MHD simulation of cloud formation by the thermal instability and consequent massive star feedback

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We have used the AMR magnetohydrodynamic code, MG, to perform 3D MHD simulations of the formation of a molecular cloud through the action of the thermal instability, with self-gravity and magnetic fields. Two initial diffuse atomic conditions have been investigated: 1) a 100 pc-diameter 17,500 solar mass spherical cloud; and 2) a 200 pc-diameter 135,000 solar mass spherical cloud. For both initial conditions, we investigated the hydrodynamic case of no magnetic field and the magnetic case of magnetic/thermal pressure equivalence (plasma beta=1). We have further investigated the evolution of the clouds in the presence of galactic shear. We have found a range of structures form with molecular cloud densities. In particular, the hydrodynamic case leads to the formation of a clumpy spherical molecular cloud, until shear is introduced, which extends the structure into a thick corrugated sheet-like cloud, eventually collapsing into a thin sheet. The magnetic case sees material 'trace a flow' along the magnetic field lines and form an initially thick, but at late times thin, corrugated sheet-like cloud perpendicular to the magnetic field. In projection, the cloud appears remarkably filamentary. The introduction of galactic shear triggers high-density thermal condensations at earlier times, accelerating the evolution of the molecular cloud and in the magnetic case, a large inclination to the magnetic field away from the perpendicular cloud formed in non-shear case. At high resolution, we have examined the evolution of individual clumps, their collisions and their evolution towards star-forming cores. Into these structures we have introduced mechanical stellar feedback from single and multiple massive stars ranging from 15 to 120 solar masses and their consequent supernovae. Throughout, we have tracked the dynamic and thermal evolution of the molecular material, revealing information about the survival of the molecular cloud. We conclude with a demonstration that the striking structure of the Rosette Nebula can be understood in terms of these cloud formation models with supporting evidence from Planck-based magnetic field observations and Gaia-based proper motions of the stars in the central cluster.

Molecular Clouds