Contribution ID: **172** Type: **Talk**

Possible role of fragmentation and accretion on the stellar Initial Mass Function?

Tuesday 8 September 2020 14:05 (7 minutes)

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 one 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. We have quantified the role of these processes with numerical simulations, varying the initial gas temperature from 10 to 50 K, assuming transonic turbulence and a ratio of rotational to gravitational energy of 1 %. We pursued two sets of models with different random seeds to initialize the turbulence, corresponding to different realizations with the same statistical properties. Before the transition to the regime dominated by accretion, there is no evidence of a temperature dependence, confirming previous reported findings. As a result, one may expect a rather universal IMF if the star formation efficiency (SFE) is low enough. If higher SFEs are reached, our simulations show that one would expect a dependence of the accretion process on temperature. This could be caused by local radiation backgrounds that heat up the gas. The minimum temperature of the gas is expected to increase with cosmic redshift, as cooling becomes inefficient below the CMB temperature. The temperatures explored here correspond to a redshift range from 2.7 to 17.3, if interpreted to be due to the temperature of the CMB, thus covering a significant range in redshift, while in the presence of a sufficiently strong radiation background heating the gas, the models can be applied at lower redshift as well. Our approach implicitly assumes the presence of dust, as the latter regulates the transition from an approximately isothermal to an adiabatic regime. 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 associated to the warmer clouds until the SFE reaches ξ = 15 % at the end of our simulations. 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 after a critical SFE of about ξ = 5 to 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.

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Session Classification: X- & CR RAYS, QM, SNOVAE, GRAVITY, DM, COSMOLOGY, PARTICLES, COMPACT STARS, GALAXIES