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A Field-Particle Correlation Technique to Explore the Collisionless Damping of Plasma Turbulence[1]

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The nature of the dominant mechanisms which damp turbulent electromagnetic fluctuations remains an unanswered question in the study of a variety of collisionless plasma systems. Proposed damping mechanisms can be generally, but not exclusively, classified as resonant, e.g. Landau and cyclotron damping, non-resonant, e.g. stochastic ion heating, and intermittent, e.g. energization via current sheets or magnetic reconnection. To determine the role these mechanisms play in turbulent plasmas, we propose the application of field-particle correlations to time series of single spatial point observations of the type typically measured in the solar wind. This correlation, motivated by the form of the collisionless Vlasov equation, is the time averaged product of the factors comprising the nonlinear field-particle interaction term. The correlation both captures the secular transfer of energy between fields and perturbed plasma distributions by averaging out the conservative oscillatory energy transfer, and retains the velocity space structure of the secular transfer, allowing for observational characterization of the damping mechanism. Field-particle correlations are applied to a set of nonlinear kinetic numerical simulations of increasing complexity, including electrostatic, gyrokinetic, and hybrid Vlasov-Maxwell systems. These correlations are shown to capture the secular energy transfer between fields and particles and distinguish between the mechanisms accessible to the chosen system. We conclude with a discussion of the application of this general technique to data from current and upcoming spacecraft missions, including *MMS*, *DSCOVR*, *Solar Probe Plus* and *THOR*, which should help in determining which damping mechanisms operate in a variety of heliospheric plasmas.

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