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Elucidation of the finite electron inertia effects in MHD scale K-H vortices

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We have performed two-fluid simulations of MHD-scale Kelvin-Helmholtz (KH) vortices in a magnetopause-like situation. When the electron mass is set to zero (Hall-MHD) the vortex behaves just as in MHD studies, in which a highly rolled up state remains rather stable. In contrast, when a finite electron mass is included, smaller vortices appear inside the main KH vortex in the highly rolled up stage. As the smaller vortices grow quickly in time and expand outward, the main vortex is destroyed.

As such, the electron inertia effects make the MHD-scale structure to decay. The striking feature of this new finding is that the size of secondary vortices is propotional to the main KH vortex and the decay process does not depend on the ratio Le/D. Where Le is the electron inertia length and D is the KH vortex size. Through a series of numerical experiments, we have shown that such a hydrodynamic scaling of the decay process can be understood by taking into account the coupling between the current sheet instability at the hyperbolic point and the velocity shear at the edge of the KH vortex surge.