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From Quarks to Cosmos

Departamento de ASTRONOMÍA
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Fragmentation & Accretion in the context of IMF

Abstract: The stellar Initial Mass Function (IMF) appears to be close to universal within the Milky Way galaxy. However, it is strongly suspected to be different in the primordial Universe, where molecular hydrogen cooling is less efficient and the gas temperature can be higher by a factor of 30. In between these extreme cases, the gas temperature varies depending on the environment, metallicity and radiation background. We explore if changes of the gas temperature affect the IMF of the stars considering fragmentation and accretion. We have good indications that typical features of the IMF such as the mean, minimum and maximum stellar mass are regulated by the two key physical processes of fragmentation and mass accretion. Our simulations indicate the presence of two distinct regimes of protostellar mass growth, one where the protostellar masses are dominated by the initial fragmentation, and the other where they are dominated by the accretion process. In the fragmentation dominated regime one expects at best a very weak dependence on the initial temperature of the gas, as the Jeans mass is very similar at the transition point from an approximately isothermal to an adiabatic equation of state (EOS). In the accretion dominated regime, on the other hand, we find that the average mass correlates with the gas temperature. The total number of protostars in each of our models and the associated protostellar mergers as a function of star formation efficiency (SFE) also provide an insight which support the existence of a transition from a fragmentation dominated to an accretion dominated phase inside collapsing gas clouds. Despite the lesser number of mergers the warmer gas clouds show a higher mean mass after a critical SFE of about $\xi = 5$ to 7 %.

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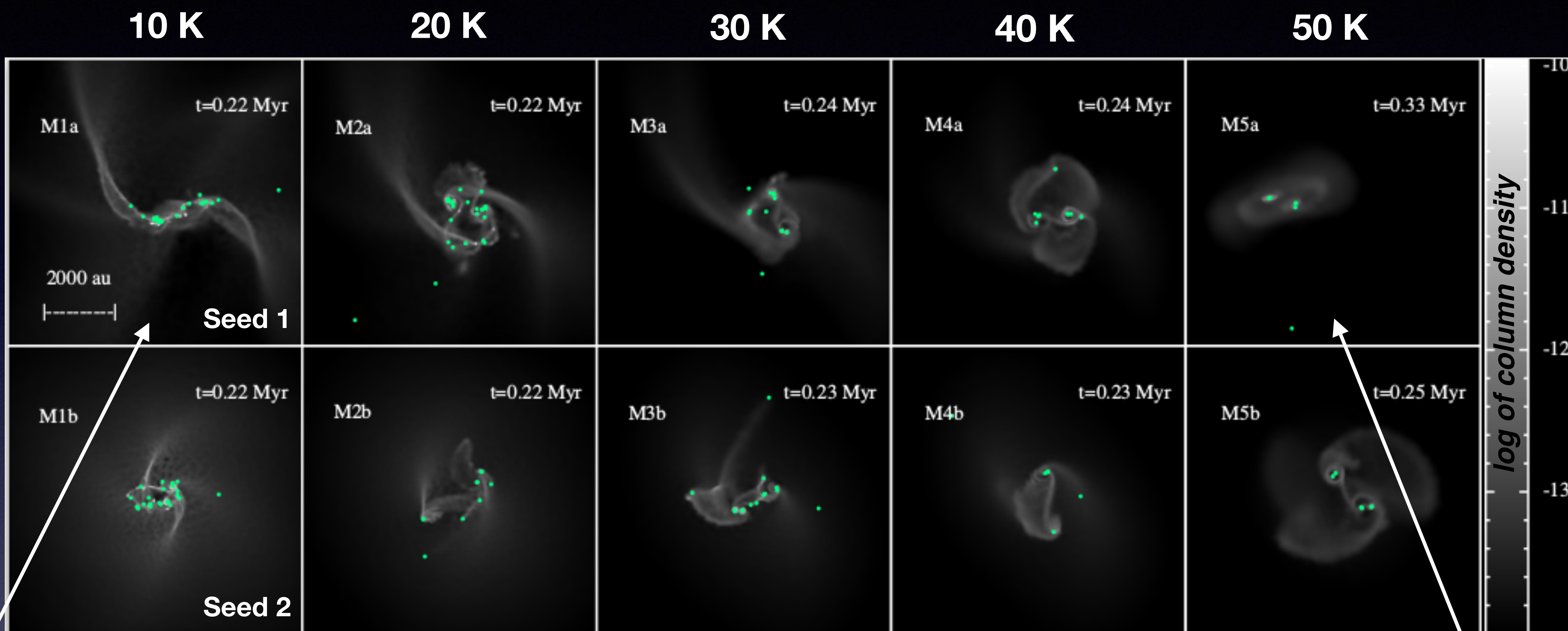
Treated Problem: CMB & other **radiation sources** may affect the **IMF**

Key equation in play

$$M_{\rm J} = \frac{\pi}{6}\left(\frac{k}{\mu m_{\rm H} G}\right)^{3/2} \rho^{-1/2}\, T^{3/2} \sim \rho^{-1/2}\, T^{3/2}.$$



- During the gravitational collapse the gas thermodynamics is modelled with the **barotropic EOS**
- The **EOS** mimics the transition from *pure isothermal* to *adiabatic* phase of collapse

More densely packed star cluster with the hosting filamentary structure

Colder gas environment

At what density the phase transition should occur

$$T = \left(\frac{k^3}{12\sigma^2 m_{\rm H}}\right)^{1/5} n_{\rm H}^{2/5},$$

What should be the gas pressure before and after such a transition

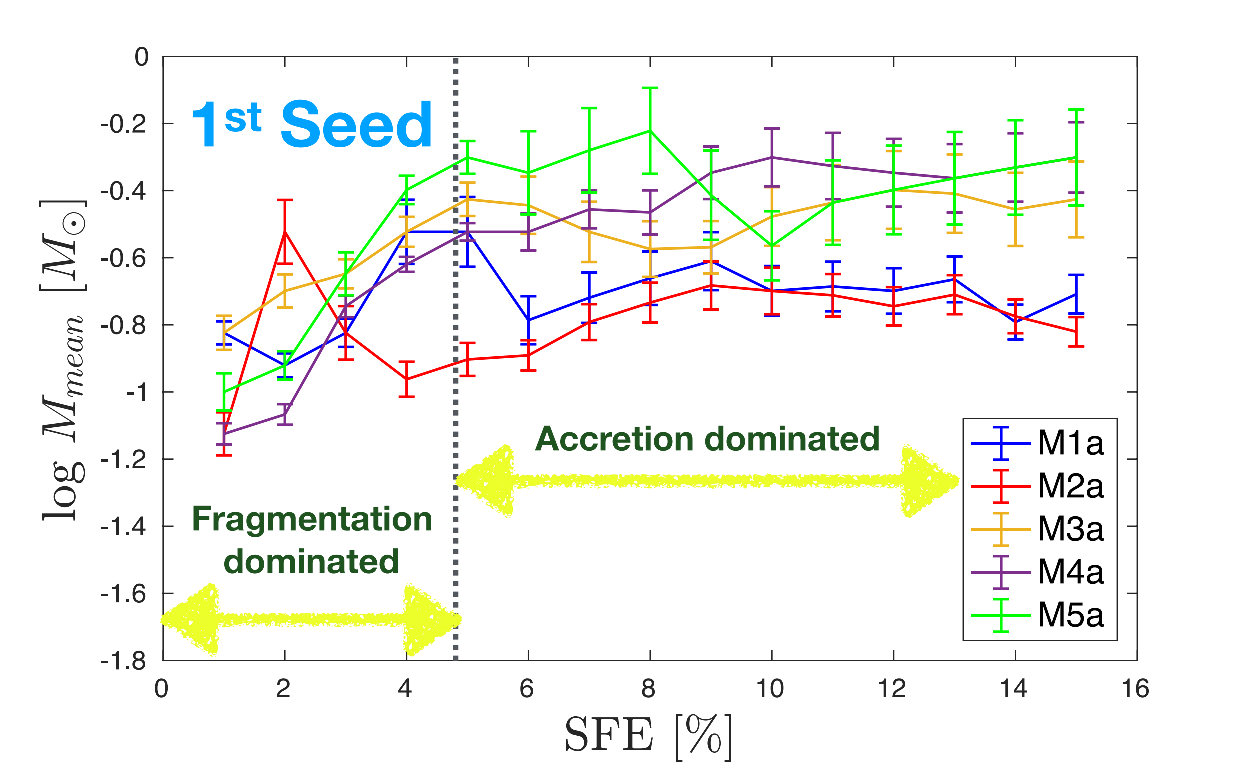
$$P = \rho c_0^2 \left[1 + \left(\frac{\rho}{\rho_{\rm crit}}\right)^{\gamma-1}\right].$$

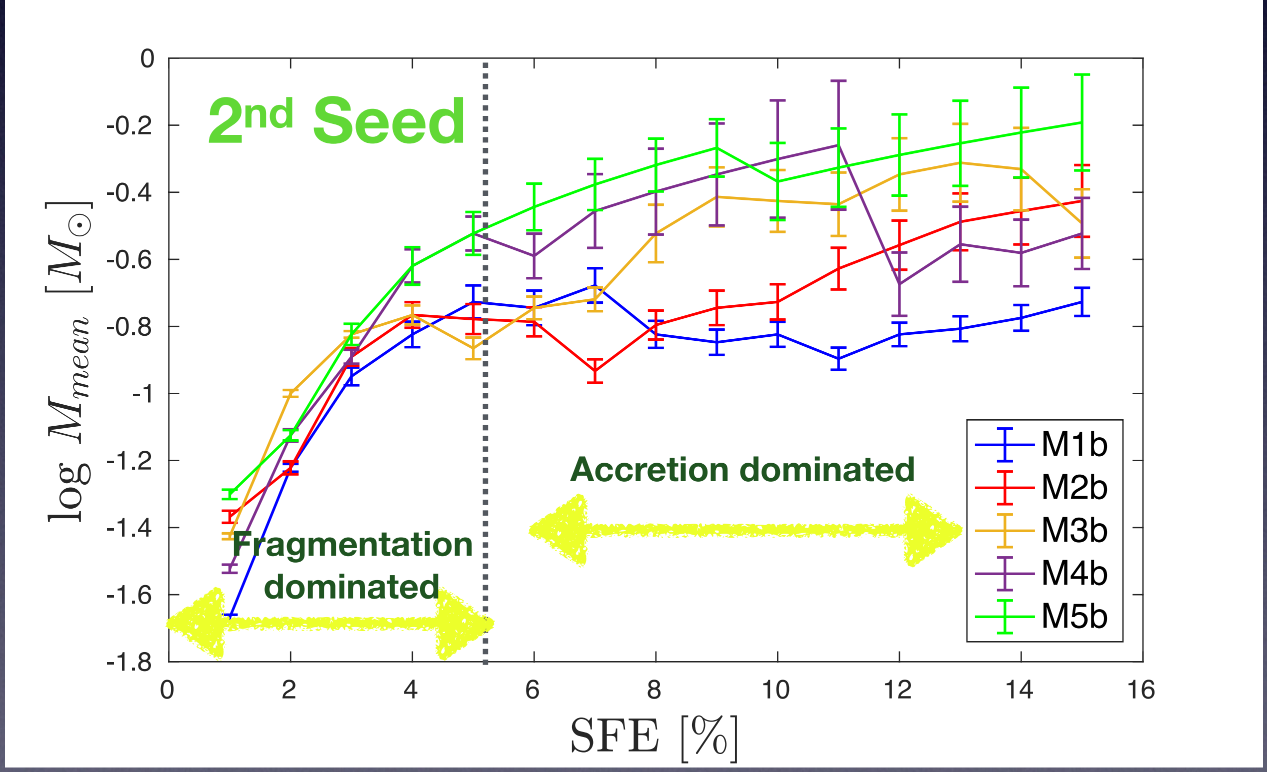
Lesser # of protostars with the less pronounced hosting filamentary structure

Warmer gas environment

Results:

- The **effective mass accretion phase** helps the protostars to grow in mass as well as in number which lead to the eventual **higher mean masses M_{mean}** associated to the warmer mean clouds until the SFE reaches $\xi = 15\ \%$.
- The **total number of protostars** in each of our models and the associated **protostellar mergers** as a function of SFE also provide an insight which support the existence of a *transition from a fragmentation dominated to an accretion dominated phase* inside collapsing gas clouds.
- Despite the lesser number of mergers the **warmer gas clouds** show a higher mean mass M_{mean} after a critical SFE of about $\xi \sim 5\text{–}7\ \%$.
- Our analysis of **mass accretion** for the **longest surviving protostar** in each model provides a demonstration of the transition from the fragmentation dominated regime to accretion dominated regime in star forming gas clouds.





Conclusion: We suspect that the observed trend, for the **mean** and **maximum mass** in particular, could be an indication that the **increasing thermal pressure** in the star forming gas **removes stars from the low-mass end** of the IMF. Overall, our results suggest that the IMF will be influenced by the **initial temperature of the gas** if the SFR is high enough.