Revealing the Core Formation in Supersonic Molecular Cloud by 3D Hydrodynamic Simulation

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Stars form from dense cores embedded in turbulent molecular clouds. Recent observations suggest that turbulence plays a more significant role in core formation than previously thought, with gravitationally unstable prestellar core counts (S. Fielder et al. 2026)and separations better matching predictions from turbulent sonic scale than thermal Jeans length(Ishihara et al. 2025a,b).

In this study, we conduct 3D hydrodynamic simulations in a uniform, periodic 3pc (mean number density = 10^3 cm^{-3})box with 1024^3 resolution. To compare the influence of the strength of turbulence on the core morphology and dynamics, the turbulence is continuously driven to maintain Mach numbers of 5, 7, and 10, and the gas is assumed to be isothermal at 10 K. These simulations are performed using the AMR code ENZO.

For all simulations, after several turbulent crossing times — sufficient to develop a log-normal density PDF characteristic of fully developed turbulence — we identify dense cores using the *astrodendro* package with varying parameters. The sonic scale — where turbulence transitions from supersonic to subsonic — varies with Mach number and is thought to coincide with the characteristic filament width as suggested by Federrath et al.2020. To obtain a robust core separation compared with the sonic scale, we examine how the minimum resolved size in core identification affects the measured core properties, especially separations. The core separations decrease with the resolved size decrease, eventually converging to a constant value above the sonic scale. These results reveal a new insight into the stability and universality of turbulent core fragmentation.