Linking Collisionless Turbulent Dissipation to Kinetic Plasma Processes in Earth Magnetosheath: The Role of Magnetic Reconnection and Kinetic Micro-instabilities

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Abstract

Among the major challenges in the study of collisionless plasma turbulence is understanding which of the wide array of kinetic processes – from magnetic reconnection and stochastic acceleration in nonlinear electric fields to wave-particle resonances and kinetic micro-instabilities - are responsible for dissipating the turbulent fluctuations. The answer to this question can have consequences for how the energy dissipated through turbulence is ultimately partitioned both between different particle species and across phase space. Over the past 10 years, Magnetospheric Multiscale (MMS) has provided us with an exceptional dataset for probing the detailed kinetic structure of turbulent plasmas in our near-Earth plasma environment allowing us to begin disentangling this complex web of dissipative processes. In this work, we employ MMS data from across Earth's magnetosheath to perform a statistical examination of turbulent energy conversion associated with magnetic reconnection and kinetic micro-instabilities, as well as the relationship between the turbulent fluctuations and localized deformations to the shape of the particle distribution functions. We find that small-scale magnetic reconnection events embedded within the turbulence can account for up to 20% of the observed turbulent cascade rate in the magnetosheath and can potentially generate local anisotropic heating signatures within the turbulent plasma. Evidence of enhanced energy conversion is further found in association with kinetic temperature anisotropy instabilities for both the ions and electrons. While the net energy conversion associated with the instabilities may be minor compared to the overall energy dissipation, the observations provide evidence that such instabilities are playing an active role repartitioning energy within phase space and regulating the thermodynamics of the turbulent plasma.

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