2013 SHINE workshop: Session on the “Turbulent Dissipation Challenge”

Converging Ideas!!

Turbulence Challenge
Session Summary

Chadi Salem & Tulasi Parashar
Great discussion led by the 4 invited speakers

- Chuck Smith – Observational challenges
- Ben Chandran – Theoretical questions & concerns
- Jason Tenbarge – Simulations
- Homa Karimabadi – Simulations
Major difference in interpretations of data/understanding of the nature of the turbulent cascade in the inertial range.

- How much energy is in $k_{\perp}$ vs $k_{\parallel}$ at kinetic scales?
- What is the nature of fluctuations that are fed into the dissipative scales.
What is the source of controversy?

- Non-specific or contradictory analyses
  - Different data techniques conclude different things
  - Different data sets yield different results

- Non-overlapping theories and simulations
  - MHD has no plasma kinetic physics
  - Gyrokinetics has no cyclotron damping
  - Until recently, kinetic codes did not handle turbulence

- …and, of course, personalities!
<table>
<thead>
<tr>
<th>Method</th>
<th>Assumptions</th>
<th>Yields</th>
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| Bieber Analysis | 1. Taylor Approx.  
2. Specific Geometry Superset | Multi-Component Geometry                    |
| k-Telescope     | 1. Perfect Tetrahedron  
2. Single Wave per s/c freq. | Wave vector per s/c freq.                  |
| Salem Method    | 1. Single s/c  
2. Dispersion Relation | Wave vector per s/c freq.                  |
Do Linear Wave Modes Provide Guidance into Some Aspects of the Turbulent Fluctuations?

What fraction of the total dissipation power in the solar wind comes from low-frequency turbulence, and what fraction comes from high-frequency waves through, e.g., cyclotron heating?

- Depends on energy cascade and instabilities.

What kinetic mechanisms damp low-frequency turbulence at small scales?

How is the turbulent heating power divided between protons, electrons, and alphas, and between parallel and perpendicular heating?

How do proton/electron/alpha heating rates in numerical simulations compare to rates inferred on the basis of linear wave damping or (nonlinear) reconnection?

What are the quantitative measures of intermittency of fluctuations and dissipation in the solar wind and in different types of numerical simulations?

Can observations rule some mechanisms out?
Suggested to keep the first step as more of a code comparison rather than direct attack at the physics questions.
- Almost everybody in the room agreed to it.
- Argued (based on wave number couplings of 3D incompressible MHD) that 2D simulations might not be useful (other than code comparison)
  - Discussion about the issues related to the importance of Reynolds number vs out of plane couplings.
Homa claimed that 2D vs 3D is not a crucial aspect

Despite major differences in the solution in 2D vs 3D, reconnection rate and level of particle acceleration remain similar
Also emphasized the importance of inertial range physics

- The discussion led to the consensus that we modify the simulations from small boxes to large boxes with self consistent cascade to small scales (hoping to self consistently model the nature of fluctuations available for damping at kinetic scales).
Simulations for the challenge

- First simulations to emphasize the code comparison.
- The simulation setups almost the same as original:
  - Main modification is the size of the simulation box will be much bigger.
  - One simulation will have waves as initial condition (mean field in plane of simulation). Request Peter Gary to provide the details of initial conditions and parameters.
  - Second simulation will be a Kelvin-Helmholtz instability simulation (mean field out of the plane of simulation) with the same parameters as above simulation.
Action Items

- Change the emphasis to code comparison as the first step.
  - Second step would be physics comparison
- Have Peter Gary send us the detailed initial conditions for the wave damping problem.
- Homa will provide the equivalent KH condition to compare the current sheets
- Have simulators provide the login info for the AFRL computing center
- Meet at AGU to discuss preliminary results
- Provide observers with preliminary cuts through simulations.
- Get together in next SHINE to discuss the results.