Numerical simulations of the formation and early evolution of protostars and protostellar disks

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The new generation of interferometers provide unprecedented constraints on the protostellar disk formation process. Observations indicate that most protostellar disks have a small extent at the Class 0 stage and that disks grow in size at latter stages. I will present the results of 3D protostellar collapse calculations that cover a wide range of initial mass (from 0.5 to 500 solar mass), as well as different initial rotation and/or turbulence support. The calculations are performed using the RAMSES code, including the effect of non-ideal MHD with the ambipolar diffusion and radiative transfer. I will show how ambipolar diffusion is regulating the disk and outflow formation at the early stages of the Class 0 phase. I will discuss the disk properties: magnetisation level, magnetic field lines topology, stability. In a second part, I will present models of the protostar formation (second collapse) where the effects of non-ideal MHD (ambipolar and Ohmic diffusion) are taken into account. I will highlight the differences with previous results obtained with ideal MHD and show to what extent these kind of models can provide constraints on the protostellar evolution (disk, protostar). I will finally present recent results of protostellar collapse models which include coupled dust and gas dynamics which constitute a new standard numerical models framework to study protostellar collapse.

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