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Turbulence within the Kelvin-Helmholtz instability at Earth's magnetopause: MMS observations and comparisons with kinetic simulations

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The Kelvin-Helmholtz instability is a velocity shear driven instability that is known to occur at Earth's magnetopause. This instability can play an important role in the dynamics of the magnetosphere by facilitating the onset of magnetic reconnection and allowing for mixing of solar wind and magnetospheric plasma across the magnetopause, even during northward interplanetary magnetic field configurations. Additionally, the onset of secondary instabilities within the Kelvin-Helmholtz vortices is thought to drive turbulence. Utilising high-resolution measurements from the Magnetospheric Multiscale mission and fortuitous observations of a continuous train of Kelvin-Helmholtz vortices that lasted for over an hour, we analyse the fluctuations within the Kelvin-Helmholtz vortices focusing on the spectra of both electromagnetic field and particle variables, intermittency and third-order structure function expressions for the energy cascade rate. The observational results are quantitatively compared with hybrid simulations of plasma turbulence. Despite the simulations being driven at large scales by random Alfvénic fluctuations, and not by Kelvin-Helmholtz vortices, remarkable agreement is found between the observations and simulations, supporting the interpretation of Alfvénic turbulence within the observations. The agreement with the simulations is likely aided by the relatively short magnetohydrodynamic (MHD) scale inertial range for the Kelvin-Helmholtz turbulence, which allows the simulations to capture the largest scale of the turbulence. Even with the relatively short MHD inertial range, evidence for a cascade of energy to small-scales and intermittency well into the kinetic range are found. The results demonstrate the presence of turbulence within Kelvin-Helmholtz vortices, even at relatively early times in the development of the instability, which may have implications for plasma mixing and magnetic reconnection within the vortices, and validate the ability of hybrid simulations to accurately reproduce the behaviour of turbulence into the kinetic regime.