Energy transfer in space plasma turbulence from multipoint measurement

F. Pecora[1], Y. Yang[1], W. H. Matthaeus[1], A. Chasapis[2], K. G. Klein[3], M. L. Stevens[4], S. Servidio[5], A. Greco[5], L. Primavera[5], D. J. Gershman[6], B. L. Giles[6] and J. L. Burch[7]

[1] *University of Delaware, Department of Physics and Astronomy, Newark, DE, United States*

[2] *Laboratory for Atmospheric and Space Physics, Boulder, CO, United States*

[3] *Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ, United States*

[4] *Smithsonian Astrophysical Observatory, Cambridge, MA, United States*

[5] *Università della Calabria, Department of Physics, Rende, Italy*

[6] *NASA Goddard Space Flight Center, Greenbelt, MD, United States*

[7] *Southwest Research Institute, San Antonio, TX, United States*

Exploration of plasma dynamics in space, including turbulence, is entering a new era of multi-satellite constellation measurements with unprecedented configurations and available number of points.

Familiar but imprecise approximations will need to be abandoned and replaced with more advanced approaches. A new technique named Lag Polyhedral Derivative Ensemble (LPDE) has been developed to measure the energy cascade rate in turbulent plasmas without employing the familiar approximations of isotropy and frozen-in flow. The technique is based on the third-order Yaglom-Politano-Pouquet theory and uses numerous increment-space tetrahedra to evaluate the energy cascade rate. We tested LPDE embedding HelioSwarm-like trajectories in isotropic and anisotropic three-dimensional magnetohydrodynamics (MHD) turbulence simulations. The application of LPDE to Magnetospheric Multiscale (MMS) mission data is supported by the exceptional agreement between the numerical HelioSwarm 9-spacecraft constellation with the exact simulation statistics. The method differs from existing approaches in that it

(i) it is inherently three-dimensional;

(ii) it provides a statistically significant number of estimates from a single data stream; and

(iii) it allows for a direct visualization of energy flux in turbulent plasmas.

This new technique will ultimately provide a realistic, comprehensive picture of the turbulence process in plasmas.