Characterizing filament properties in simulations of magnetized, turbulent clumps

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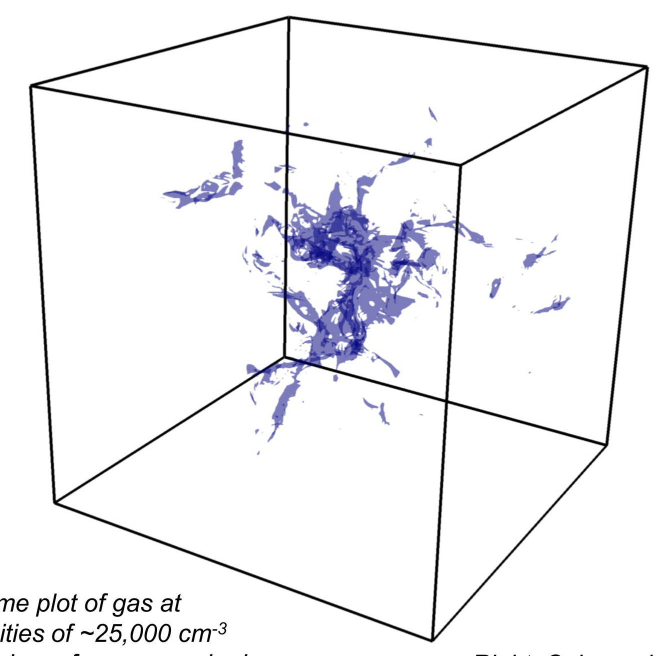
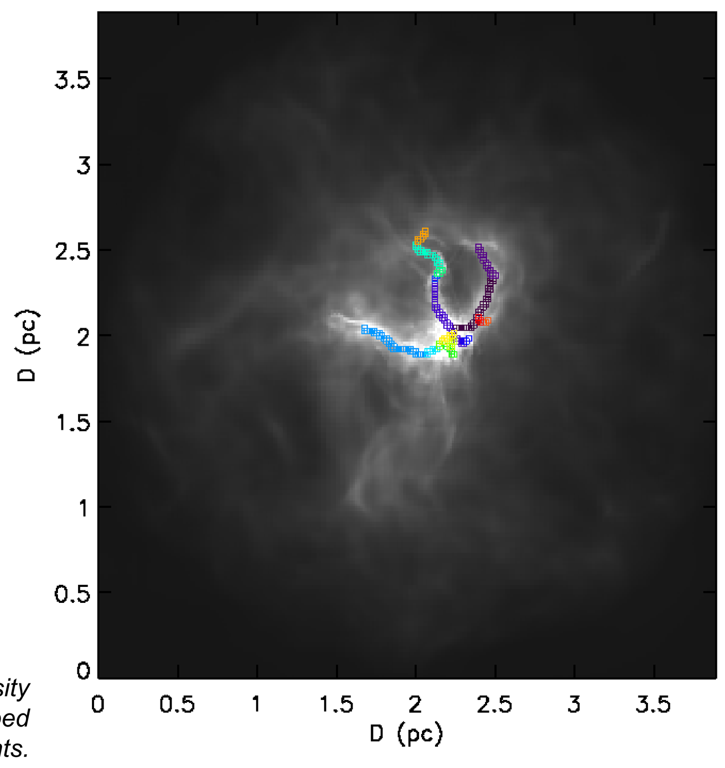
Introduction

Supersonic turbulence within molecular clouds gives rise to networks of filaments, now revealed with unprecedented clarity and detail by Herschel.

We can now begin comparing observations to simulations of turbulent, magnetized molecular cloud clumps.

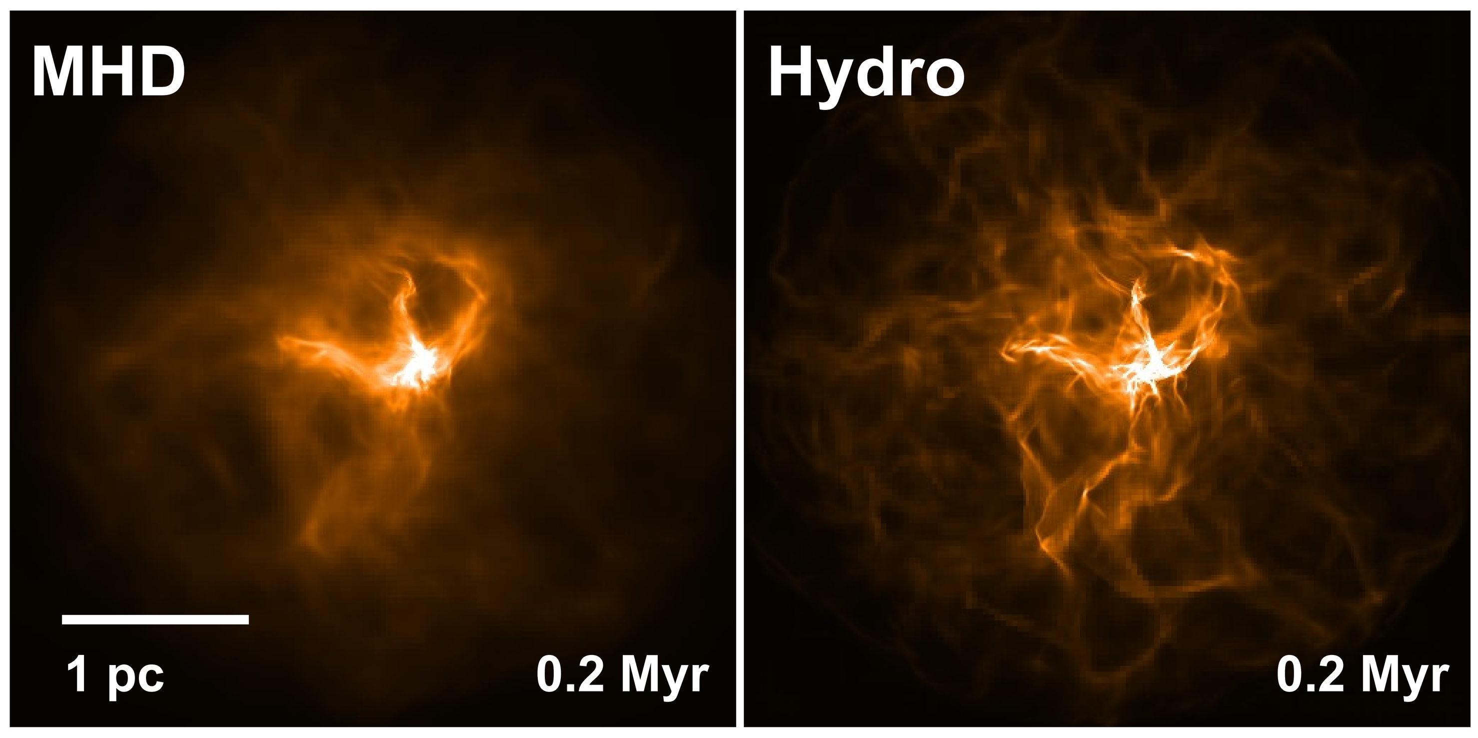


Volume plot of gas at densities of ~25,000 cm^{-3} and above from a pure hydro simulation in 2^3 pc^3 box and Mach 6 Burgers turbulence.



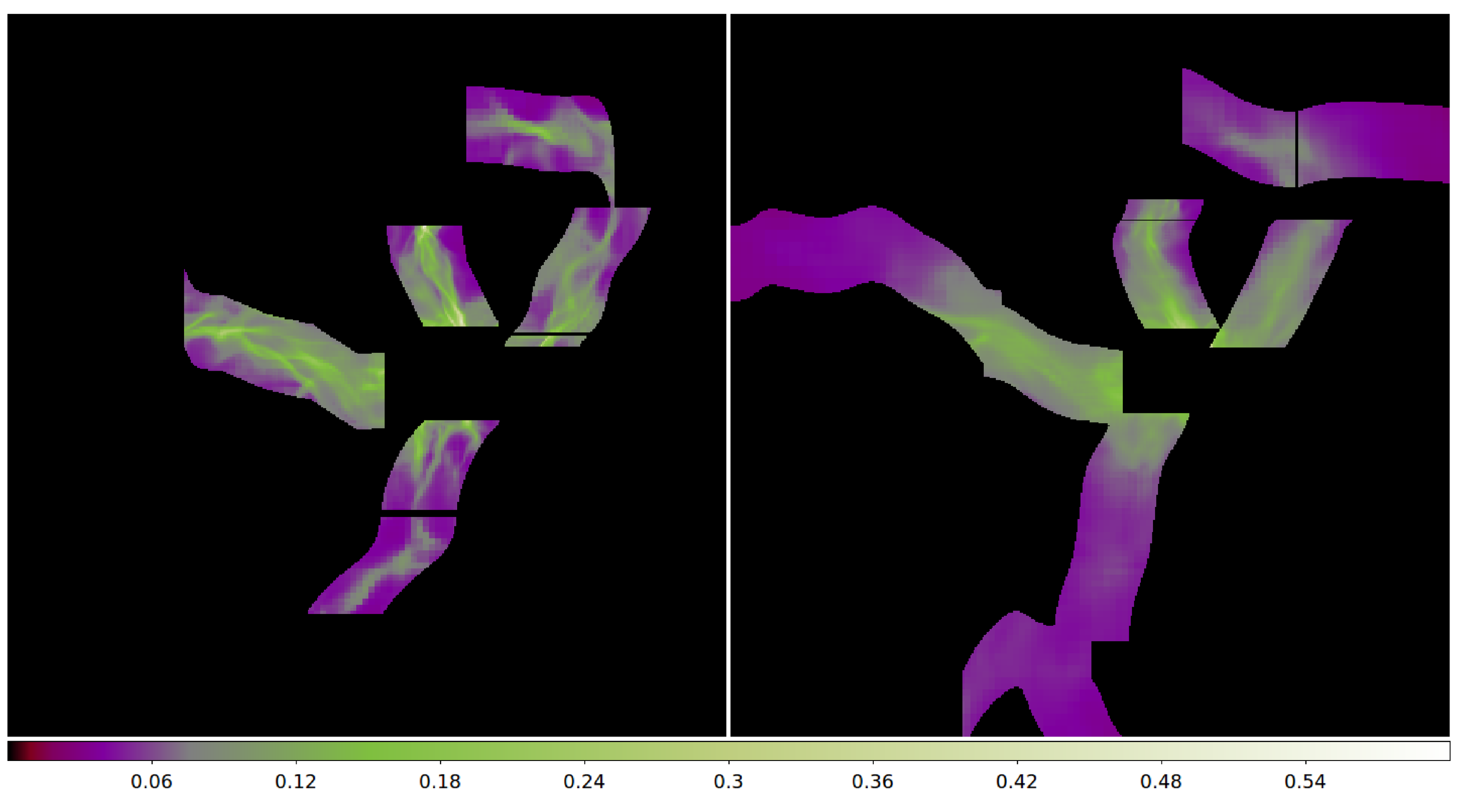
Right: Column density projection with mapped filaments.

Magnetic Fields



Above are column density projections from an MHD simulation (mass-to-flux ~2.33, relative to critical value) vs. a hydro simulation similarly evolved. The MHD case appears "puffier", which we attribute to magnetic pressure support. The hydro case is more condensed. Column densities in main filaments are around 0.1 g/cm^2, while central values approach 1 g/cm^2.

Filament Analysis



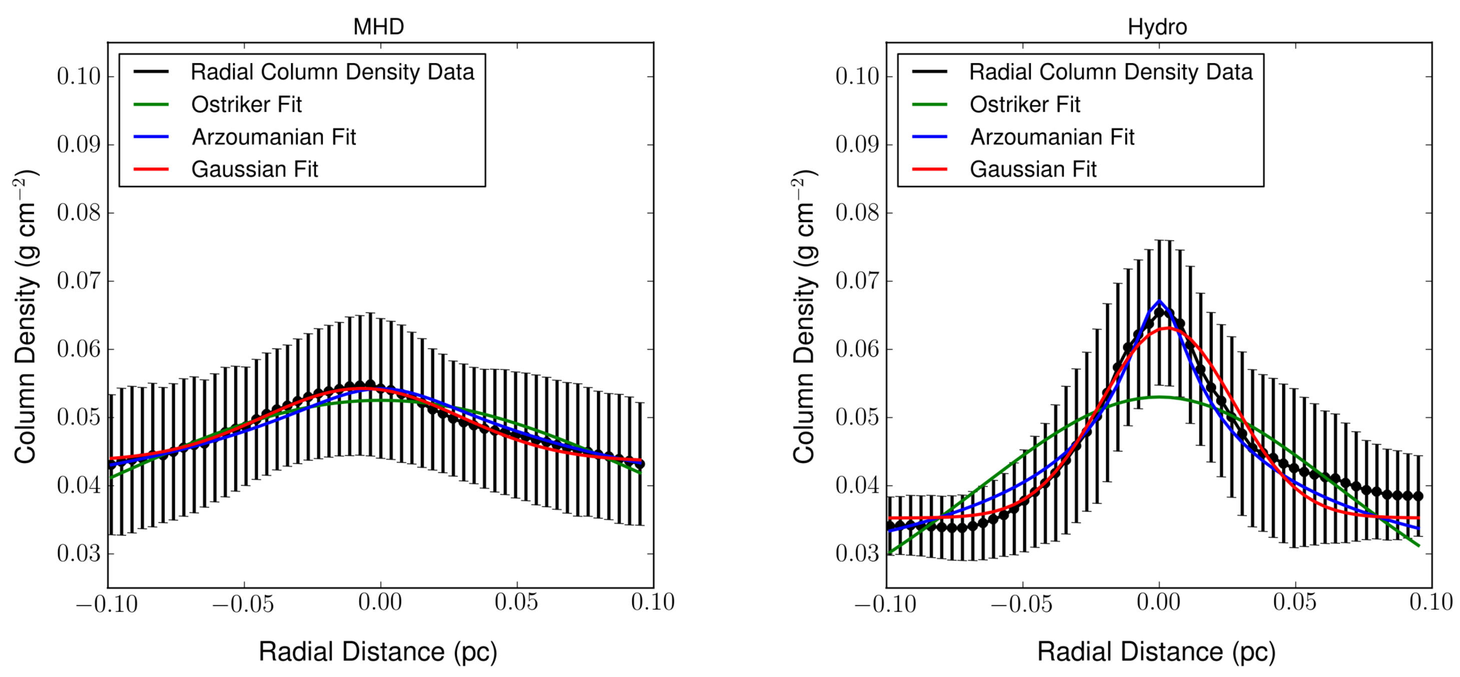
We simulate turbulent molecular cloud cores using the FLASH astrophysics code, which solves the fluid equations on an adaptive mesh and includes MHD, molecular and dust cooling, Lagrangian sink particles, self-gravity, and radiative feedback.

We perform simulations of 500 M_{sol} and 1000 M_{sol} cores with radial power-law density profiles, testing simulations including magnetic fields against runs which are unmagnetized.

To analyse the filamentary structure, we first produce column density projections of the simulation data, then use the DisPerSE algorithm (Sousbie 2011) to extract the filament structure.

By masking parts of the image (as above), we can analyse individual filaments from subregions of the column density map. Colors show mass per unit length normalized to the critical value for gravitational collapse. Here, all filaments are subcritical.

Column Density Profiles



$$\Sigma_p(r) = A_p \frac{\rho_c R_{flat}}{[1+(r/R_{flat})^2]^{\frac{p-1}{2}}}$$

We take radial cuts across individual filament segments and measure the radial column density profile, averaging across the length of the filament. Above, we compare MHD vs. pure hydro (errors bars show standard deviation).

We fit the radial profiles with a standard function as in Arzoumanian et al. 2011 and compare to various other fits. The fits do not agree with the Ostriker (1964) model.

The full-width at half-maximum (FWHM) of the radial column density profile is broader for MHD simulations. The p-value for the Arzoumanian-type fit was found to be $1.1 \leq p \leq 1.5$ for most filaments in both MHD and pure Hydro cases.

These results will be submitted as Kirk et al. 2013 (in prep.). Gas motion along filaments is discussed in Poster 1K008 (Helen Kirk).

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