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From Cores to Stars and the non-Universality of the IMF

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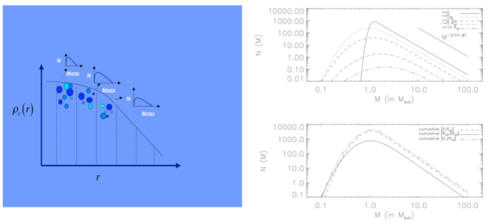
Observed variations of the IMF

A popular assumption in the community today is that the IMF of individual clusters is drawn from a universal distribution similar to the one obtained for the field stars IMF in the Galaxy. The latter, shown initially by Salpeter (1955) to follow a power-law distribution for a sample of nearby field stars (dN/dLogM ∝ $M^{-\Gamma=-1.35}$) is now usually described, over a more extended mass range, by a lognormal distribution (Chabrier 2003) or a multi-component power-law function (Kroupa 2002). Yet, there is strong observational and theortical evidence that this might not be the case (e.g.,):

- The IMF of starburst clusters (e.g., Arches, NGC3603) seems to be shallower than the 'universal' IMF in the intermediate to high mass end (Stolte et al 2005, Kim et al. 2006).
- The IMF of the Orion Nebula Cluster, when compared to the Kroupa IMF, seems to be missing about 30 OB stars (Pflamm-Altenburg & Kroupa 2006). These stars are not observed around the ONC.
- In order to reproduce the metallicity distribution of the bulges of the Galaxy and M 31, the slope of the IMF of the bulge in the high mass end has to be smaller than the Salpeter value ($\Gamma \leq 1.1$) (Ballero et al. 2007).

Our IMFs model

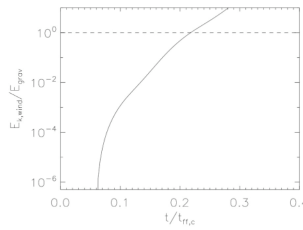
We have developed a model which describes the co-evolution of the mass function of dense molecular cloud cores (DCMF) and of the IMF in a proto-cluster forming clump. The clumps and the cores are characterized by various structural and dynamical properties such as their mass, lifetime, peak density, and level of turbulence. Local populations of dense cores evolve under the influence of gas accretion and/or core coalescence.The cores collapse to form star, and hence populate the IMF, whenever their local timescales for accretion/coalescence become longer than their contraction timescales. Feedback from the newly formed OB stars expels the gas from the proto-cluster region and quenches core and star formation. The IMF of the cluster is thereby set.



$\Rightarrow$

$$\frac{dN(r,M,t)_{coal}}{dt} = \frac{1}{2}\eta(r)\int_{M_{min}}^{M-M_{min}} N(r,m,t)N(r,M-m,t)\sigma(m,M-m,r,t)v(r)dm - \eta(r)N(r,M,t)\int_{M_{min}}^{M_{max}} N(r,m,t)\sigma(m,M-m,r,t)v(r)dm \qquad (1)$$

$$\frac{dN(r,M,t)_{acc}}{dt} = \left(-\frac{\partial N}{\partial M}\dot{M} - \frac{\partial \dot{M}}{\partial M}N\right)(r,M,t) \qquad (2)$$

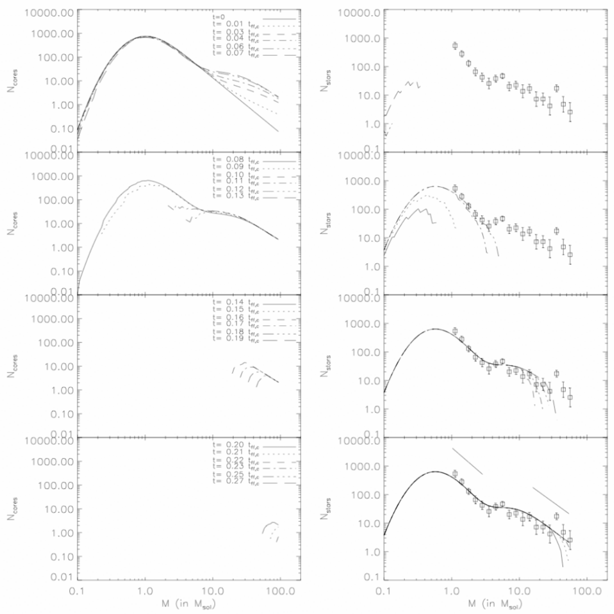


Step 1- Define a proto-cluster clump model, a dense core model, and an initial DCMF at different radii in the clump. The latter results from the turbulent fragmentation of the clump (e.g., Padoan & Nordlund 2002)

Step 2- Solve the equation for the time evolution of cores under the effect of coalescence (1) or accretion (2).

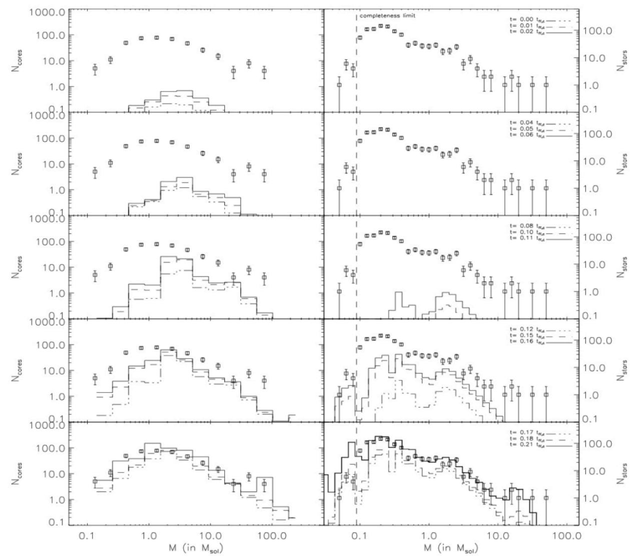
Step 3- Stop core formation, and hence star formation, when gas is evacuated from the cluster by stellar winds from OB stars.

Effect of core coalescence: Implication for the IMF of starburst clusters



Time evolution of the pre-stellar core mass function (left) and stellar mass function (right) in the region of the proto-cluster cloud between 1 and 2 times the core radius. The coalescence of cores in this model is efficient in the early stages when the cross section of the proto-stellar cores are large and causes the flattening of the DCMF at high masses and a depletion of cores at lower and intermediate masses. The stellar mass function is compared to that of the Arches cluster (Kim et al. 2006). Fits to the IMF yield slopes of $\alpha=-2.04\pm0.02$ and $\alpha=-1.72\pm0.01$ in the mass ranges [1-3] M_sol and ≥ 15 M_sol in perfect agreement with the observations..

The effect of time dependent gas accretion on the dense core mass function: Application to Orion



Time evolution of the pre-stellar core mass function (left) for cores accreting with a time dependent accretion rate (and that are injected uniformly over time) and of the IMF (right). The model is compared to the population of dense cores in the Orion star forming region (data from Nutter & Ward-Thompson 2007) and the IMF is compared to that of the Orion Nebula cluster (Hillenbrand 1997). The problem of the 30 missing OB stars is solved.

Further details can be found in:

-Dib, S., Kim, J., Shadmehri, M. 2007, MNRAS, 381, L40

-Dib, S., Shadmehri, M. Padoan, P., Maheswar, G., Ojha, D. K., Khajenabi, F. 2010, MNRAS, 405, 401