

Generating Synthetic Turbulence in Astrophysical Plasmas

Introductory Talk

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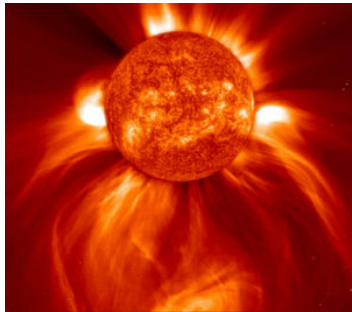
Zeuthen, 07.08.2019



Background

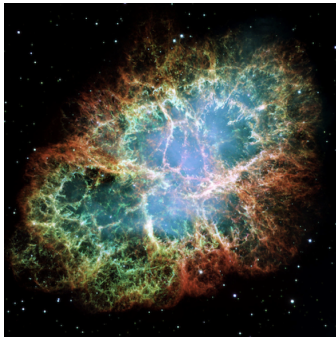
What is a Plasma?

- > Ionised volume of gas where EM forces dominate
- > Over 99.9% of observable matter is plasma (Pablo 1998)



Turbulence in Plasmas?

- > Supernovae, solar wind, turbulent accretion flows etc.
- > Cosmic Ray Scattering and Influences Solar Particles (Yan, Lazarian 2004)



Standard Method

- > Turbulence simulated by solving the incompressible MHD equations (Eyink et. al, 2013)
- > Takes 0.1-1 million CPU hours
- > Want to generate turbulence data cheaply

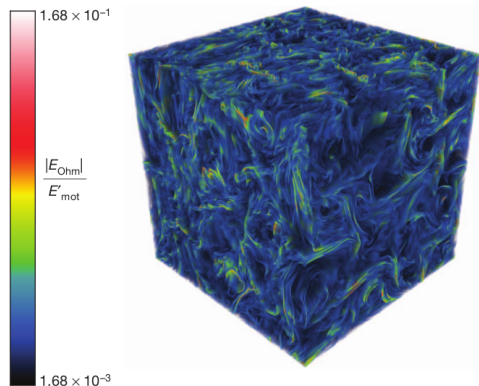


Figure: A 1024^3 point cube of the Electric Field. Colours display turbulent flow.

Theory

Two important pieces of theory describing turbulence in plasmas:

- > Kolmogorov (1941)
- > Goldreich-Sridhar (1995)

GS-95 describes a spectrum for the turbulence:

$$E = k_{\perp}^{-7/3} \exp \left(- \frac{k_{\parallel}}{k_{\perp}^{2/3}} \right), \quad (1)$$

where $E^{1/2}$ is the amplitude of the waves in the plasma in 2D implementation

Synthetic Data Methods

- > Two methods to create turbulence data according to the GS-95 Spectrum:
 - Squares
 - Displacement

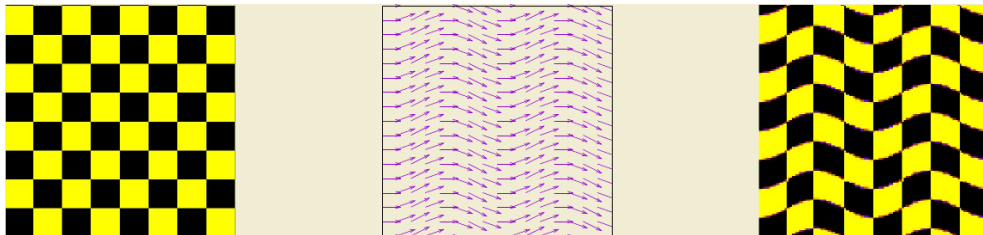
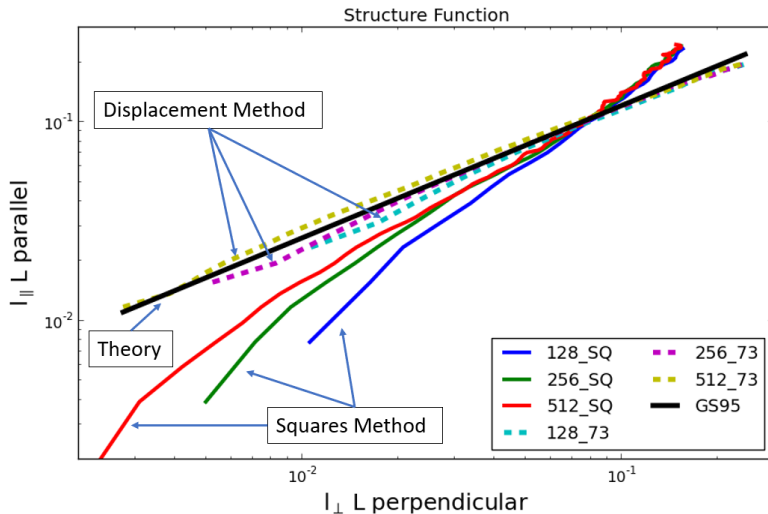


Figure: Displacement Method: Given an initial scalar field (left) and a magnetic field (centre), the scalar field should be deformed to follow the magnetic field (right)

Project Outline

- > Squares initially thought to work well for small scales
- > Displacement thought to work well for large scales
- > To make these methods work, compare and contrast
- > Try to find best method either by combining/improving
- > Implement both in 3D and parallelise

Results



Thank you!

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