Ion kinetic effects to nonlinear processes of the Kelvin-Helmholtz instability

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The nonlinear evolution of the Kelvin–Helmholtz (KH) instability at a transverse velocity shear layer in an inhomogeneous space plasma is investigated by means of a four-dimensional (two spatial and two velocity dimensions) electromagnetic Vlasov simulation. When the rotation direction of the primary KH vortex and the direction of ion gyro motion are the same (i.e. the inner product between the vorticity of the primary velocity shear and the magnetic field vector is negative) there exists a strong ion cyclotron damping. In this case, spatial inhomogeneity inside the primary KH vortex is smoothed and the secondary Rayleigh–Taylor/KH instabilities are suppressed. It is also found that another secondary instability on the electron inertial scale is simultaneously generated at secondary shear layers for both cases, but at different locations. The small-scale secondary instability takes place only when the inner product between the vorticity of the secondary shear layer and the magnetic field vector is positive, suggesting the damping of small-scale processes by ion gyro motion. These results indicate that secondary instabilities occurring in the nonlinear stage of the primary KHI show different evolutions depending on the sign of the inner product between the magnetic field and the vorticity of the velocity shear layer. The difference of the nonlinear evolution depending on the ion-to-electron mass ratio will also be discussed.