performing similar studies in different control fields at the same galactic latitude. We estimate the luminosity function and mass spectrum of present survey and compare them with previous studies in the association and other young regions.

Introduction

The Upper Scorpius OB association (145 pc, 5-6 Myr; de Zeeuw et al. 1999; Preibisch & Zinnecker 1999), is one of the youngest and closest OB associations to the Sun. Youth, proximity and low extinction makes Upper Scorpius an ideal site to search for very low-mass stars and substellar objects. Previous studies have confirmed the existence of a large population of very low-mass stars and brown dwarfs in this association (Preibisch et al. 2001, 2002; Ardila et al. 2000; Martín et al. 2004). More recently, isolated and planetary-mass companions have been identified (Lodieu et al. 2007, 2008; Béjar et al. 2008; Lafrenière et al. 2008).

Search and candidate selection

We have searched for very red and faint candidates using the IJKs and JHKs photometry in the Denis and 2MASS catalogs, respectively (correlation radius of 1") in an area of 168 deg^2 in the Usco association. Our candidate selection criteria is based in I,I-J and I,I-Ks color-magnitude diagrams of 330 previously known members of the USco association with available Denis I-band and 2MASS JHKs-band photometry. The lower envelop for candidates selection is obtained from the average sequence of Usco members shifted to bluer colors by 2-σ (see Fig. 1). We estimate that the completeness of our search is about 95% of the members.

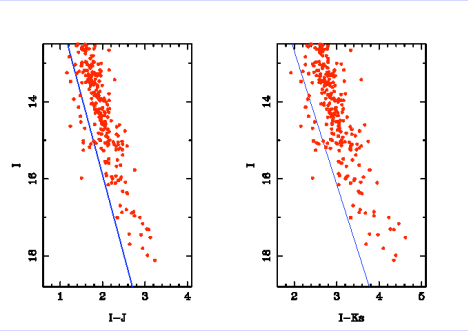

Figure 1. I,I-J and I,Ks colour-magnitude diagrams of previously known members of Usco with available Denis and 2MASS data (red circles). The lower envelop (blue line) is given by the average photometric sequence of them shifted to bluer colors by 2-σ.

Results

From I,I-J and I,I-Ks color-magnitude diagrams, we have selected 1257 candidates in the magnitude range I=13-18.5, redder and brighter than the lower envelop of our selection criteria (see Fig.2). Spatial distribution of them is shown in Fig. 3.
According to evolutionary theoretical models (Baraffe et al. 1998; Chabrier et al. 2000), they have estimated masses in the range of 0.25-0.020 M_{Sol} , adopting the most probable age of 5 Myr for the association.
We have performed a similar search in four control fields at the same galactic latitude than Usco (b=20) and centered in galactic longitudes of l=230, 250, 270 and 310, covering areas of 12, 12, 11 and 9 deg2, respectively. We have found 71 objects in these regions and based on these results we estimate that about 270±30 objects contaminate our survey (20% of our sample).

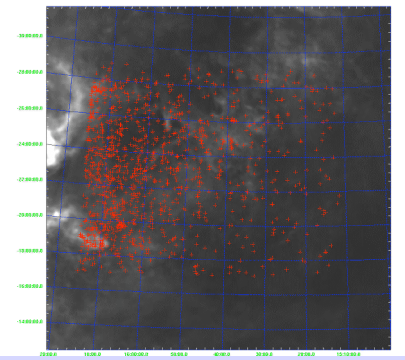

Figure 3. Denis-2MASS survey in USco. Selected candidates are plotted with red crosses, over an extinction map obtained from the IPAC website using IRAS/DIRBE data.

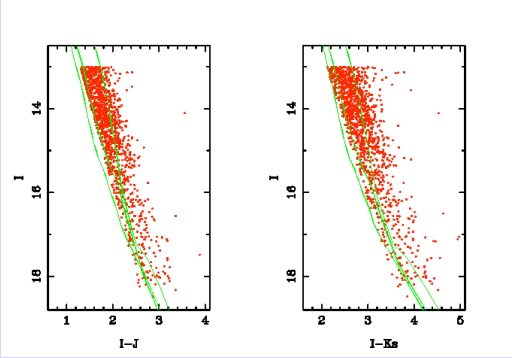

Figure 2. I,I-J and I-Ks diagrams of selected candidates (red circles). The 1, 5 and 10 Myr isochrones from Lyon group are also shown by green lines

Luminosity and mass function

From the 1257 selected candidate members, we have derived the I-band luminosity function in the magnitude range I=13-18.5 (see Fig.4).
We have obtained the mass spectrum (dN/dm) from the I-band luminosity function and the mass-luminosity relations given by theoretical models (Baraffe et al. 1998; Chabrier et al. 2000), using color and Teff-spectral type relations and bolometric corrections from Leggett et al. 2001 and Golimowski et al. 2004 to transform the bolometric luminosity into magnitudes (See Fig. 5). The mass spectrum is a rising function from 0.25 to 0.027 M_{Sol} and can be represented by a power law ($dN/dm \sim m^{-\alpha}$) with α=0.4±0.2. This is consistent with previous results in Usco (Preibisch et al. 2002; Lodieu et al. 2007) and other regions (Caballero et al. 2007) in a similar mass range.

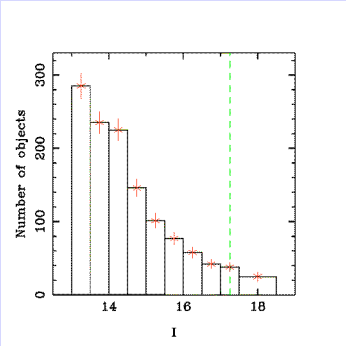

Figure 4. I-band Luminosity function. The completeness magnitude is shown by the vertical dashed green line. Data points error bars are poissonian

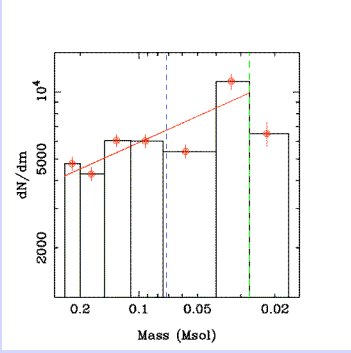

Figure 5. Mass spectrum (dN/dm) for the 5Myr isochrone form the Lyon group. The best power-law fit ($\sim m^{-\alpha}$) with α =0.4±0.2 is represented by the red line. The separation between stars and brown dwarfs and the completeness mass is shown by vertical dashed blue and green lines, respectively. Data points error bars are poissonian.

Conclusions

- Using Denis and 2MASS catalogs, we have found 1257 very low-mass stars and brown dwarf candidate members in an area of 168 deg^2 in the very young USco association

-Based on theoretical models, they have estimated masses between 0.25 and 0.020 M_{Sol} for an age of 5Myr. About 400 of these objects are brown dwarfs. This is probably the most numerous substellar population found in young clusters or associations to date.

-The mass spectrum from 0.25 to 0.027 M_{Sol} is rising and can be described by a potential law with an exponent of α=0.4±0.2.

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