Star Formation: Bridging the gap between Theory and Observations

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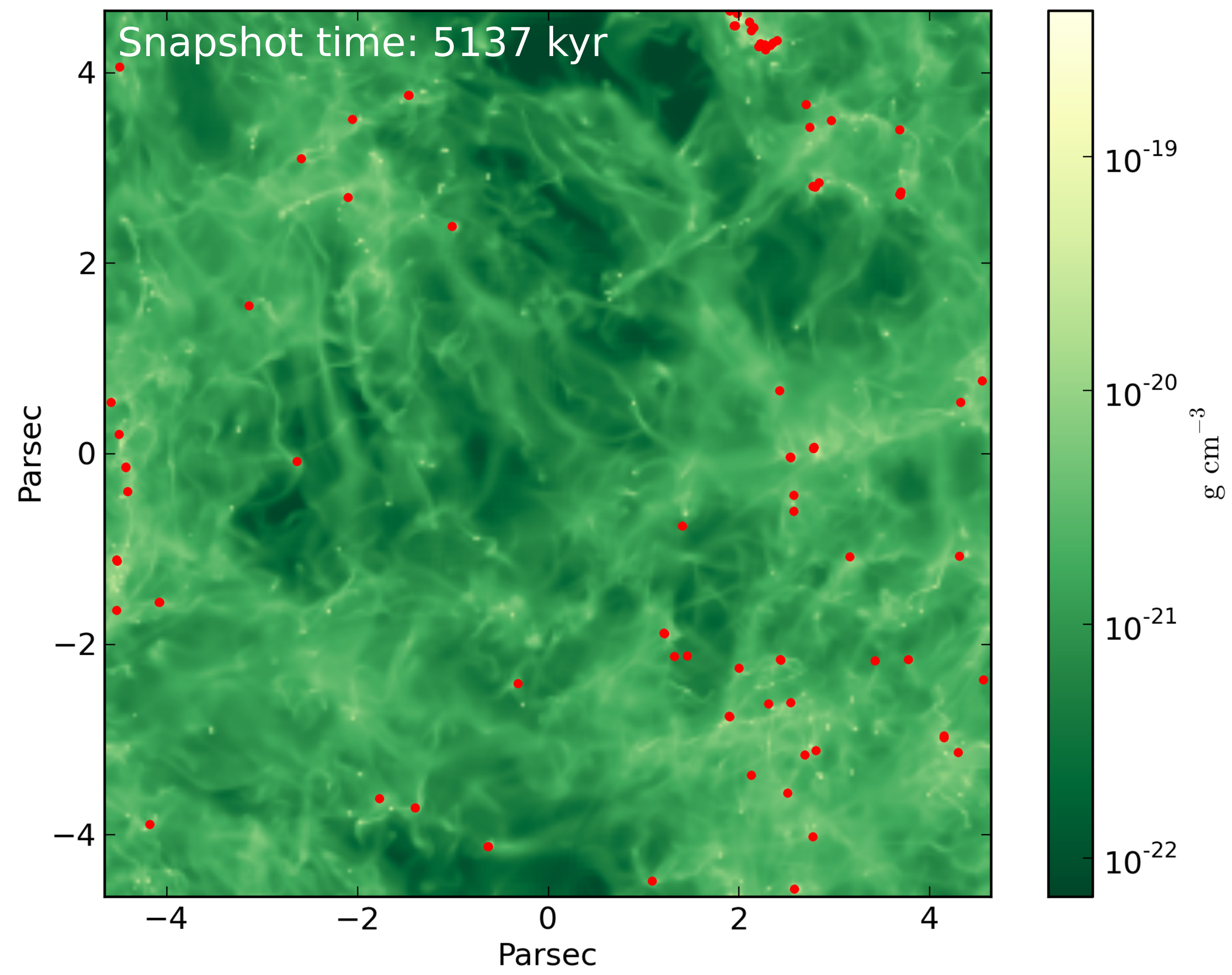
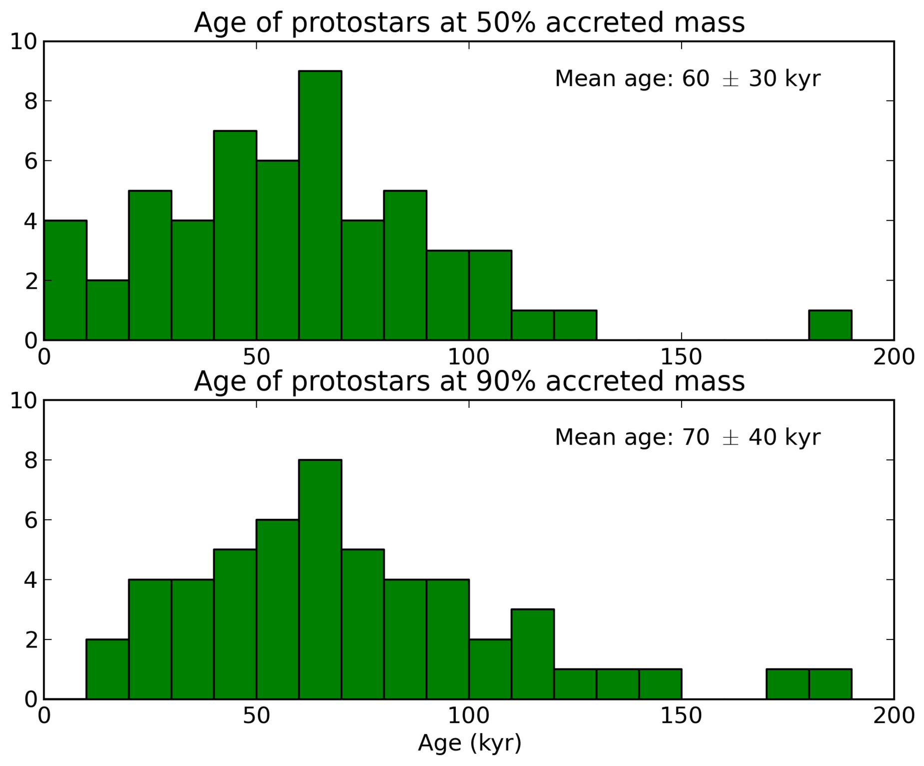
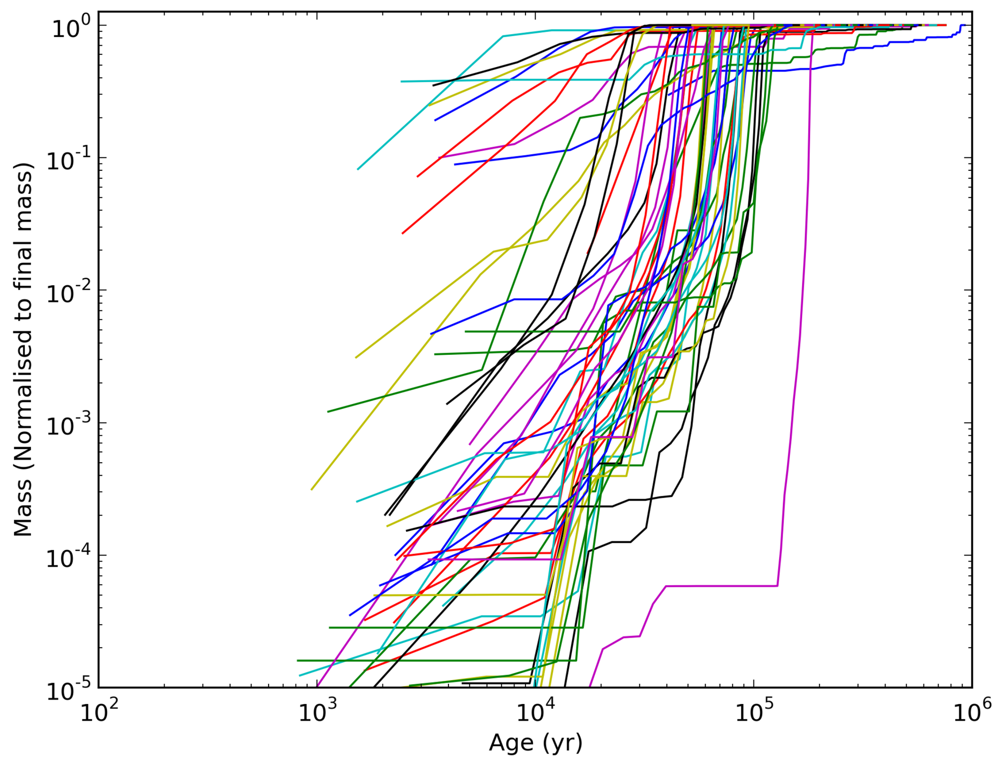
Introduction

Studies of star formation and circumstellar disks see a lot of progress these years: The Atacama Large Millimeter Array (ALMA) and the Submillimeter Array (SMA) will make it possible to zoom in on the protostellar cores in their earliest stages and map their gas and dust content. At the same time magnetohydrodynamic (MHD) simulations of molecular clouds have reached a level, where it is becoming possible to evolve the cloud on parsec scales, while simultaneously resolving the neighborhood around the stars with an AU-scale resolution.

Here we present the first results from a study of protostellar cores taken from the numerical simulations of Haugbølle et. al. (2013). The goal of this, and subsequent studies, is to compare simulations to real observations thereby providing a link between theory and observation.







Top: Projected mean density of the entire numerical simulation. The red dots indicate the protostars.

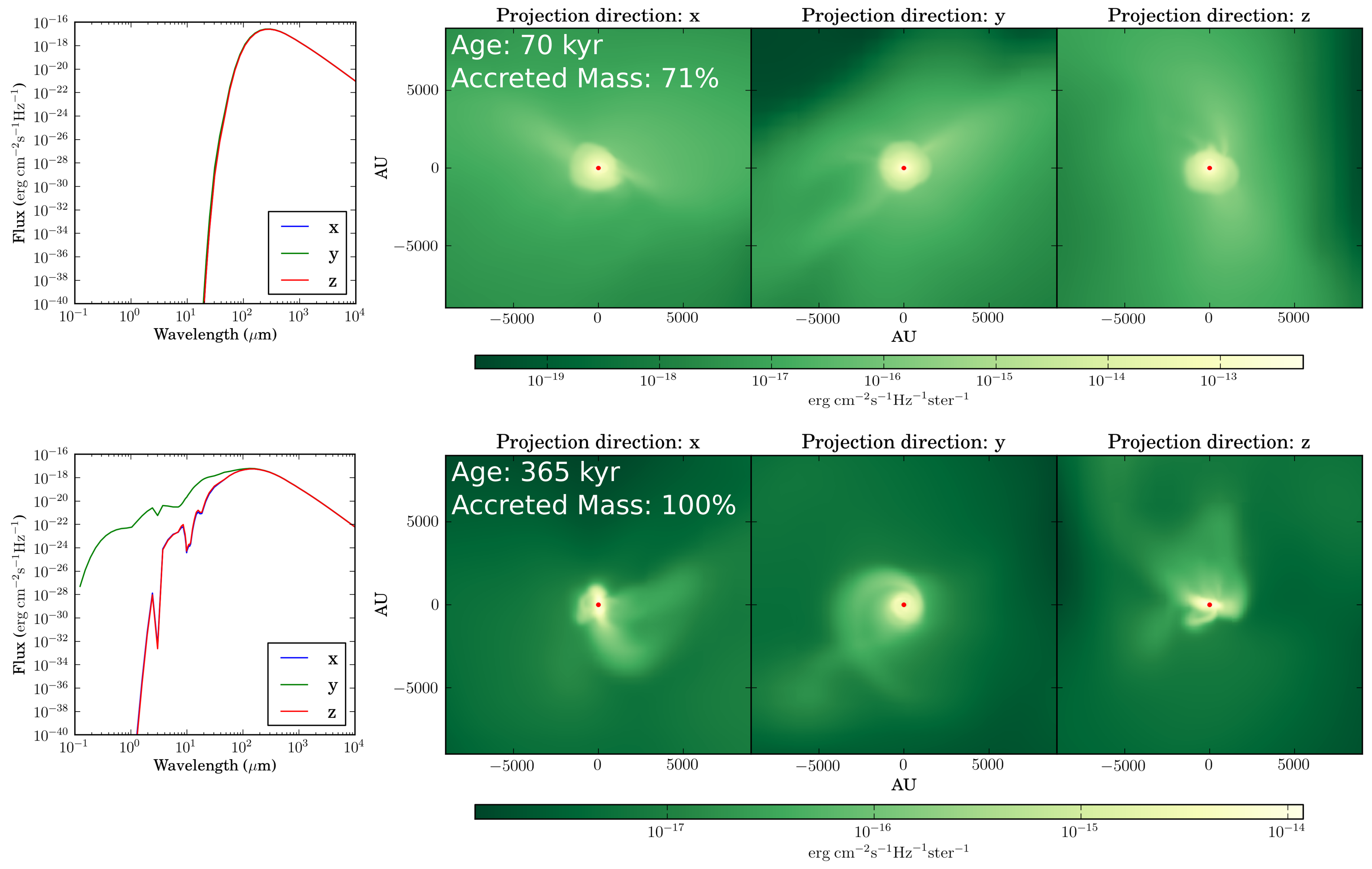
Left: Accretion history of all protostars in the simulations, that do not belong to a multiple system, and have converged to their final mass.

Far left: Histograms showing the ages of the protostars after accreting 50% and 90% of their mass.

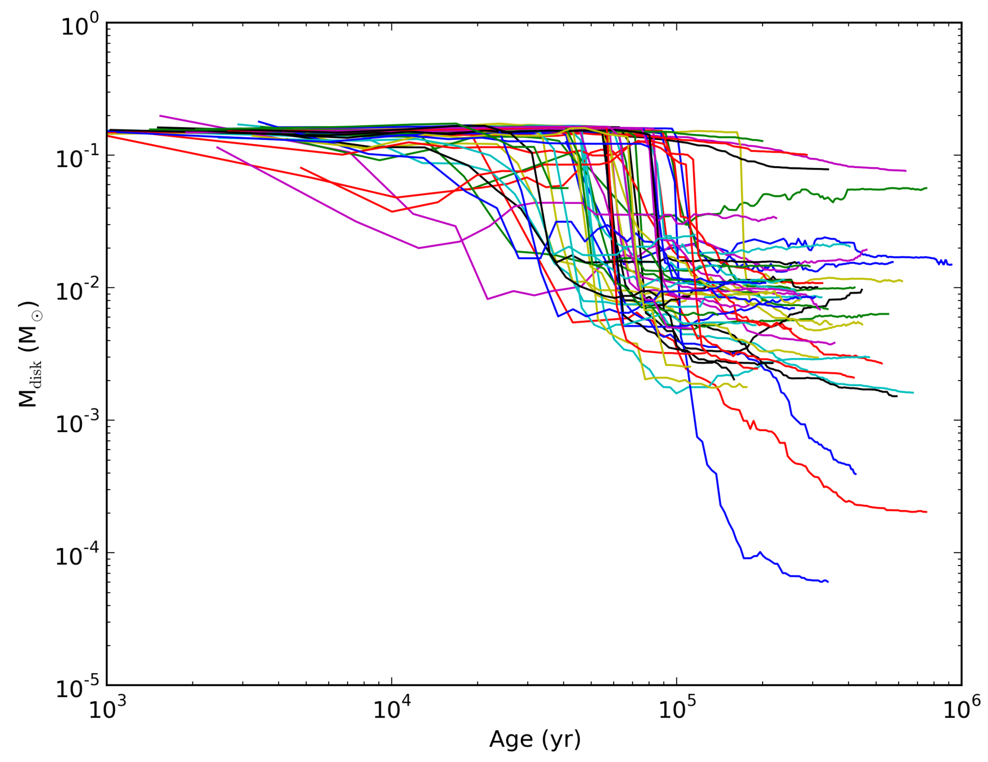
Bottom: Radiative transfer models and SED of a protostar at different ages. The central object is a blackbody with the same parameters as the Sun. Notice, for the later age, how the SED changes depening on the viewing angle of the disk. The radiative transfer modelling was done using RADMC-3D (Dullemond et. al. in prep), with dust opacities from Ossenkopf & Henning (1994).

Stellar Mass Accretion

The accretion of mass onto the protostars is very rapid process, occuring over 10 to 100 kyr. The youngest protostars are termed Class 0 objects, and are deeply embedded objects that emit more than 0.5% of their luminosity at wavelengts longer than 350 μm. This again is thought to reflect that they have accreted less than half of their final mass (André et. al. 2000). The histograms show that once the protostar has accreted 50% of the mass, the rest of the mass is accreted very rapidly afterwards. Radiative transfer models, however, show that an object may still be deeply embedded even after the protostar has accreted most of its mass.



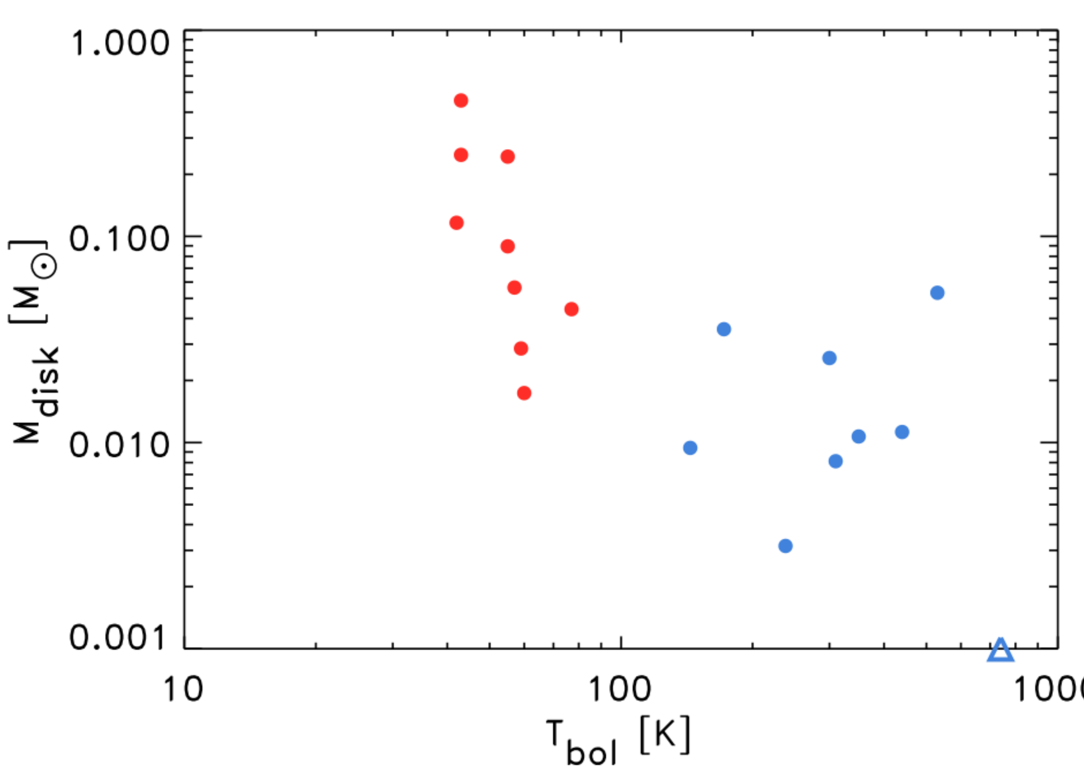
Evolution of disk masses with time, in the simulation.



Disk Masses

The disk masses of the protostellar systems all start out at roughly similar masses, but as time goes evolve to take on a whole range of different masses. This is in agreement with the results in Jørgensen et. al. (2009) who, in a sample of 20 Class 0 and I protostars, could not detect any evolution in the disk masses going from a Class 0 to I protostellar system.

Derived disk masses from the sample of protostars studied by Jørgensen et. al. (2009). Red and blue points are Class 0/I sources respec-tively. Notice the large spread in disk masses, and lack of correlation between Class 0 and I proto-stars.



References

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