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Theoretical models for filamentary structures and collapse of pre-stellar cores

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Molecular are the sites of star formation, made by networks of filaments (e.g., Andre'et al. 2014, Hacar et al. 2023).
Individual filaments composing a molecular cloud accumulate mass by accretion from the parental cloud, until they become gravitationally unstable and fragment into cores, that eventually collapse into stars and stellar clusters. The candidates for supporting the clouds are large-scale magnetic fields and turbulence (e.g., Pattle et al. 2023).
In a contest where these processes are interplaying at different time- and length-scales, is crucial to understand their role in the equilibrium and in the dynamical evolution of molecular clouds as well as how the gravitational collapse can affect them.

In this talk, I will present an analysis of the stability and contraction of molecular clouds both in the hydrodynamical and magnetohydrodynamical case, in the quasi-static and dynamical phase of evolution. Under the hypothesis that the observed filaments and
cores can be represented by a sequence of hydrostatic or magnetostatic models, I will analytically study their radial density profiles and stability properties (Toci & Galli 2015 a,b).
However, molecular clouds must contract and fragment in order to form stars.
I will show an analysis of the growth of small-scale density perturbation during the hydrodynamical collapse of a molecular core, simulated using a modified version of the ECHO (Del Zanna et al.2017) code to include a generic anisotropic metric that allows stretching in all directions. I also analytically estimated the transition time to non-linear regime in analogy with the Burgers equation. The results point out that the formation of shocks and the subsequent dissipation prevents the onset of gravitationally unstable perturbations, thus other kind of mechanism are needed to explain the process of fragmentation in cores (Toci et al. 2021).

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