The Mass Distributions of Protostellar and Starless Cores in Gould Belt Clouds

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Introduction

Stars form in cold, dense regions in molecular clouds. Observations of these dense regions (see Figure 1), or “cores,” have revealed populations of cores with and without an embedded young star (YSO) (Di Francesco et al. 2007). Populations of starless cores seem to have a mass distribution similar to that of stars (i.e., Motte et al. 1998, Johnstone et al. 2000, Ward-Thompson et al. 2007), suggesting that stellar mass is related to the processes in molecular clouds that organize material to stellar precursors. To obtain an accurate starless core mass function (CMF), starless cores must be differentiated from those containing YSOs. Many authors have proposed ideas for this classification, and we add our own core classification technique. With this technique we have examined the CMF in four clouds (Ophiuchus, Taurus, Perseus, and Orion).

Our Technique:

We used 850 µm SCUBA data to identify cores and 3.6-24 µm Spitzer data to detect YSOs with two sets of selection criteria. First, we selected red IR colours (see Figure 2). Second, we required that YSO-like sources fell within 75% of the flux difference between the peak and core boundary (see Figure 3, Sadavoy et al. 2010) so,

\[ S > S_{\text{peak}} - 0.75 \left( S_{\text{peak}} - 90 \text{ mJy beam}^{-1} \right) \]

where \( S_{\text{peak}} \) is the peak flux of the core and 90 mJy beam\(^{-1}\) is the flux-limited boundary of our 850 µm cores. This technique ensures that all YSOs are contained within a core.

Core Mass Functions

Figure 4 shows the starless CMFs for our four well-sampled clouds with best-fit slopes (red line). The average best-fit slope for our 4 clouds is -1.28 ± 0.19. Our best fit slopes agree with the Salpeter power-law within errors, though the slopes for the individual clouds may hint at differences. More sensitive observations of clouds will enable a more stringent comparison with the Salpeter IMF.

Figure 5 shows the dependence of the CMF on core classification technique. Our technique shows reasonable agreement with the Jørgensen and Enoch methods, in spite of different YSO identifications and different comparisons between YSO-like sources and submillimetre cores. These similarities suggest that our method can well classify cores. Some methods, however, tend to label high mass cores (large cores) as protostellar, resulting in a sharper decline at the high-mass end.

Future Work

We identified several starless cores with masses a few times greater than their Jeans masses (see Figure 6). Cores with such masses should be thermally unstable and collapsing. Therefore, these “super-Jeans” starless cores may be on the cusp of collapse. Alternatively, these cores may be supported by non-thermal processes. In either case, super-Jeans starless cores are interesting targets for future observations.

References

Di Francesco et al. 2007, PPV, 17, 32

Ward-Thompson et al. 2007, PPV, 33, 46

Fig 1: Extinction map of Ophiuchus. Green contours show the regions observed by SCUBA. The blue arc gives the boundary between Ophiuchus and Scorpius.

Fig 3: Separation criteria for protostellar cores using our method. An IR source must fall within the limiting flux contour (red).

Fig 4: Starless CMFs for our clouds with red lines showing the best-fit slopes from linear least squares (numerical values also shown).

Fig 5: Starless CMFs for Ophiuchus (left) and Perseus (right) using three different core classification techniques. Our method is in the top panel, the Jørgensen et al. (2007) method is in the middle panel and the Enoch et al. (2008) method is in the bottom panel. Red lines represent Salpeter power-law slopes (\( \alpha = -1.35 \)).

Fig 6: Comparisons of core size with ratios of core mass to Jeans mass for Ophiuchus and Perseus. Red lines indicate M/M\(_{\text{J}}\) ratios of 2 and 4 for Ophiuchus and Perseus, respectively.