P126b 3D Hydrodynamic Simulations of Core Formation in Turbulent Molecular Clouds

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Stars form from dense cores embedded in turbulent molecular clouds. In the standard model, these cores form via gravo-thermal fragmentation. However, recent studies (Ishihara et al. 2025a,b) suggest that turbulent fragmentation, rather than gravity, plays the dominant role in core formation within turbulent environments.

In this study, we conduct 3D hydrodynamic simulations of turbulent molecular clouds of turbulent fragmentation, focusing on the interplay between turbulence and self-gravity. The setup uses a uniform-density box of 5 pc with a mean number density of 10^3 cm^{-3}. Supersonic turbulence is continuously driven to maintain the $\mathcal{M} \approx 10$. The gas is assumed to be isothermal at a temperature of 10 K. Simulations are performed using the ENZO hydrodynamics code, with a uniform 128^3 grid without adaptive mesh refinement.

After several turbulent crossing times, the gas develops a log-normal density probability distribution function, with the maximum density reaching 215 times the initial value. Dense compact structures ("cores") are identified with Astrodendro package using parameters: minvalue $= 7 \times 10^3$ cm^{-3}, mindelta $= 1.4 \times 10^3$ cm^{-3}, and $\mathrm{min}_{\mathrm{npix}} = 5^3$. In the non-self-gravitating simulation, a total of 88 cores are identified, 97% of which have mean densities greater than 10^4cm^{-3}. Bases on virial parameter, 67 cores are considered bound, among which 60 are bound solely due to external pressure. This result, with an analysis of core lifetimes, provides an insight into the stability and potential longevity of pressure-confined structures formed by turbulent fragmentation.