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A rotating disk from a non rotating cloud: is the angular momentum conserved?

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Planet-forming disks are fundamental objects thought to be inherited from large scale rotation, through the conservation of angular momentum during the collapse of a prestellar dense core. We investigate analytically and numerically the possibility for a protostellar disk to be formed from a motionless dense core which contains non-axisymmetric density fluctuations.

We show that the angular momentum in the frame of a stellar object which is not located at the center of mass of the core is not conserved, due to inertial forces. The rotation is thus generated locally by the asymmetry of the collapse. Our simulations quickly produce accretion disks at the small scales in the core. We study the velocity gradients at different scales in the simulation as it is done with observations. This analysis reveals projected velocity gradients of amplitudes similar to the ones observed in protostellar cores, and which directions vary, sometimes even reversing when small and large scales are compared. Our results from simulations without initial rotation are more consistent with recent observations where these complex kinematics patterns appear than when solid-body rotation is initially imprinted. Lastly, we show that the disks formed grow to reach sizes larger than observed ones, before fragmenting. We show that including magnetic field in these simulations reduces the size of the outcoming disks, and prevents them from fragmenting, as showed by previous studies.

In this scenario, large disks are generic features which are natural consequences of the hydrodynamical fluid interactions and self-gravity. These results open a new avenue to explore in our understanding of the early phases of disk formation, since they suggest a fraction of the protostellar disks could be the product of non-axisymmetrical collapse and not resulting from the conservation of large scale angular momentum in rotating cores.

Field

InterStellar Medium

Auteur principal: VERLIAT, Antoine (CEA/AIM)

Co-auteurs: Dr MAURY, Anaëlle J. (CEA/AIM); GAUDEL, Mathilde; Dr HENNEBELLE, Patrick (CEA Sacaly - AIM)

Orateur: VERLIAT, Antoine (CEA/AIM)

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