

# Modeling the bimodal orientation of filamentary molecular clouds

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# Introduction:

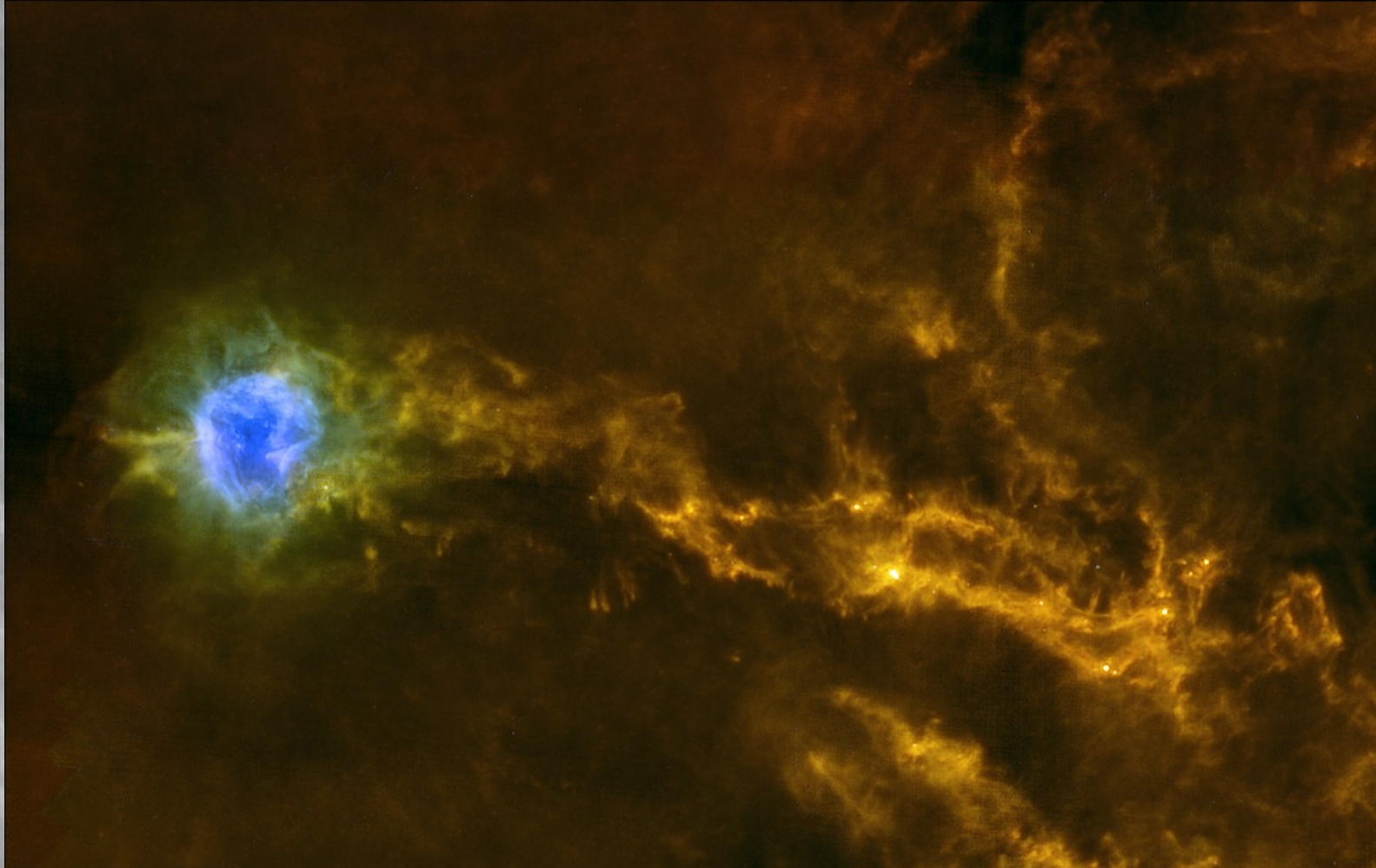
molecular clouds form filaments



Example: IC 5146 / Barnard 168

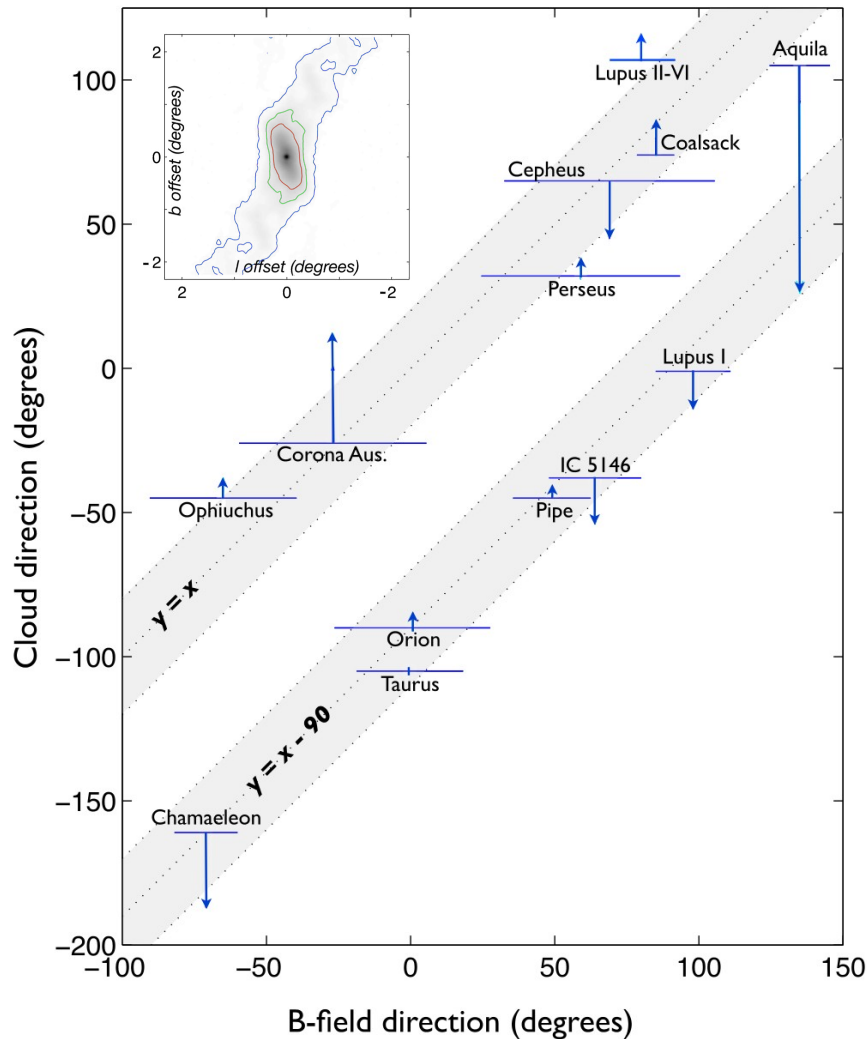
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molecular clouds form filaments



Example: IC 5146 / Barnard 168

# Observation: bimodal cloud orientations



- study of 13 filamentary molecular clouds in the Gould Belt
- clouds are aligned either parallel or perpendicular to the magnetic field of the local inter-cloud medium
- strong significance: probability for this correlation to occur from random orientations  $< 0.6\%$

## Data Sources:

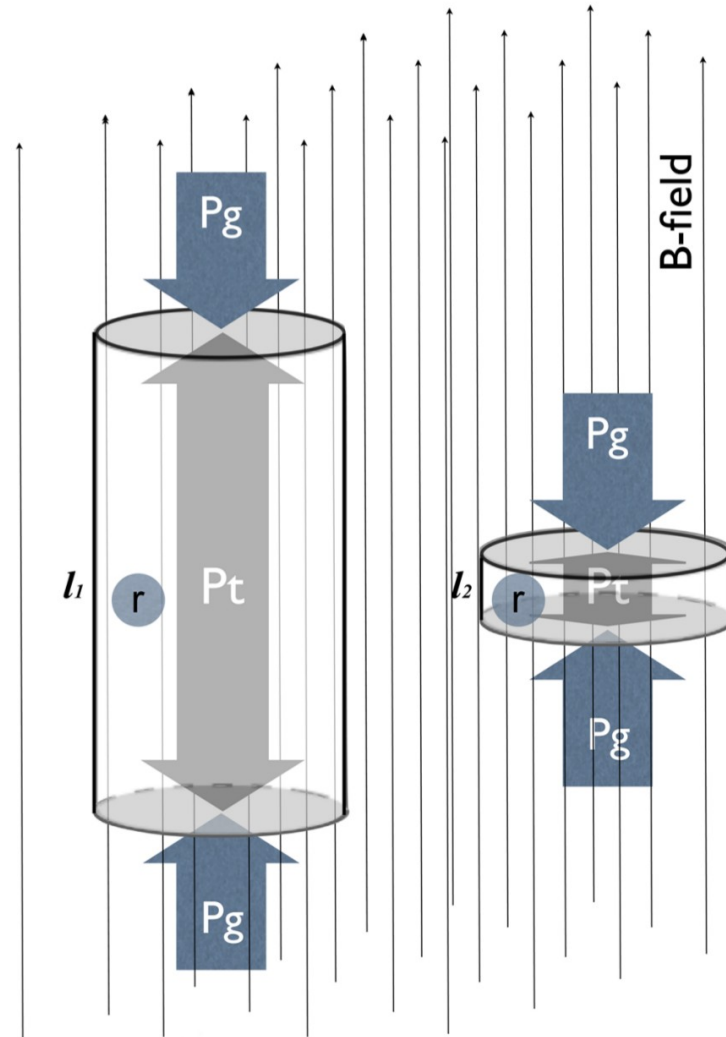
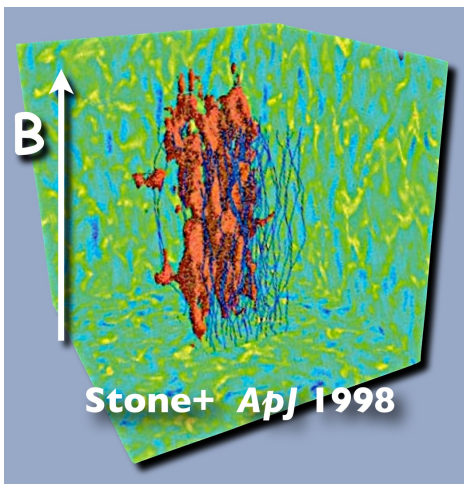
- filamentary structures determined from dust extinction maps (Dobashi 2011)
- ICM B-field direction obtained from optical stellar polarimetry data (Heiles 2000)

# Interpretation: B-fields are dynamically important

## Type I

$$P_{\text{turb}} > P_{\text{grav}}$$

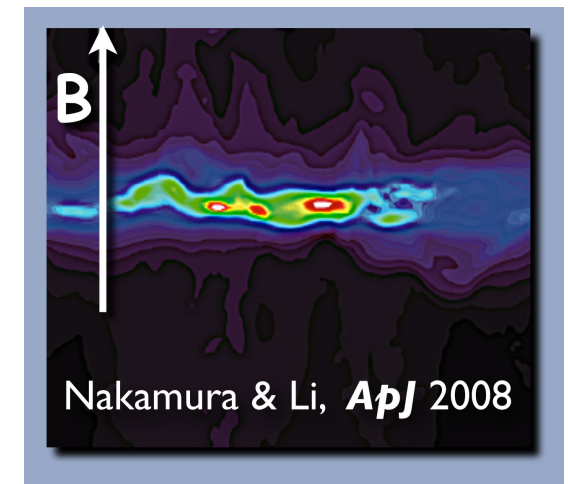
B-field channels  
anisotropic  
sub-Alfvénic  
turbulence



## Type II

$$P_{\text{grav}} > P_{\text{turb}}$$

B-field channels  
gravitational  
contraction



# Computational Setup

- Code: ZEUS-MP + modifications
- Simulation volume:  $(300\text{pc})^3$
- Grid:  $128^3 \dots 512^3$ , periodic
- Turbulence [Stone et al. ApJ 508, L99 (1998)]

$$\delta \mathbf{v}_k^2 \propto k^6 \exp(-8k/k_0)$$

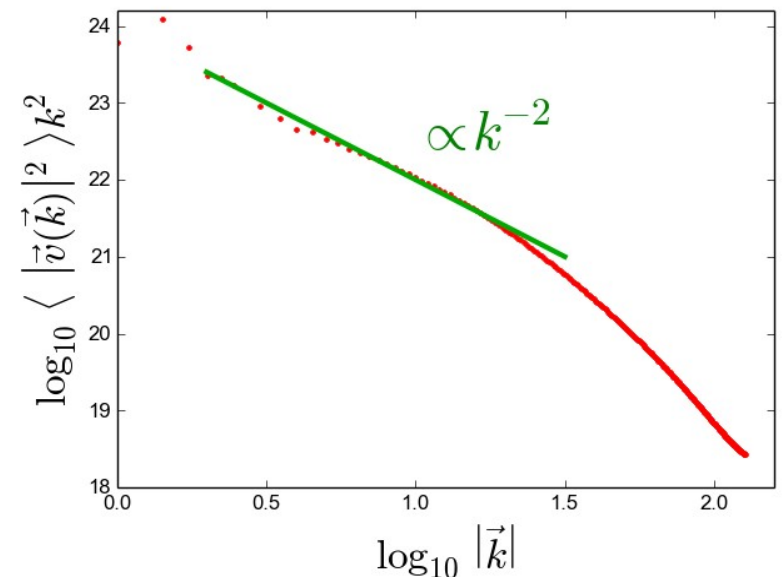
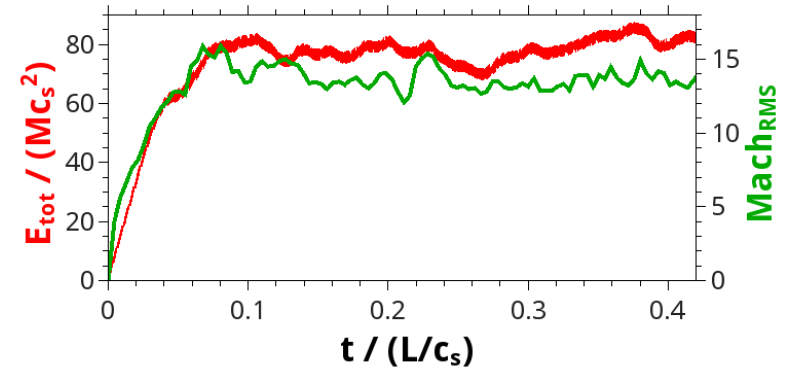
$$\nabla \cdot \delta \mathbf{v} = 0$$

$$\int \rho \delta \mathbf{v} d^3x = 0$$

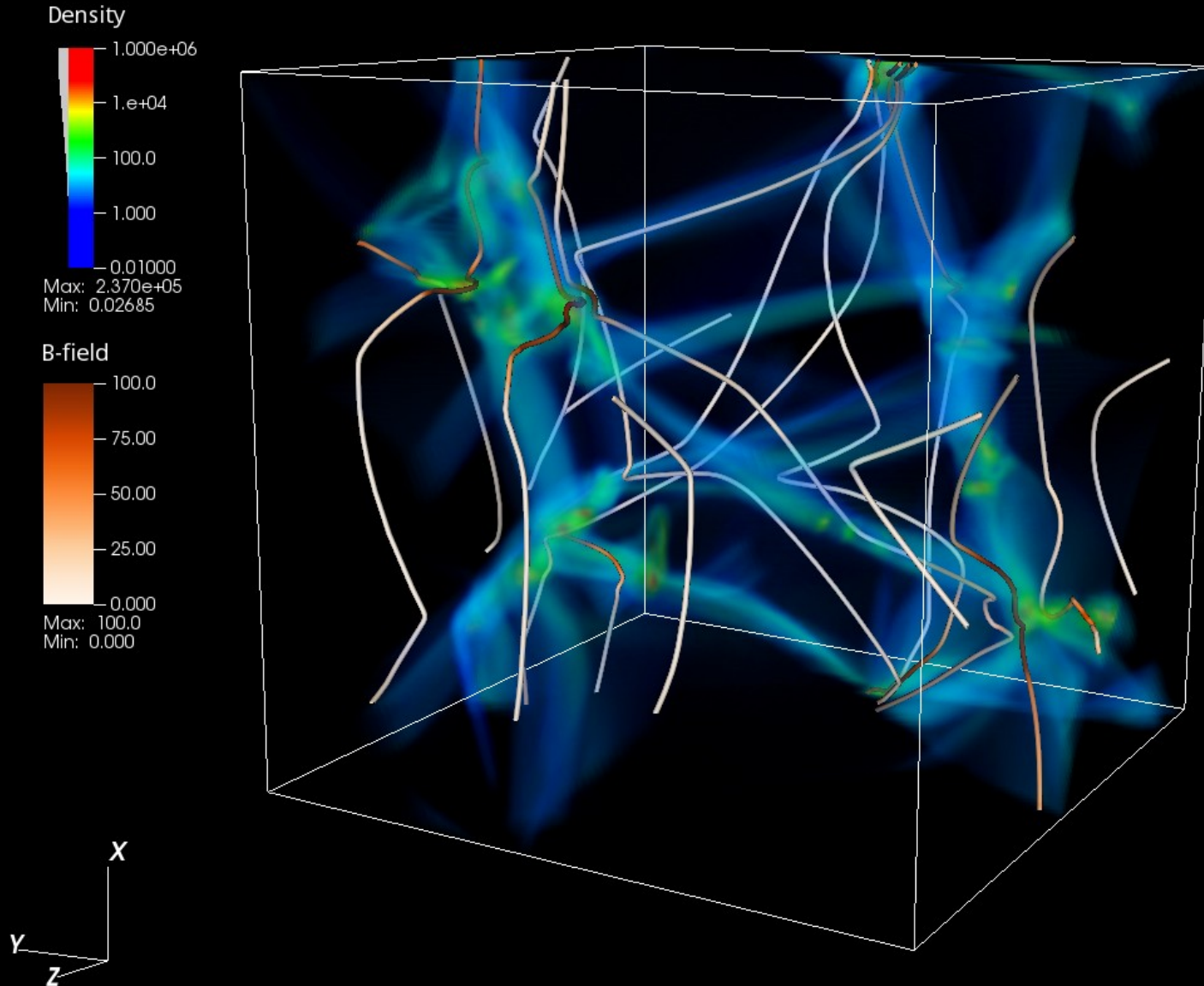
$$dE/dt = \text{const}$$

- isothermal
- uniform initial density, B-field

**What conditions lead to bimodal field-cloud alignment?**



# Preliminary Results

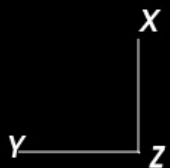
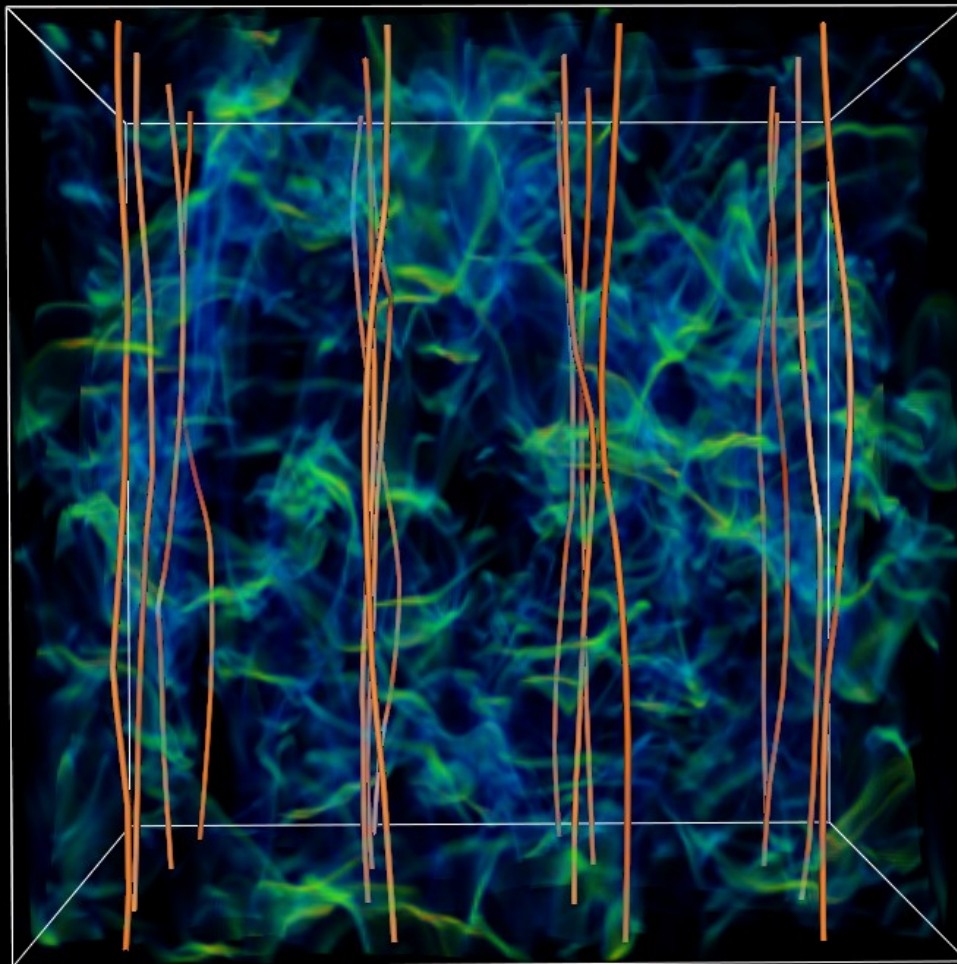
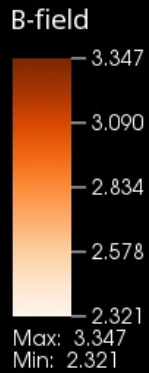
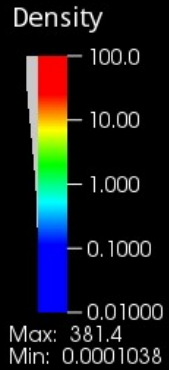


- high mass
- strong turbulence
- weak B-field



- very long filaments
- B-field dragged into filaments
- B-field enters filament at angle  $\sim 90^\circ$

# Preliminary Results



- low mass
- moderate turbulence
- strong B-field



- many filaments at various scales
- B-field unaffected
- filaments mostly orthogonal to B-field



# Outlook

- automatic filament identification & correlation (WIP)
- simulate single filaments
- find clumps inside filaments:  
classify as sub-critical / super-critical
- correlation between filament alignment and SFE?

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# Acknowledgements

- Hua-bai Li (CUHK)
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**Thank you for your attention!**