The Core Mass Function of Massive Star-forming Regions

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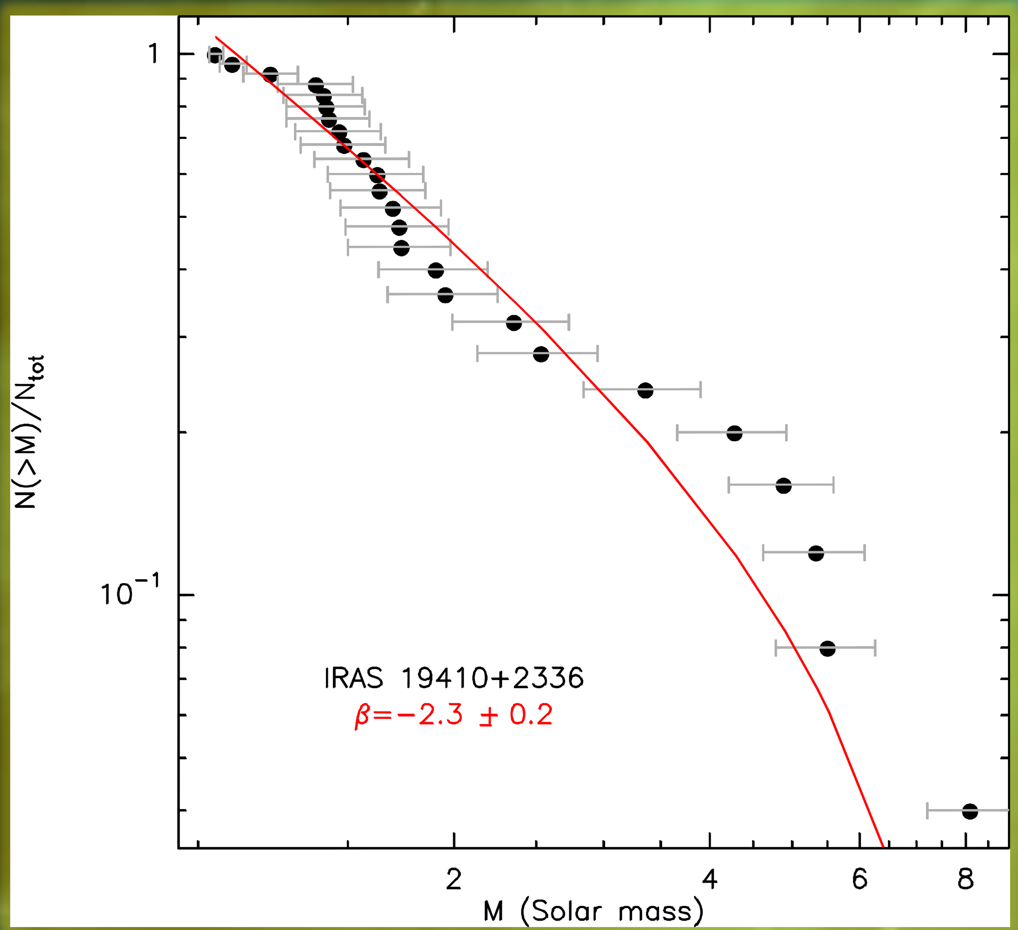
Abstract

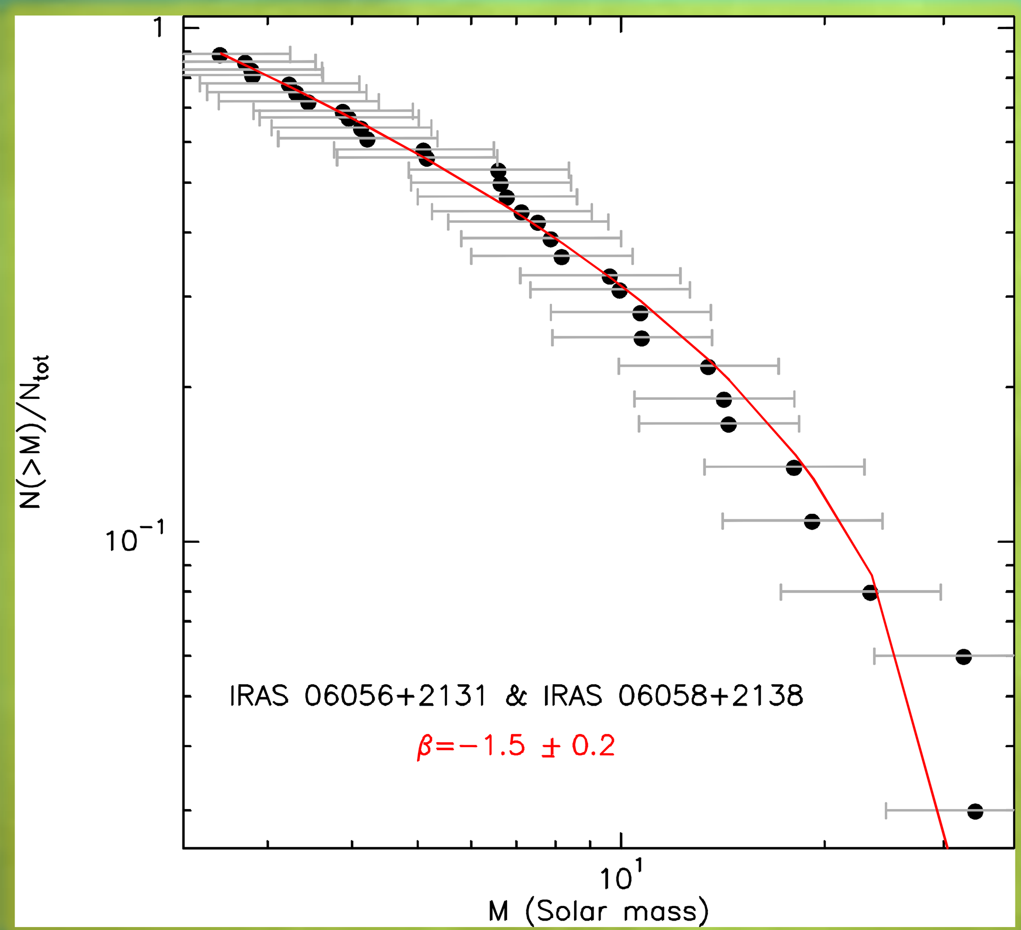
When observing at spatial scales on the order of ~0.1 pc, it is found that the Clump Mass Function of massive star-forming (MSF) regions is similar to the high-mass end of the Salpeter stellar IMF [1], suggesting that the IMF is set at the moment of the fragmentation of the cloud.

We have observed at 1.4 mm with the PdBI and SMA several MSF regions at ~2 kpc with a spatial resolution of ~0.01 pc (~ 2000 AU), and derived their CMF.

For one of the regions we indeed find a CMF with a slope of β=-2.3±0.2, comparable to the Salpeter value for the IMF, however for the other regions the CMF slope is β=-1.5±0.2, comparable to the Clump Mass Function derived for molecular clouds at larger scales. The regions are similar in luminosity and distance, and we detect a similar number of cores in each region. Why are the CMFs so different then? We discuss probable causes, among them a possible evolutionary effect, and what observations and/or numerical simulations would be needed to test them.

Cumulative CMF





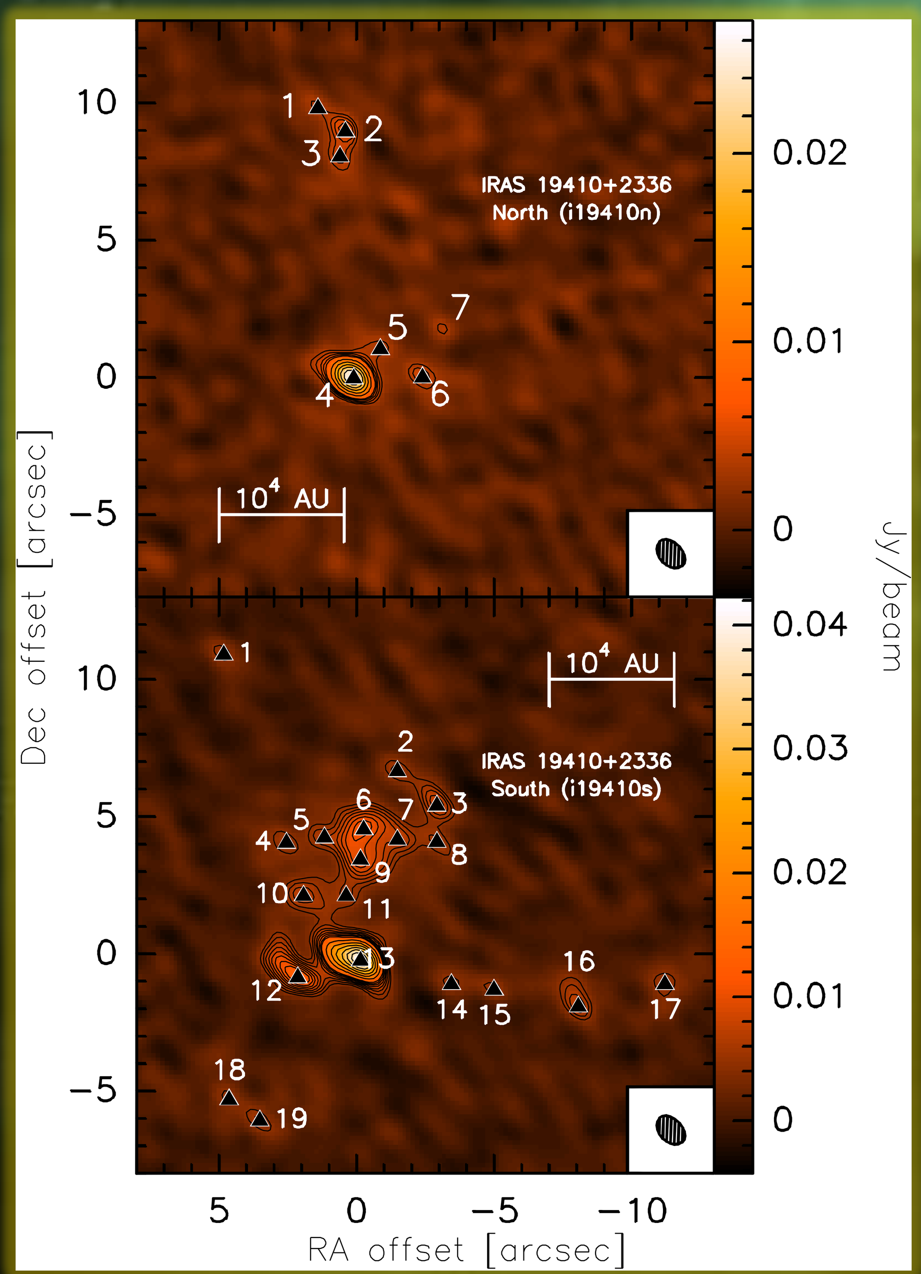
The CMF slope of i19410 is β=-2.3±0.2, steeper than the β=-1.5±0.2 found for i06056/i06058. In both cases we reached similar sensitivities and angular resolutions in the observations. We also have a similar number of cores, we used the same procedure to derive the masses and the CMF, and in both cases the respective differential and cumulative CMF agree on the slope. Furthermore, the regions have similar luminosities and distances. All this suggests that the difference in slope is coming from an intrinsic difference between the regions.

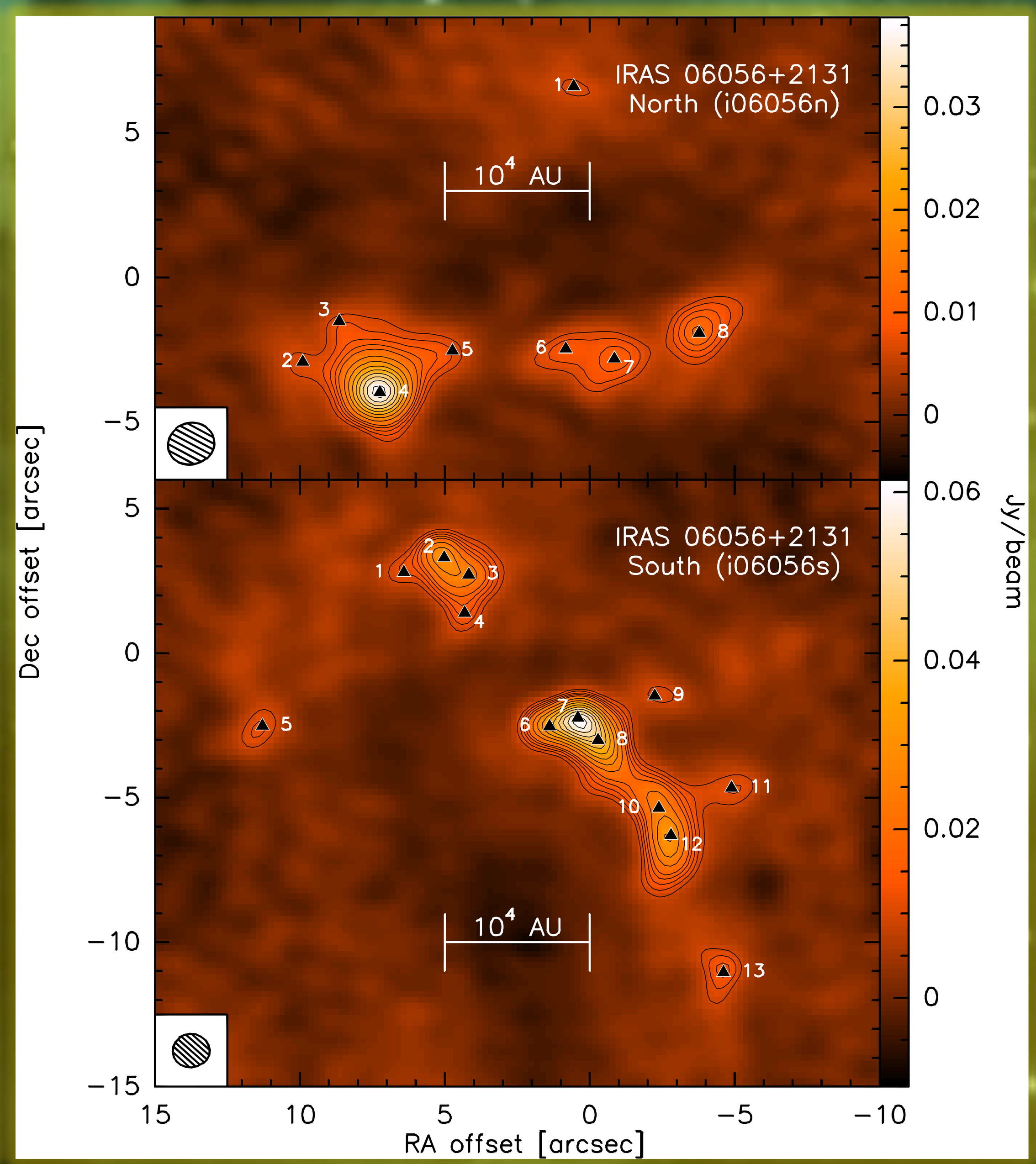
Why are the slopes different?

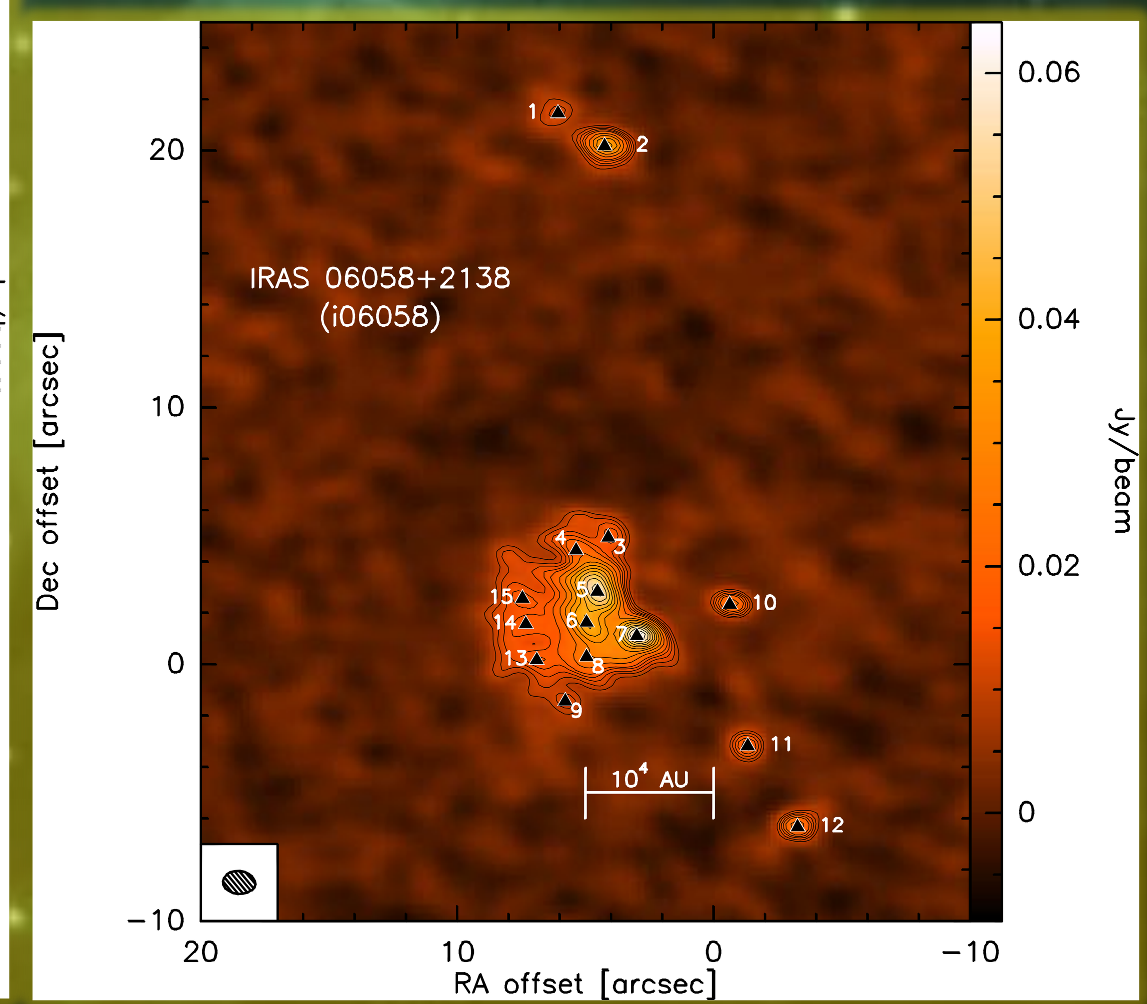
- The regions are ~2kpc from the Sun,towards the inner Galaxy (i19410), and the outer Galaxy (i06056/i06058). This implies an average n(H_2) decrease among them by a factor ~3.6, according to [2]. We found this difference in the data, and would imply a factor 2 smaller Jeans scale in i19410 than in i06056/i06058, which will likely favor the formation of more massive cores in the latter. This would result in an overall shift of the mass function towards higher masses. Simulations of the cloud fragmentation different initial average n(H_2) could show if there is a relationship between the slope of the resulting CMF and the density.

- Different star formation processes: Strong interactions between the cores could make the CMF different from IMF, while weak interactions might keep them about the same. Simulations show that hierarchical fragmentation alone produces a mass function with a slope $\beta \sim 2$. Now if the IMF comes mostly from fragmentation, regardless of the origin of that fragmentation, then if there are physical processes favoring the formation of massive cores the slope will be flattened at high masses. Such processes might include the ablation of low-mass protostars, heightened accretion, coalescence and multiple-star interactions [3].

- Simulations show that if the cloud is gravitationally dominated, the slope is $\beta \sim 1.5$, while when the cloud is supported by turbulence the slope is $\beta \sim 2$ [4]. On the other hand, during their early collapse the clouds are gravitationally dominated and then during their evolution the feedback from the forming stars inject turbulence into the cloud. It could be possible then that at early evolutionary stages the mass function will be shallow, and will “evolve” into a steeper distribution as the cloud itself evolves (see [5]). This would suggest that the slope of the mass function could be indicating the relative age of the cloud, the flatter it is the younger the cloud is. With observations of deuterated-hydrogenated isotopologues pairs the relative ages of the regions can be estimated, by determining the deuterium fractionation in the cloud [6].







Continuum maps of i1940 (left-PdBI), i06056 (center-SMA), and i06058 (right-SMA) at 1.4 mm.
We observed two fields, north and south, in both i19410 and i06056.
The triangles mark the 1.4 mm continuum cores, and the beam and a scale-bar are shown in each map.

References
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