ISOCAM Observations of Young Low-mass Stars

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Abstract. One of the nearby sites of star formation, the Chamaeleon I region, is mapped in an ISOCAM survey program and we derive a preliminary luminosity function. There is a clear indication that the luminosity function for the young stellar objects continues to rise towards fainter objects (to the limit of our sensitivity, 0.01 $L_{\odot}$). Assuming that the median age of the previously studied members of the young population, 3 10^6 yr,

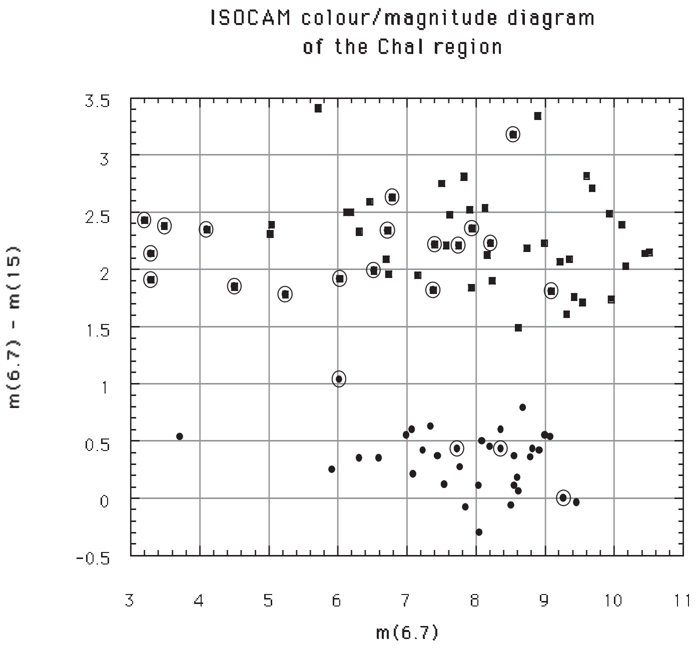

Figure 1. ISOCAM data show a clear separation of YSOs (squares) from background stars (dots). The circles mark the stars with reliable bolometric luminosities (Prusti et al. 1992). The magnitude scale is provisional.

is typical for all the ISOCAM sources, the corresponding mass function extends well into the brown dwarf region.

1. Introduction

During the early contraction phase low-mass objects, brown dwarfs and sub-solar mass stars are relatively bright. This means that regions with active star formation are favourable sites for detecting low-mass objects. At an age of 10^6 yr a 0.05 $M_\odot$ object would have a luminosity of 0.02 $L_\odot$ and a temperature of 2900 K (D'Antona & Mazzitelli, 1994). For the closest star formation regions such an object should be easily observable both from the ground in the near IR and with ISOCAM in the mid IR. One obvious difficulty though, is caused by the obscuration of the parental cloud and another is the possible additional luminosity from accretion. This means that ground-based observations in the near IR alone leave too much uncertainty in separating the effects of extinction and intrinsic IR excess. With ISOCAM we extend the wavelength coverage to 18 μm which gives us a much better possibility to define the luminosity function. The present poster paper briefly describes preliminary results for the Cha I star formation region, which is relatively well studied.

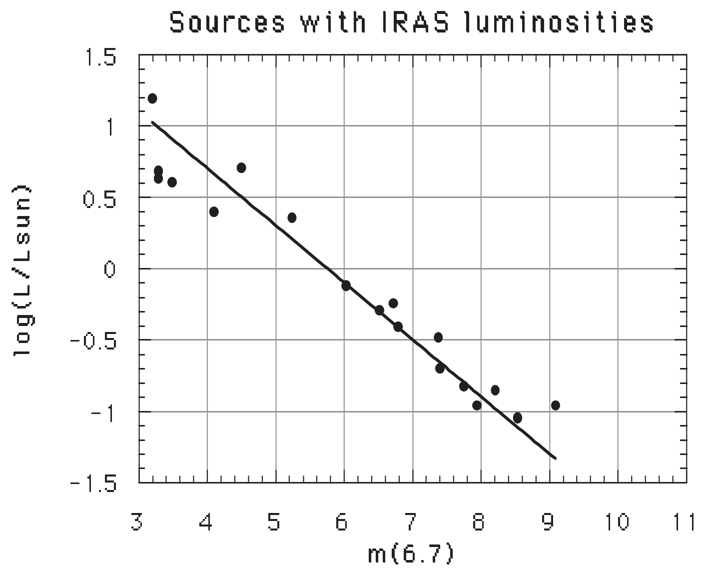

Figure 2. $L_{\rm bol}$ versus m(6.7) shows a remarkably tight correlation for the "YSO branch". We use this fit (and an extrapolation) to derive $L_{\rm bol}$ for all the YSO candidates.

2. Results

In all star formation regions observed so far we find two well separated groups in the colour-magnitude diagramme constructed from observations in LW2 (5 - 8.5 μm) and LW3 (12 - 18 μm), (see Fig. 1). There is a strong evidence that (practically) all the objects in the "red" group belong to the young population and that the other group essentially represents background stars (Nordh et al., 1996). The physical reason for this relatively constant colour index for sources varying 3 - 4 orders of magnitude in luminosity will be discussed in a forthcoming paper, but for the present discussion we simply use the groupings in the diagramme to identify young stellar objects (YSOs). A subset of the YSOs have well determined bolometric luminosities $L_{\rm bol}$ (Prusti et al., 1992) and Fig. 2 shows a close correlation between the brightness at 6.7 μm and $L_{\rm bol}$. As a next step we assume that this relation can be extrapolated to fainter sources. Thus, we assume that these sources basically have the same spectral energy distribution (as indicated by Fig. 1). As the survey is less sensitive in the LW3 filter than in the LW2 filter, we can add to the YSO list those sources which clearly lie outside the band of reddened background stars in the J - K$'$ / K$'$ - m(6.7) diagramme, and for which we have no LW3 detections. (The J and K$'$ magnitudes are from the DENIS survey). In all, this means 76 YSOs and the derived luminosity function is shown in Fig. 3. In this figure we also mark the brown dwarf mass limit which applies if we adopt an age of 3 10^6 yr, the median age of the T Tauri stars in the region (Lawson et al., 1996), also for the fainter members and the theoretical mass/luminosity function for this age (from D'Antona & Mazzitelli, 1994).

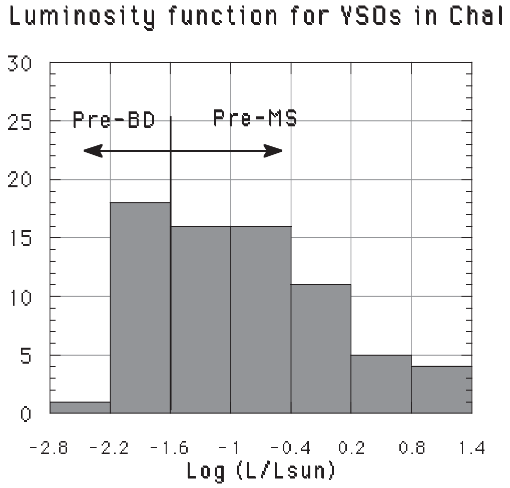

Figure 3. The derived luminosity function increases all the way to the completeness limit of our survey. The brown dwarf limit for an age of 3 million years is included in the figure.

3. Discussion

We are currently improving the photometry, which will not change the general picture, but probably shift the magnitude scales somewhat and lower the scatter in the diagrammes. The sensitivity may then improve somewhat. Additional ISOPHOT observations at 60 microns may add some more sources to the "calibration curve" in Fig. 2. Taken together, this means that the luminosity function could be slightly modified, and it is conceivable that we will be able to add some more faint sources. We expect that the general conclusion, that the luminosity function increases towards the sensitivity cut-off, will survive.

Finally, by assuming that the typical age of the T Tauri stars in the region is typical also for the fainter sources we suggest that a fraction of these objects have sub-stellar masses. This important step - transferring the luminosity function to an initial mass function - certainly deserves more careful analysis and will be postponed to forthcoming papers.

References

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