The formation of stars is a fundamental piece of the life-cycle of matter in the Universe, with consequences for understanding the energy input and development on large scales of the interstellar medium in galaxies, and the creation of planetary systems around the new-born stars on small scales. The problem is inherently multi-scale in nature, because self-gravity connects the dynamics of molecular clouds parsecs in size to the accretion flow and collapse of single cores that eventually become stars, spanning several million in dynamical range.
Two general measures describe this process: how fast is gas turned in to stars compared to the free-fall collapse time, the so-called Star Formation Rate (SFR), and what is the resulting mass distribution, the stellar Initial Mass Function (IMF).
Using a set of large-scale simulations of star formation, requiring more than 100 million CPU-hr, describing the evolution over several million years of a four-parsec star forming region with a maximum resolution of 50 AU, we explore the necessary ingredients to properly recover the observed SFR and IMF. We compare our results with the predictions of the turbulent-fragmentation scenario for the origin of the stellar IMF, and show how it is in accordance with our simulations. Using a large dynamic range in both space and time we recover for the first time the full spectrum of stellar masses from brown dwarfs to massive stars, and test the numerical convergence, and the dependence of the SFR and IMF on physical parameters. We find strong support for the model predictions, including the initial time evolution of the IMF.