The Observable Prestellar Phase of the IMF

(arXiv:1108.2543v1)

Paolo Padoan (ICREA and ICC, University of Barcelona)

Åke Nordlund (STARPLAN and NBI, University of Copenhagen)

The observed similarities between the mass function of prestellar cores (CMF) and the stellar initial mass function (IMF) have led to the suggestion that the IMF is already largely determined in the gas phase. However, theoretical arguments show that the CMF may differ significantly from the IMF. We study the relation between the CMF and the IMF, as predicted by the IMF model of Padoan and Nordlund.

RESULTS:

1) The observed mass of prestellar cores is on average a few times smaller than that of the stellar systems they generate, so the efficiency is larger than unity, $\varepsilon_{\rm core} > 1$.

2) The CMF rises monotonically with decreasing mass, with a noticeable change in slope at approximately 3-5 $M_\odot$, depending on mean density.

3) The selection of cores with masses larger than half their Bonnor-Ebert mass yields a CMF with the same peak as our model IMF, thus suitable to estimate the local efficiency of star formation, $\varepsilon < 1$.

Dense cores are formed by converging flows in the turbulence, feeding a total mass m_{accr}. This total mass assembled by the flow can be larger than the core Bonnor-Ebert mass, but once the core has reached its BE mass, it will be seen as prestellar only for a time $\sim 1\ t_{ff}$.

Thus, with high enough sensitivity, cores will usually be observed in the process of formation, that is with a current mass $m < m_{accr}$. The local efficiency of star formation, based on the current core mass, can then be larger than unity, $\varepsilon_{core} = m_{star}/m > 1$. The *theoretical* efficiency is always less than unity, $\varepsilon = m_{star}/m_{accr} < 1$.

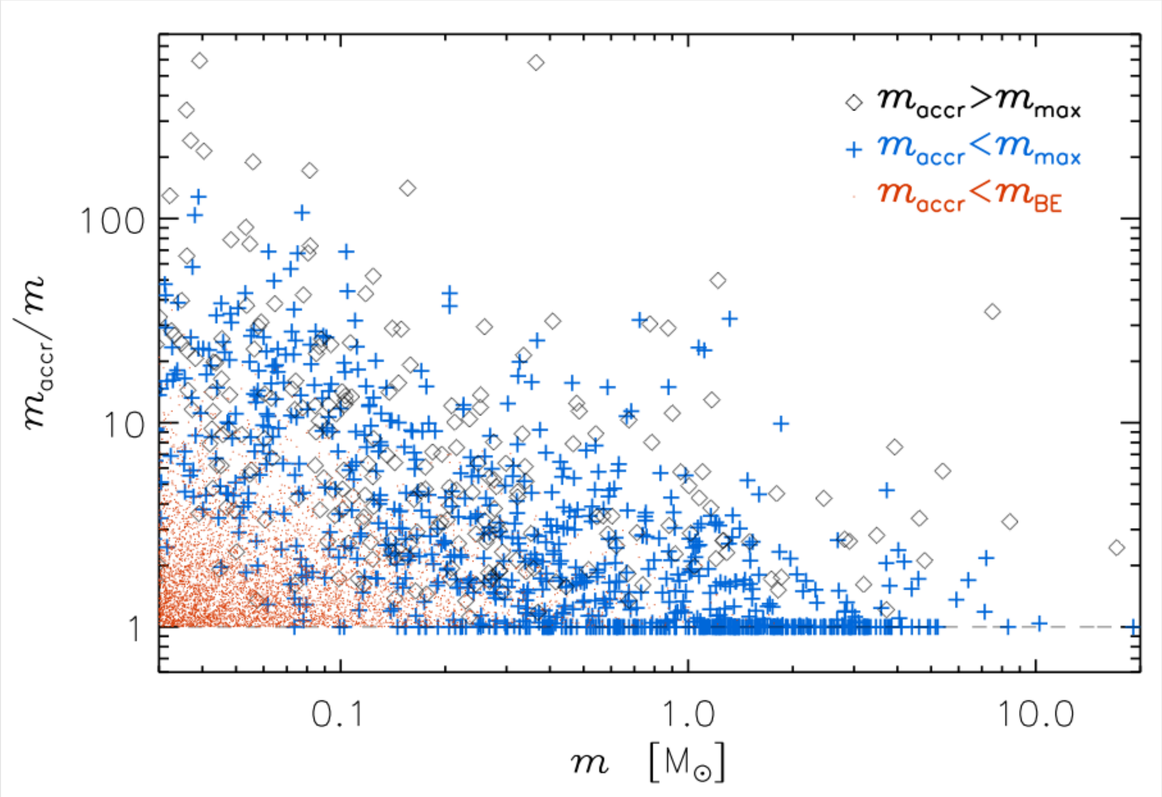

Figure 1: Ratio of the total core mass and the current core mass, m. Dots are for cores that will never collapse into stars, plus symbols for cores that form stars and can reach m_{accr} while prestellar, and diamond symbols for those that form stars but do not reach the mass m_{accr} while prestellar.

Even if they are seen as prestellar for only one free-fall time after reaching their BE mass, prestellar cores can still be found to exceed significantly their BE mass. Many small cores below their BE mass are true prestellar cores that are still growing. Conversely, many cores that are just below their BE mass will never grow to reach it (red dots).

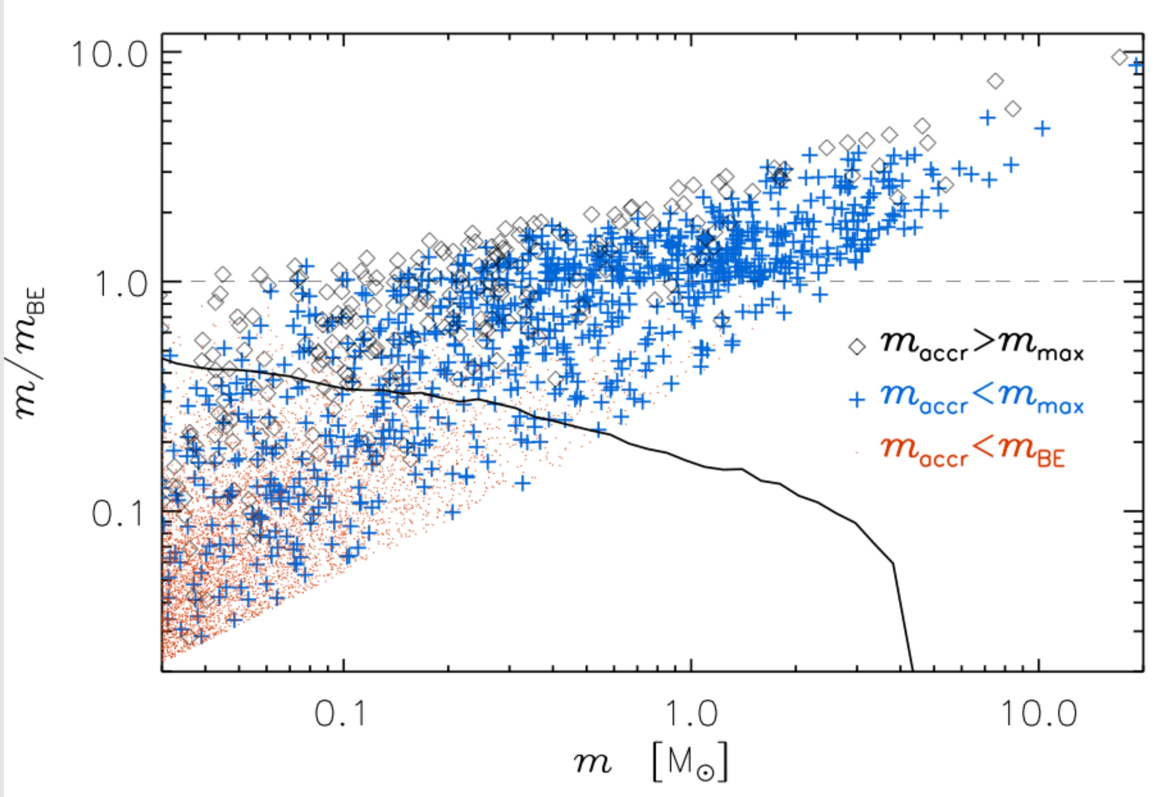

Figure 2: Ratio of current core mass to BE mass, plotted versus the current core mass. The solid line shows the ratio between the number of cores that will never collapse and form stellar systems and that of true prestellar cores, after selecting cores with $m > m_{BE}/2$.

If we assume the turbulence is scale free and generates a power-law mass function of over-densities, we can derive the core mass function (CMF). Results:

1) The **CMF grows monotonically** (*red line*), even if the IMF has a peak (green histogram)

2) The CMF has a noticeable change in slope at ~ 3-5 $M_\odot$, depending on mean density

3) A peak is recovered by selecting only the largest cores, $m > m_{BE}/2$ (*blue histogram*)

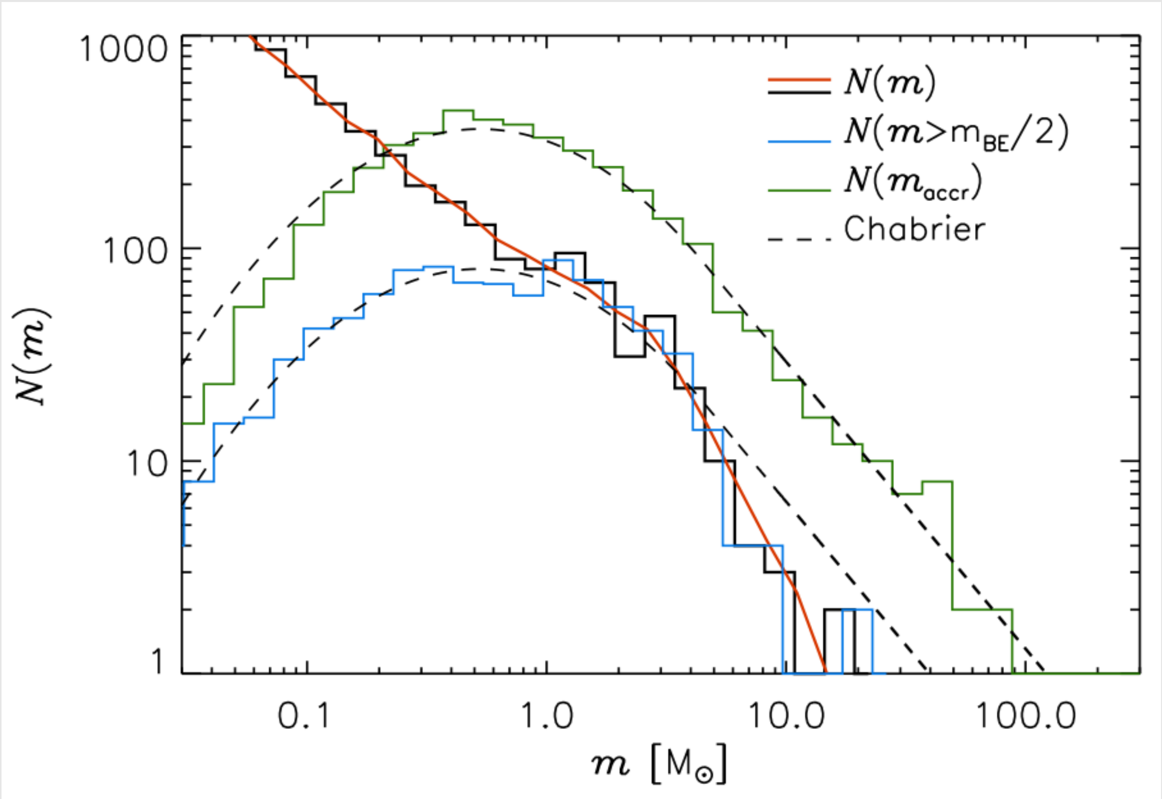

Figure 3: *Black histogram*: CMF after one dynamical time from the beginning of star formation. Blue histogram: CMF for a prestellar core subsample with masses $m > m_{BE}/2$. The same CMF derived from five different realizations of the same model is shown by the red solid line. *Green histogram*: Model IMF one dynamical time *after the end* of star formation. *Dashed lines*: Chabrier (2005) system IMFs, shifted in mass by a factor of 2.1.