Profiling Young Massive Stars

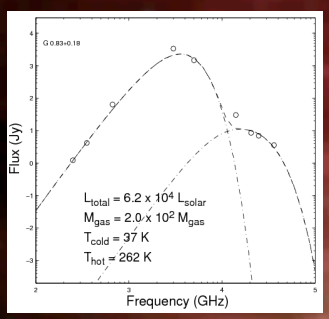
T. Hill [1,2], M. Burton[2], M. R. Cunningham[2] & V. Minier[3]

[1]Leiden Observatory, Leiden University, the Netherlands [2] School of Physics, UNSW, Australia [3]Service d'Astrophysique, CEA Saclay, France
thill@strw.leidenuniv.nl

Abstract

We have applied a Levenberg-Marquardt least squares spectral energy distribution fit to 226 of the 405 sources in the SIMBA survey of Hill *etal*, (2005, MNRAS, 363, 405) using data from the millimetre regime through to the infrared. The fits produce six source specific parameters; the luminosity, temperature, mass, H_2 number density, luminosity-to-mass ratio, and the surface density, for each of the sources profiled. We have analyzed each of these parameters relative to the different classes of source in the sample, as well as to each other, with the aim of better understanding the sources in the sample and their role in the formation of massive stars.

The mm-only cores are found to be less luminous, with smaller luminosity-to-mass ratios, than sources with a methanol maser and/or a radio continuum source. The mm-only cores display a similar range of temperatures to sources with a methanol maser and/or radio continuum association, although it is clear that the mm-only sample is comprised of a larger number of cooler cores than latter source classes, which is also reflected in the median temperature determined for each of the source classes. The mm-only cores are of comparable mass and radii to sources with a methanol maser. Together, these two classes of source are smaller and less massive than sources with an UC HII region. Hypotheses about the nature of the mm-only cores derived from spectral energy distribution fitting are proposed and discussed.



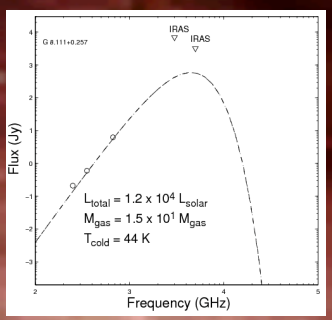
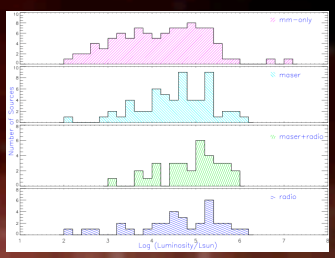
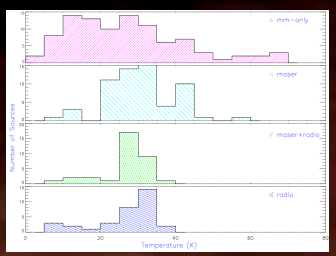


Figure1: Spectral Energy Distributions (SEDs) of two example cores from the SIMBA survey (Paper I). The fits apply a Levenberg-Marquardt least squares fit to a modified blackbody function, which models data from the infrared through to the submillimetre regime. Individual source parameters are as indicated on the figures. The dust grain emissivity index (β) = 2.





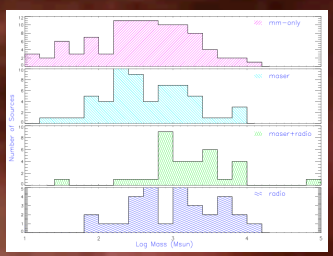
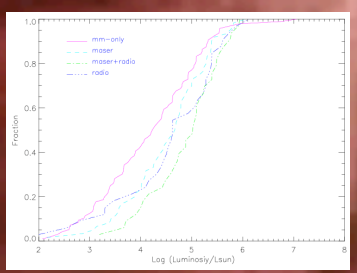
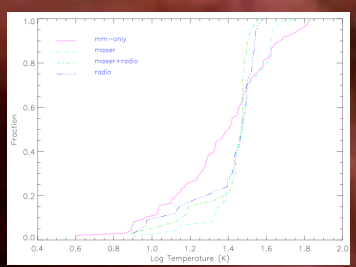


Figure 2: Histogram distributions of the four classes of sources, within the SIMBA sample. *Top (left):* Distribution of Luminosity. *Top (right):* Distribution of Temperature. *Bottom (right):* Distribution of mass.

Other Results

- At least 45 % of the mm-only cores have no mid-IR MSX emission (Paper I, Hill *etal* 2005).
- The mm-only class also have a significant portion of sources that are more dense, i.e. both surface and H_2 number densities are higher than the other three classes of source.
- Relations between the luminosity, temperature, mass, H_2 number density, radius and surface density (Σ) are best described by: $M \propto R^{0.4}$, $\Sigma \propto n_{H_2}{}^{0.6}$, $n_{H_2} \propto R^{-1.2}$, $T \propto L^{0.4}$, $\Sigma \propto T^{-2.9}$





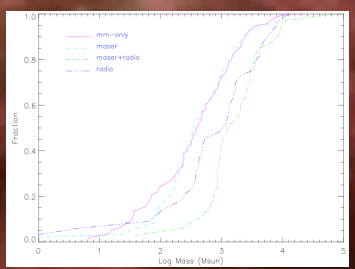
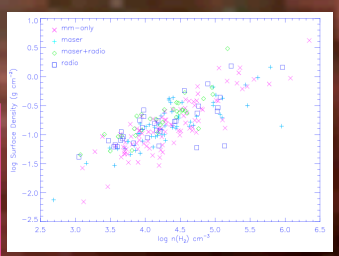


Figure3: Cumulative distributions of the four classes of source in the sample. *Top (left):* distribution of the luminosity. *Top (right):* distribution of the mass. *Bottom (left):* distribution of temperature



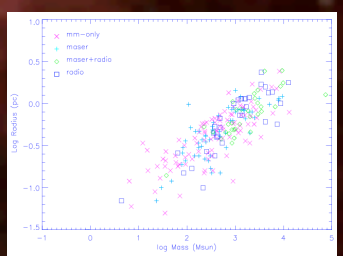
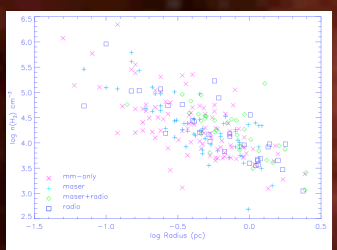


Figure 4: Correlation Plots for the four classes of source in the sample. Parameters correlated are as indicated on the plot, as too in the key. The appropriate relations are: $\Sigma \propto n_{H_2}{}^{0.6}$, $M \propto R^{0.4}$, $n_{H_2} \propto R^{-1.2}$.



Conclusions

The results leads us to conclude that the mm-only sources contain examples of massive star formation prior to the onset of methanol maser emission. As a source switches on and begins heating the core up, temperature, luminosity and L/M will increase inside it, leading to the onset of maser emission. Thus, the mm-only sources are representative of the very earliest stages of massive star formation. However, it is not clear which of these mm-only sources will form a massive cluster, although some most certainly will. Further work in order to establish which of these mm-only cores is forming stars is currently underway.

The fact that the mm-only population also contains a larger abundance of cooler cores than sources with a methanol maser and/or radio continuum source is also interesting. It is possible that the warmer mm-only cores are examples of massive star formation prior to the onset of methanol maser emission, whilst the cooler mm-only cores examples of starless cores as described by Vasquez-Semadeni *etal* (2005, ApJ 618, 344). High resolution observations of these cores, to search for embedded sources, are necessary in order to ascertain which of them are forming stars, and which will remain starless, and so test this hypothesis.