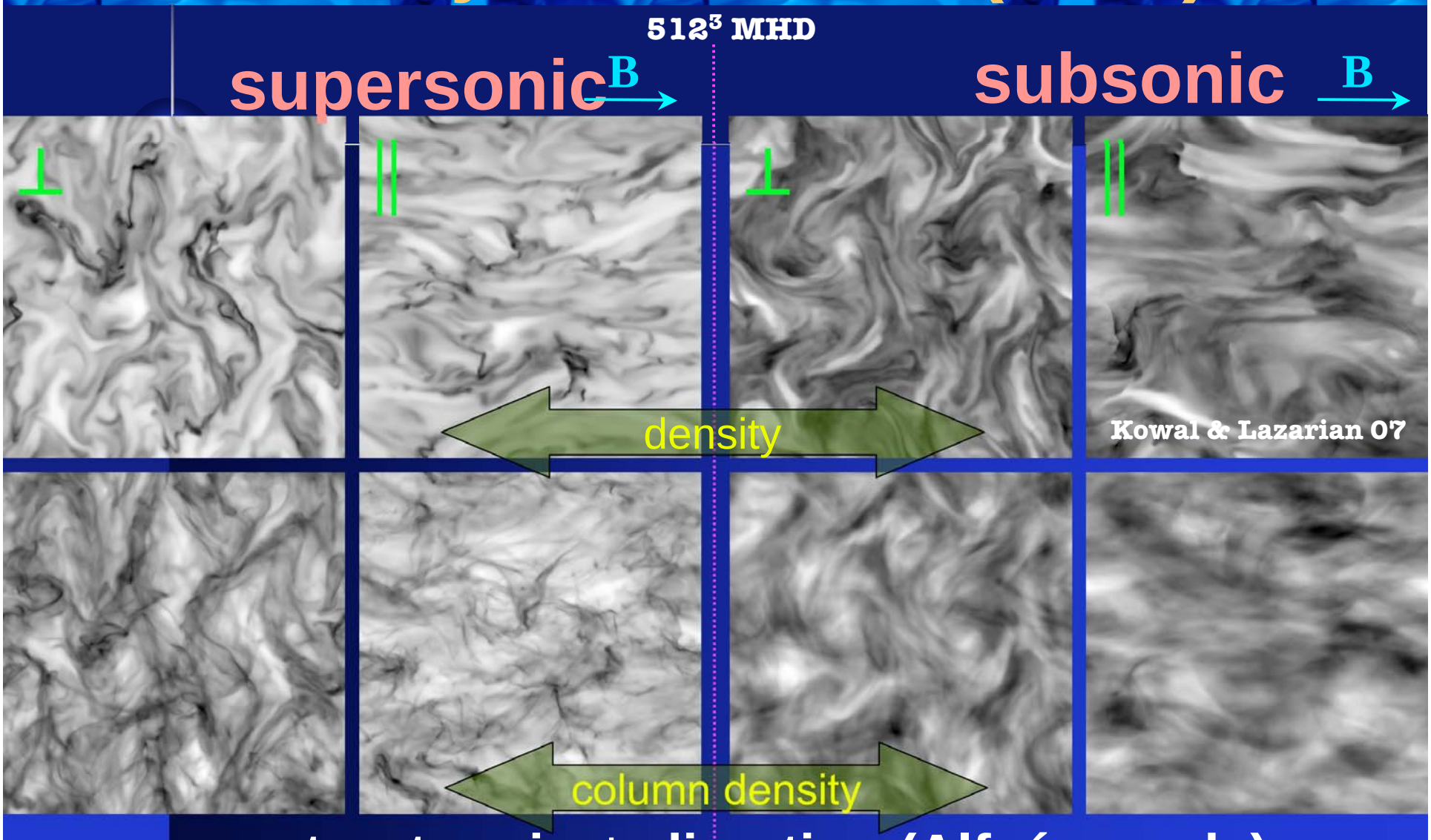
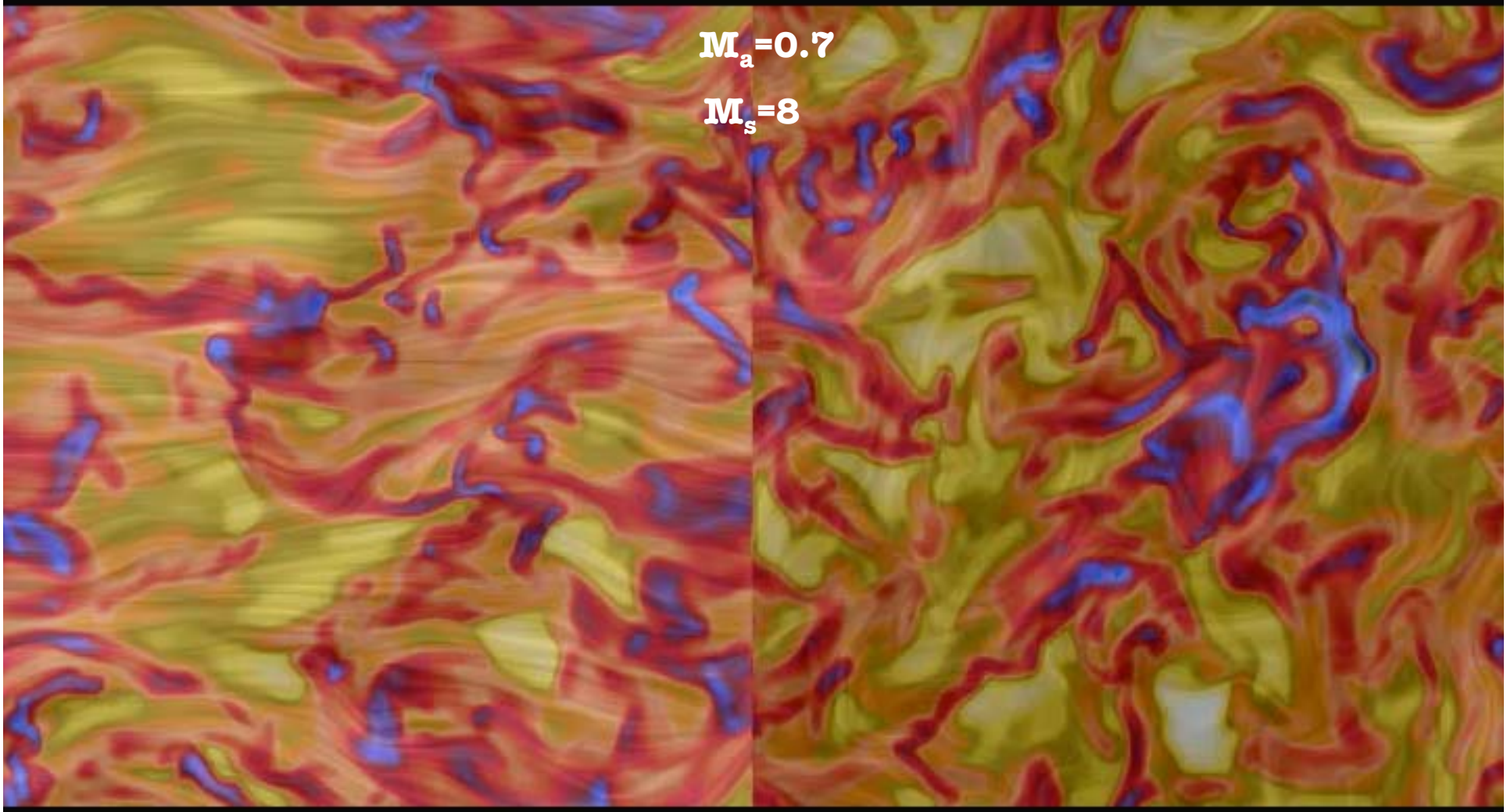
Density Fluctuations (MHD)



- more structure in ⊥-direction (Alfvén mode)
- difference in correlations – a way to study B

Visualization of Structures Formation



512^3 Compressible MHD
Kowal & Lazarian 07

Order in Chaos : Kolmogorov model

$$\frac{V_l^2}{t_{l,cas}} = \text{const}$$

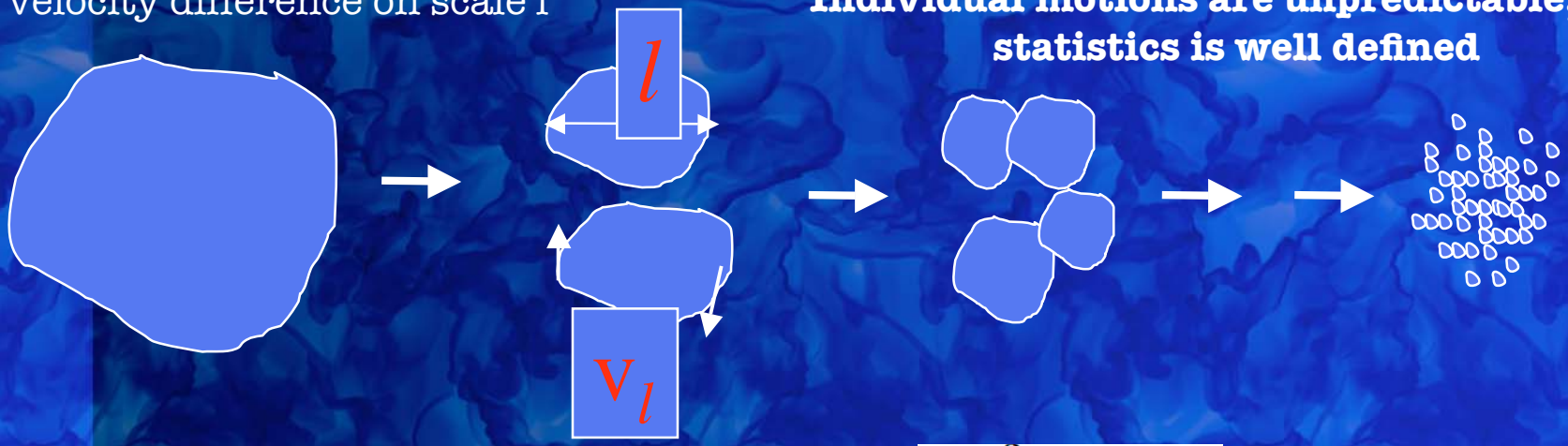
$$t_{l,cas} = l/V_l$$

$$\Rightarrow \frac{V_l^3}{l} = \text{const}, \; V_l \sim l^{1/3}$$

Incompressible Hydro

Or, $E(k) \sim k^{-5/3}$

V_l is velocity difference on scale l



Individual motions are unpredictable, but statistics is well defined

What if compressible? Can we think of

$$\rho_l^{1/3} V_l \sim l^{1/3} \; ?$$

$$\frac{\rho_l V_l^2}{t_{l,cas}} = const \; ?$$

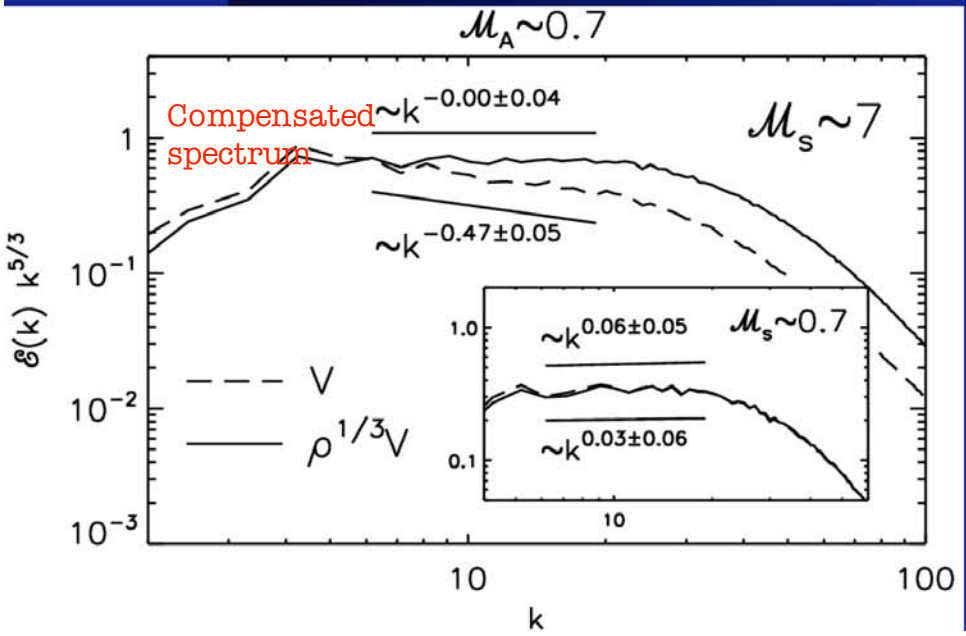
Proposed by Fleck 96

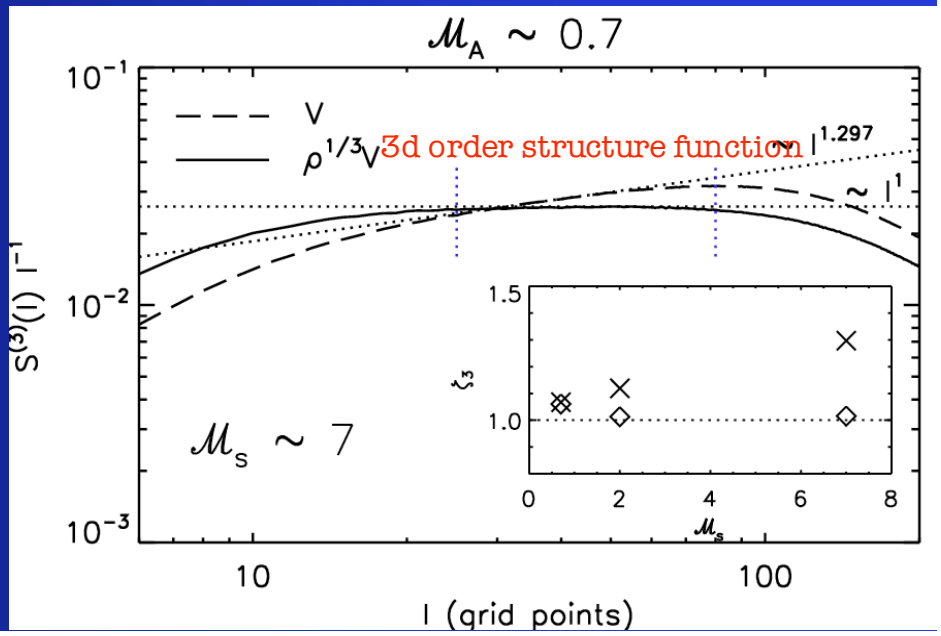
Spectrum of Compressible MHD Turbulence: Fleck 96 model

Fleck's predictions for hydro: $V_l \sim l^{1/3+\alpha}$ $\rho_l \sim l^{-3\alpha}$

Kritsuk et al. 07 used spectra of $u = \rho^{1/3} V$ *and got Kolmogorov scaling for "U" in hydro*

Kolmogorov scaling is valid in compressible MHD turbulence for modified velocity (Kowal & Lazarian 07)

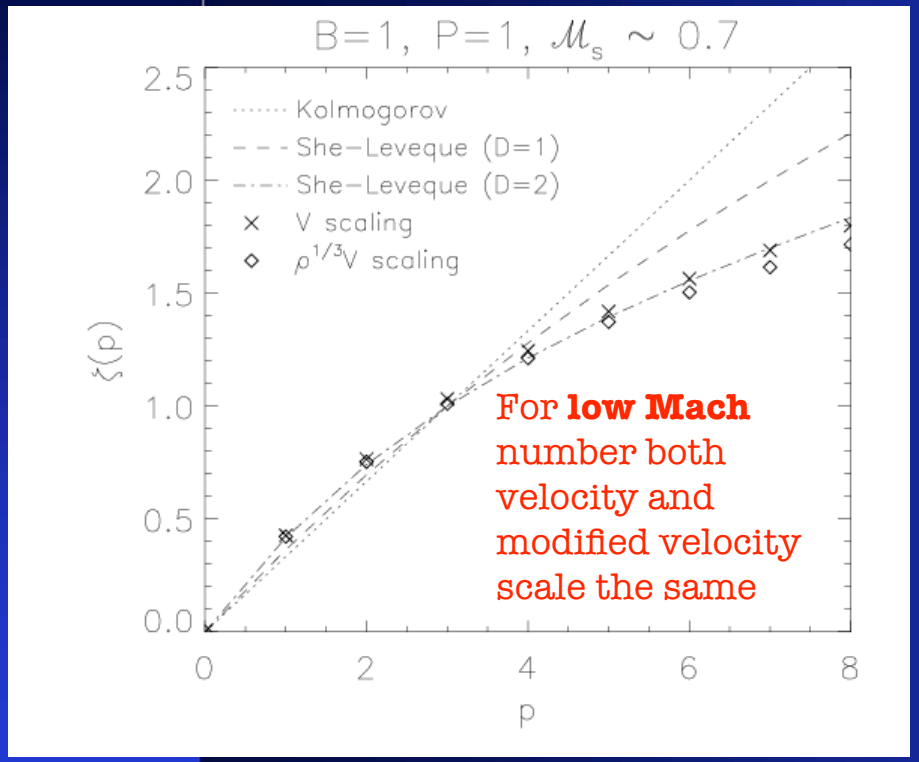


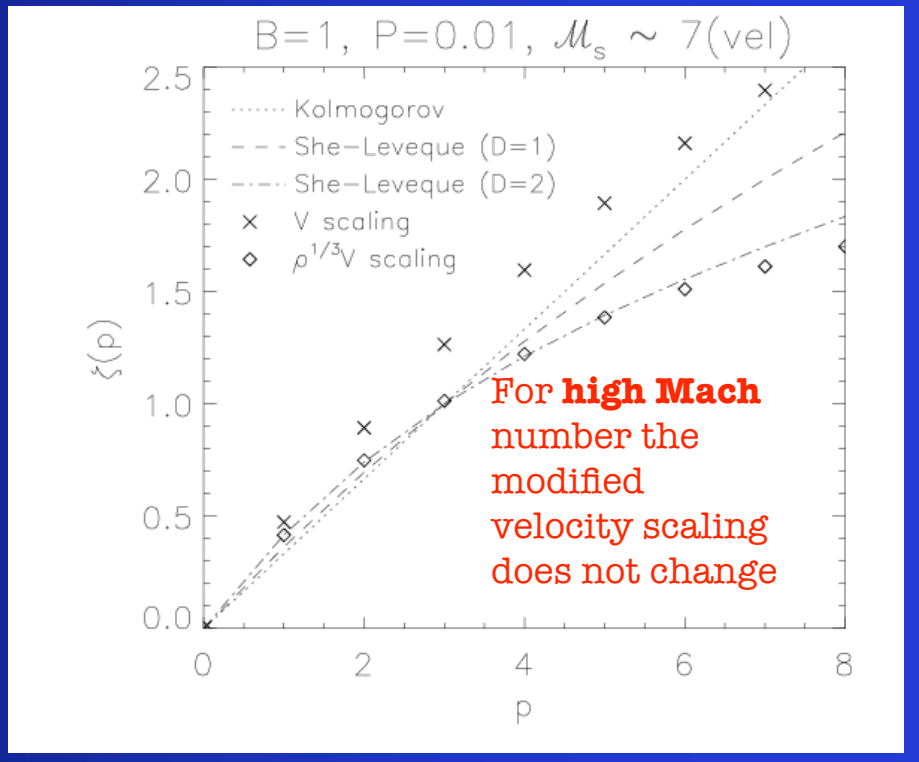


What about Other Moments in Compressible MHD?

Turbulence statistics of different orders can be described by

$$S_p(l) \equiv \langle |\mathbf{u}(\mathbf{r}) - \mathbf{u}(\mathbf{r}+\mathbf{l})|^p \rangle \sim l^{\zeta p}$$



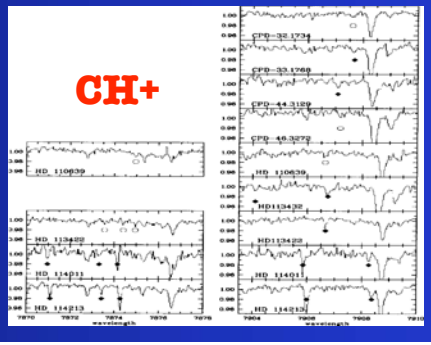


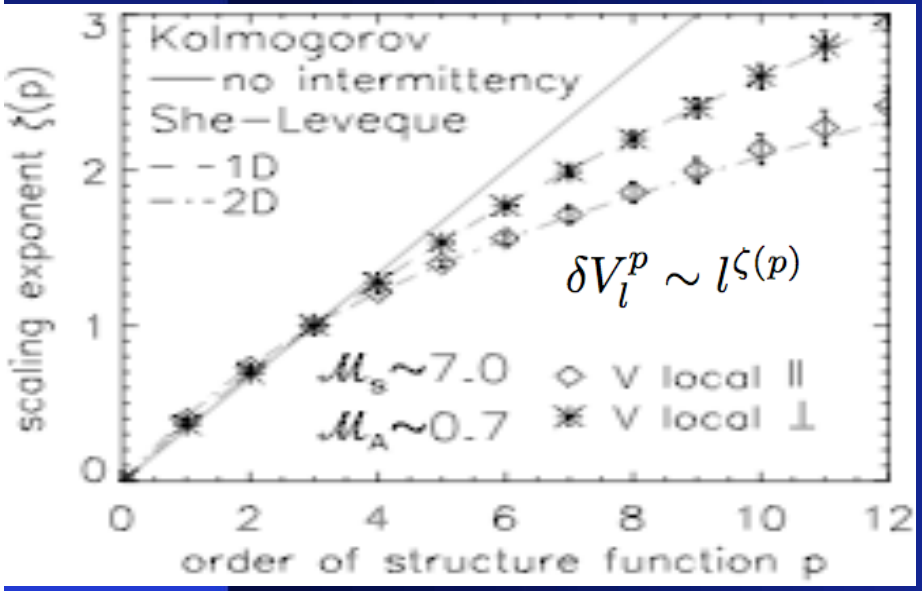
Universality holds for higher moments!

She-Leveque 94 Model of Intermittency: energy deposition

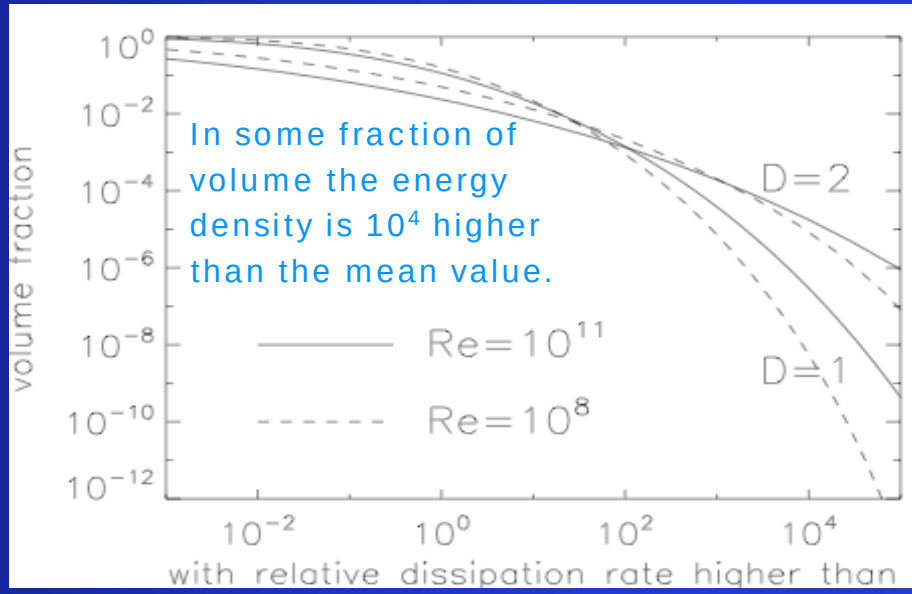
$$S_p(l) \equiv \langle |\mathbf{u}(\mathbf{r}) - \mathbf{u}(\mathbf{r}+\mathbf{l})|^p \rangle \sim l^{\zeta p}$$

Some chemical reactions may occur either in shocks or in intensive vortices. Is the latter plausible?





Kowal & Lazarian 07

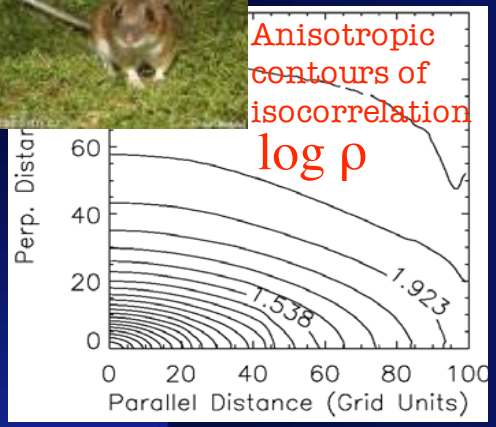


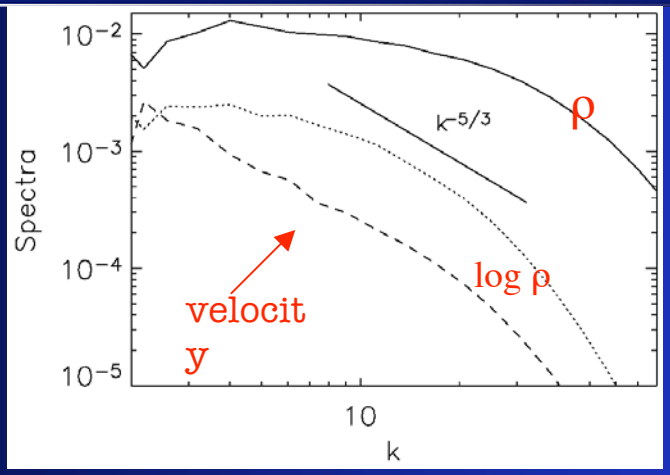
Beresnyak & Lazarian 07

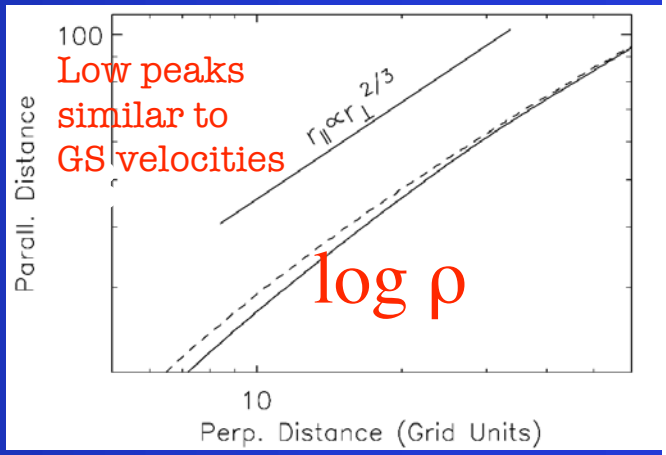
The fraction of intensive energy release is small (cf. Falgarone et al. 06)

Density in MHD Turbulence: Mice and Elephants

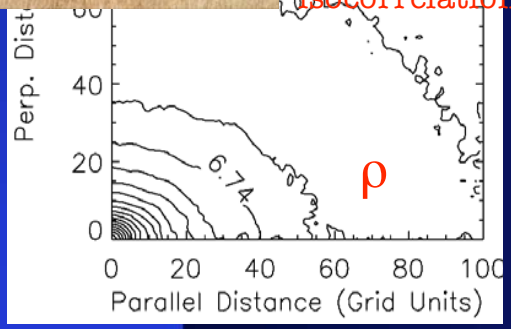
Anisotropic contours of isocorrelation log ρ





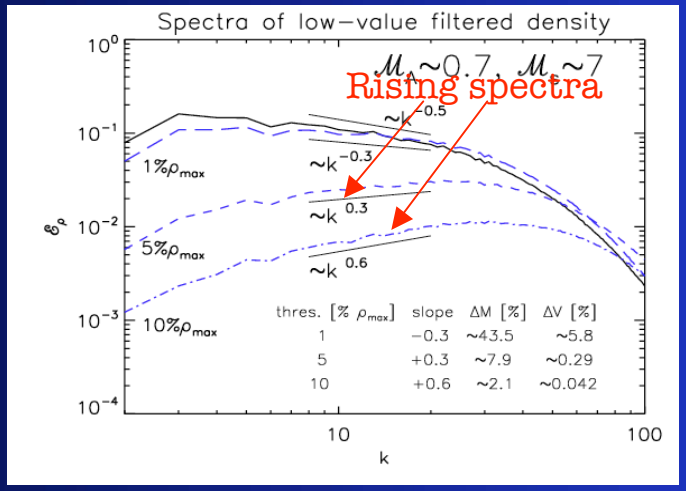


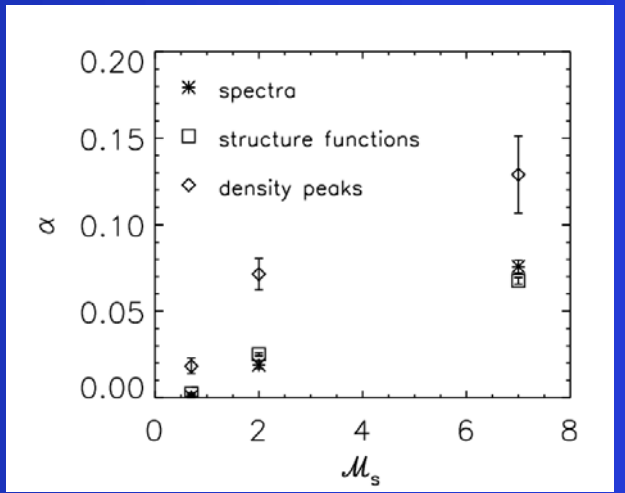
Isotropic contours of isocorrelation



Beresnyak, Lazarian & Cho 05

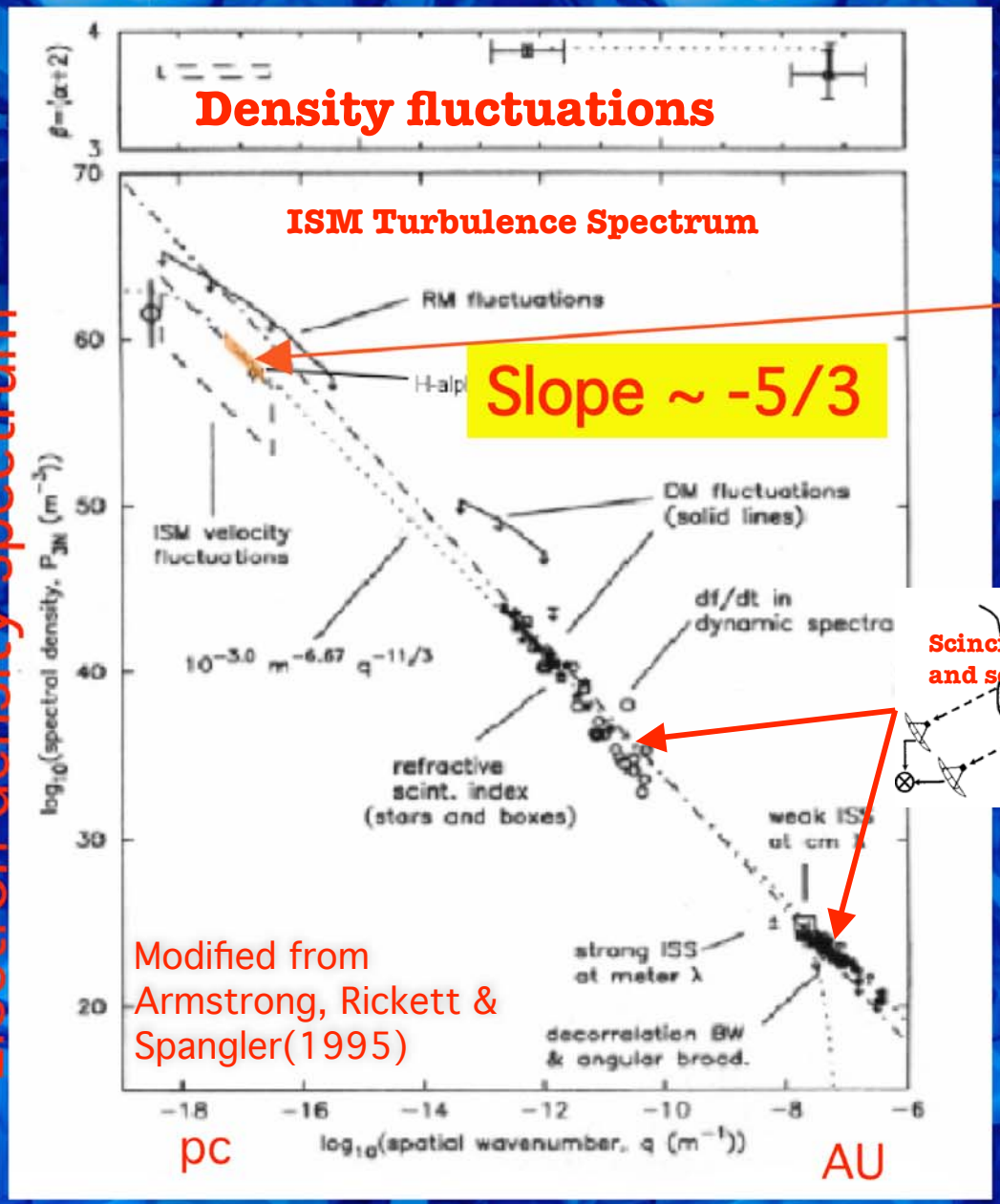
Kowal & Lazarian 07



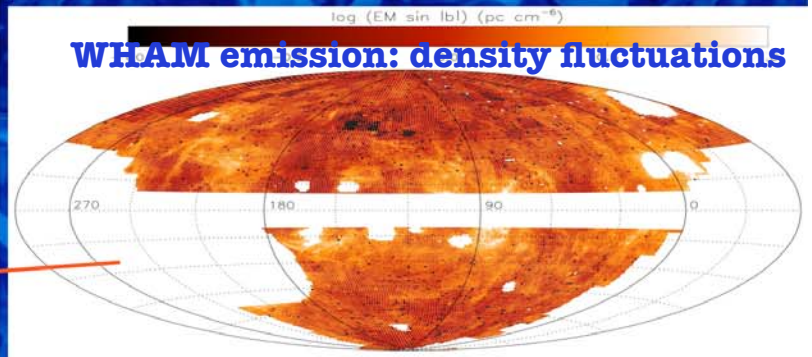


Can it explain SINS?

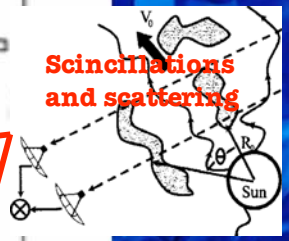
What do Observations Tell Us?



Modified from Armstrong, Rickett & Spangler(1995)



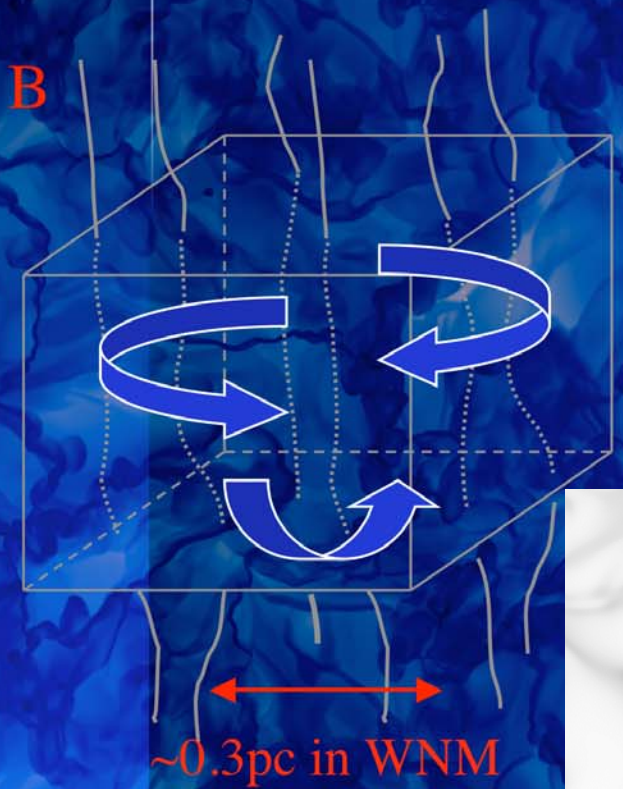
Chepurnov et al. 2007



Density fluctuations exhibit both Kolmogorov fluctuations as well as extreme scattering and absorption events

Small Ionized and Neutral Structures: SINS

Small-Scale Structures in Viscosity-Damped Turbulence

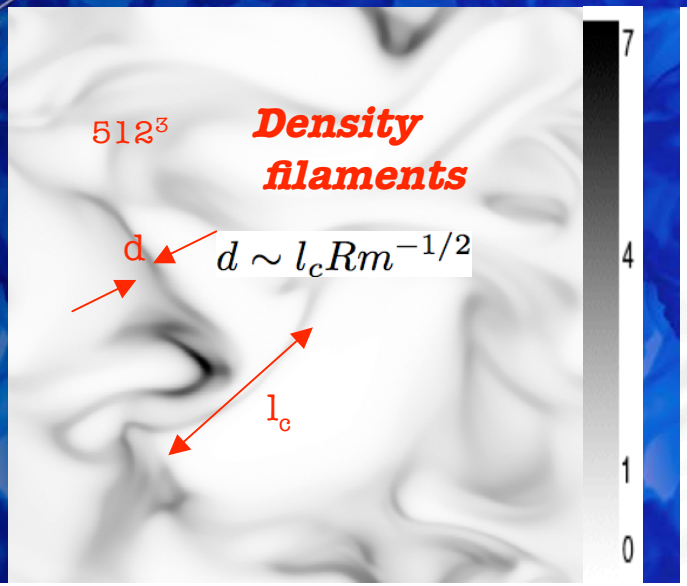


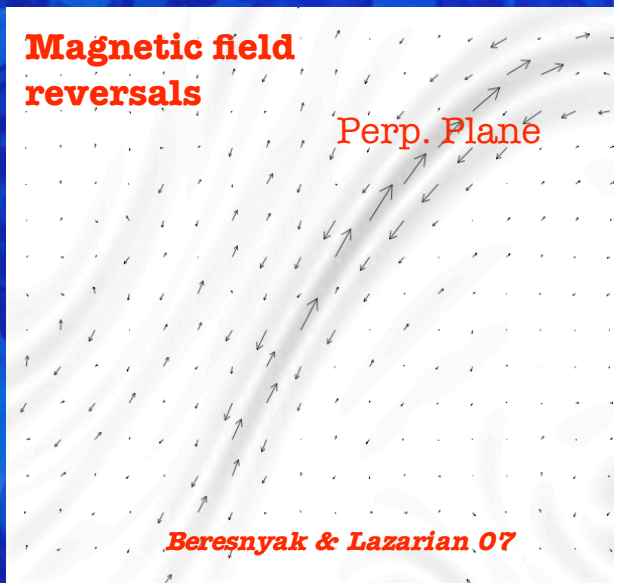
MHD turbulence does not stop at the viscous scale in partially ionized gas (Lazarian, Vishniac, Cho 04). Predict:

$E_B \sim k^{-1}$ $E_v \sim k^{-4}$

High density contrasts (Lazarian 06):

$$Pr^{5/6} Re^{5/18} \sim 10^7 (T/10^4\mathrm{K})^{5/6} Re^{5/18}$$

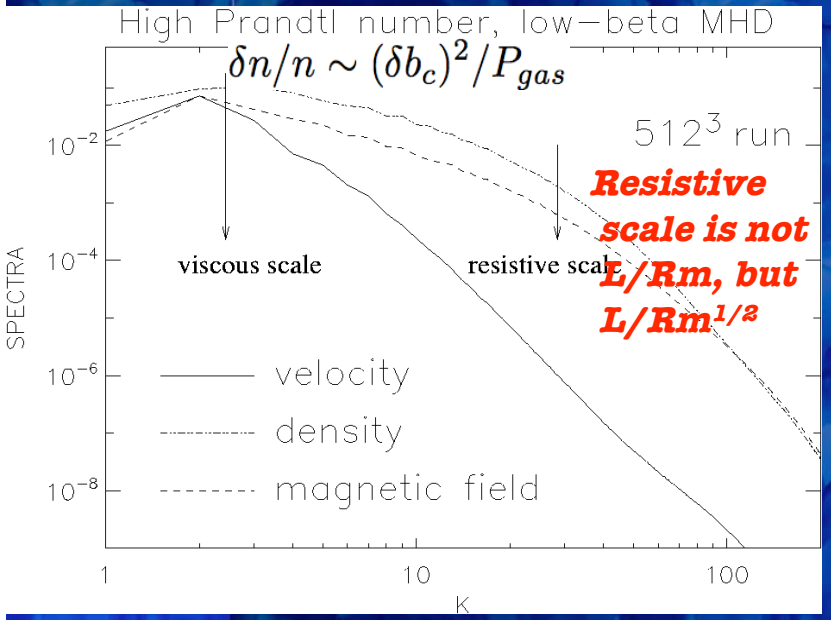




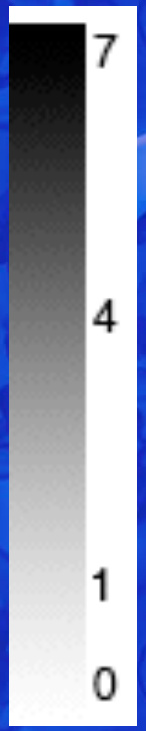
Applicable to partially ionized gas

Formation of Density Structures in Viscous Turbulent Flow

Magnetic field in viscous fluid compresses density



Beresnyak & Lazarian 07



Possible cause of SINS.