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Collisional-like dissipation in collisionless plasma: Theory, kinetic simulations and MMS Observations

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When collisions are strong in a magnetized plasma, standard closures provide simple representations of dissipation in terms of coefficients of viscosity and resistivity. In the opposite limit of weak collisions, the same underlying physical effects that lead to dissipation are present, but the simple approximations to describe them, the closures, are not available in general [1]. But how different are these relationships when collisions are absent? We review a formalism based on the Vlasov-Maxwell equations that demonstrates the pathways of energy conversion among different forms [2,3,4]. We highlight the production of internal energy by pressure-strain and pressure-dilatation interactions. These terms can also be scale filtered to study transfer across scales. Here we inquire as to whether the collisionless case admits statistical relationships analogous to the viscous and resistive closures found in collisional plasma theory plasma. We employ kinetic PIC simulation in two and a half and three dimensions, as well as MMS observations in the magnetosheath, to examine analogous viscous-like and resistive-like scalings in the weakly collisional regime. Possible theoretical bases for these empirical relationships are discussed, pointing the way to possible closures as well as deeper understanding of the nature of collisionless dissipation.

References

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