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Applying Field-Particle Correlations to Assess Turbulent Heating in the Solar Wind

Kristopher Klein (1), Gregory Howes (2), Jason TenBarge (3), Francesco Valentini (4), and Justin Kasper (1)

(1) Climate and Space Sciences, University of Michigan, Ann Arbor, United States (kriskl@umich.edu), (2) Department of Physics and Astronomy, University of Iowa, Iowa City, United States, (3) IREAP, University of Maryland, College Park, United States, (4) Dipartimento di Fisica, Universita della Calabria, Rende, Italy

Characterizing the mechanisms that drive the dissipation of turbulence and the associated heating is of significant importance to understanding the evolution of the solar wind as it is accelerated from the solar surface and expands through the heliosphere. A number of classes of mechanisms have been proposed to transfer energy between the electromagnetic fields and plasma particles, including resonant (e.g. Landau and cyclotron damping), stochastic, and intermittent (e.g. energization associated with current sheets and reconnection sites) mechanisms. We have proposed a method to trace the velocity-dependent energy transfer to and from the plasma velocity distribution using field-particle correlations constructed from single-point measurements of the type typically made in the solar wind. The velocity-dependent nature of the energization will allow for improved characterization of mechanisms which act to damp the turbulent fluctuations and heat the plasma. A derivation of the form of the correlation employed is outlined, which follows the form of the nonlinear field-particle interaction term in the Vlasov equation. The correlation is applied to increasingly complex plasma simulations, ranging from simple electrostatic to turbulent electromagnetic cases, revealing the nature of the energy transfer in each system. We finally consider the application of this method to spacecraft observations, including those from current (DSCOVR and MMS), future (Solar Probe Plus and Solar Orbiter), and proposed (THOR) missions. The single-point nature of the method is ideally suited to in situ observations of space plasmas and will help in revealing the sought after heating mechanisms.