Energy conversion through various channels in turbulent plasmas induced by the Kelvin-Helmholtz instability at the Earth's magnetopause

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Abstract
Energy conversion in collisionless plasmas is central to the plasma heating and particle energization problems in space and astrophysical plasmas. Though it is known that electromagnetic energy is converted to the flow and random kinetic energy (via J.E), a detailed understanding of how the electromagnetic energy is converted into particle energy and finally dissipated to heat is still lacking. The Kelvin-Helmholtz (KH) instability is a flow shear instability that allows plasma mixing and energy transfer. It has been inferred in remote observations such as at Orion Nebula and solar atmospheres, as well as observed in situ at planetary magnetospheric boundaries, and more recently in the solar wind. We consider energy conversion in turbulent plasmas induced by the KH instability at the Earth's magnetopause where multi-spacecraft, high-resolution observations are available. Using in situ observations from the Magnetospheric Multiscale mission, we consider the energy conversion from (1) the electromagnetic fields into the flow and (2) from the flow into thermal energy for each plasma species through the pressure work (via -P.∇.v). We find that the KH vortex regions, where the plasmas from either side of the magnetospheric boundary mix, are the key sites of energy conversion activities. Considering the accumulation of the energy conversion through various channels with time, we find that the accumulated energy conversion rate through the electromagnetic channel constantly increases. However, the accumulated energy conversion rate through the pressure work channel only increases when the KH waves reach the nonlinear stage of development. Moreover, while the energy conversion between flow and heat via -P.∇.v is very dynamic for electrons, we find that the (positive) accumulation of -P.∇.v is greater for ions which indicates a preference for turbulent dissipation into ion heating. By separating the contributions of J.E and -P.∇.v into multiple terms, we will discuss kinetic processes that are likely responsible for the energy conversion. We will also discuss the partitioning of energy conversion through the different channels for each species. This work paves the way toward an understanding of energy transfer across scales in turbulent plasmas as mediated by KH waves.