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The Real Solar Neighborhood Protostars

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Abstract. Characterization of how dense molecular cores evolve into stars has historically been made through observational changes in their 2 to 25 μm spectral energy distribution (SED) or bolometric temperature via the Class system. Linking these observational classes to a physical protostellar phase or Stages in a consistent manner remains challenging. In order to provide a uniform indicator of whether an observationally classified embedded protostar candidate is likely to be a physical phase Stage 0 or I protostar, we performed an HCO^+ ($J = 3-2$) survey of Class 0+I and Flat SED young stellar objects (YSOs) in the Spitzer nearby (D < 500 pc) Gould Belt cloud surveys. We use criteria from van Kempen *et al.*(2009) to classify sources as Stage 0+I or bona fide protostars and find 84% of our HCO^+ detected sources meet that criteria. We recommend 0.54 Myr as an evolutionary timescale for these embedded protostars. We discuss trends in our sample with spatial distribution, molecular cloud extinction, spectral index, and bolometric temperature and luminosity.

Keywords. stars: formation, stars: fundamental parameters (classification, colors, luminosities, masses, radii, temperatures, etc.), ISM: molecules, Galaxy: solar neighborhood,ISM: clouds, ISM: dust, extinction

1. Summary of Results

Linking these observational classes to a physical protostellar stage in a consistent manner remains challenging. We identify Stage 0+I protostars (i.e., those with a substantial dense gas envelope) among the sample of Class 0+I and Flat SED YSOs in the Spitzer nearby (D <500 pc) Goulds Belt Surveys Dunham *et al.*(2015).

Using single pointings of HCO^+ ($J = 3-2$) at source positions and the threshold integrated intensity (I_{MB}) HCO^+ emission criterion from van Kempen *et al.*(2009) to define a Stage 0+I protostar ($I_{MB} \geqslant 0.68$ K Km s^{-1}), in Heiderman & Evans (2015) we find:

- 72% of Class 0+I and 48% of Flat SED sources (84% HCO^+ detected) are physical Stage 0+I protostars.
- The concentration of the youngest YSOs to regions of high A_V (i.e., Heiderman *et al.*(2010)) is strengthened when considering Stage 0+I protostars (89% lie at $A_V > 8$ mag; Fig. 1).
- The contamination fraction defined as the number of undetected Class 0+I plus Flat SED sources divided by the total surveyed is >90% at $A_V < 4$ mag and decreases with increasing A_V (Fig. 1).
- HCO^+ emission strength versus evolutionary indicators (α−the spectral index between 2-24μm, T_{bol}, and L_{bol}): testing the data for a 3σ correlation, we require the absolute values of the Pearson correlation coefficient to exceed $3/(\mathrm{N}-1)^{0.5}$ or $|\, r \,| > 0.16$. We find trends for stronger I_{MB} with larger α, smaller T_{bol}, and no significant correlation for L_{bol}.

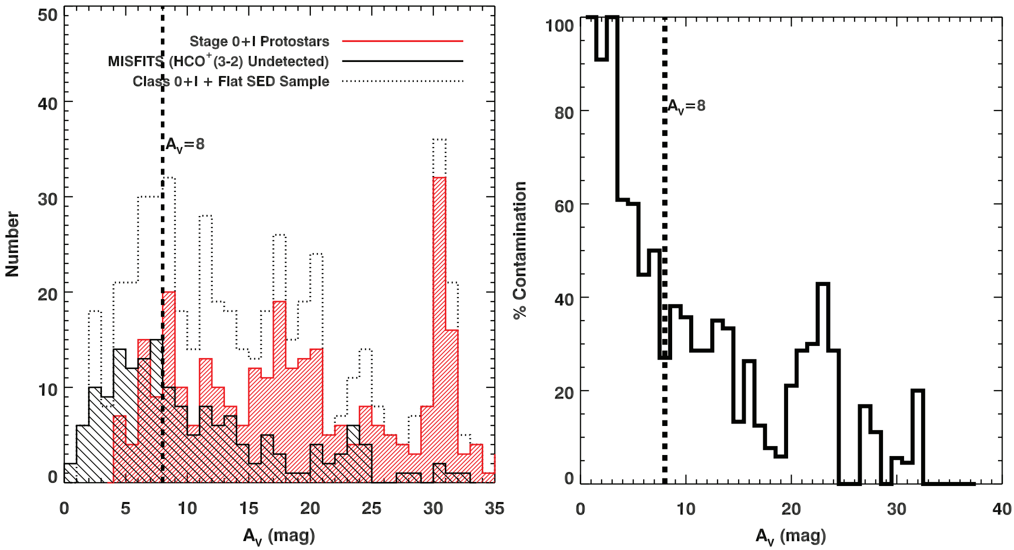

Figure 1. Left: The concentration of the youngest YSOs to regions of high A_V (i.e., Heiderman *et al.*(2010)) is strengthened when considering Stage 0+I protostars (89% lie at $A_V > 8$ mag.) **Right:** The contamination fraction defined as the number of undetected Class 0+I plus Flat SED sources divided by the total surveyed is >90% at $A_V < 4$ mag and decreases with increasing A_V

- The fraction of Stage 0+I protostars shows a strong, smooth correlation with evolutionary indicators (α, log T_{bol}, and log L_{bol}).
- The Stage 0+I fraction increases strongly with α through the Flat SED class and is 80% or greater for sources with α >0.75.
- There is a good, but imperfect agreement with far-IR or submillimeter detections among the Stage 0+I protostars sampled.
- The most appropriate timescale for the entire embedded Stage 0+I protostellar phase is 0.54 Myr.

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