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Scenarios for Ion Heating in Low Frequency MHD Turbulence[1]

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Dissipation of a magnetohydrodynamic cascade is of considerable interest in understanding the solar corona and solar wind, as well as in diverse circumstances in astrophysical and laboratory plasma physics. The problem is considerably complicated when the collisionality of the medium is low, due to the potential role of a variety of kinetic processes. Familiar cases such as cyclotron heating or linear Vlasov decay are typically described for homogeneous plasmas, and substantial generalizations may be required for the structured conditions that occur naturally in intermittent turbulence. A first step toward understanding dissipation is a description of the cascade, which when a large scale magnetic field is present is expected to be highly anisotropic in a way that favors perpendicular spectral transfer. Parallel cascade may not be entirely negligible however, especially through compressive channels. Perpendicular cascade gives rise to structures such as current sheets. Substantial evidence, using test particles, but recently in observations and in kinetic simulations, suggests that heating can occur due to ion interaction with these structures. In particular, perpendicular heating of ions is expected, and parallel heating of electrons. This may give rise to a two stage dissipation mechanism that first removes some energy near ion scales, and then much of the remaining energy at electron scales. Between these scales, wave energy may sometimes be enhanced due to reversible or linear kinetic processes. This perspective, while not fully explored in terms of self consistent inhomogeneous plasma physics, maybe provide a perspective on how low frequency waves can generate an MHD cascade that links ultimately to kinetic scales, where fluctuation energy vanishes in favor of increased entropy and internal energy. A number of observations are consistent with this picture.

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