Kinetic Effects on the Kelvin-Helmholtz Instability in Ion-to-MHD Scale Transverse Velocity Shear Layers: Particle Simulation

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We have performed two-dimensional full particle simulations to systematically investigate the ion-kinetic scale and MHD-scale physics of the Kelvin-Helmholtz instability (KHI) induced in the transverse velocity shear layer. First, we found that a kinetic equilibrium of the shear layer is established in about an ion gyro-period, and that the shear layer in the equilibrium is broadened by the ion finite gyro-radius effect. This broadening occurs when its initial thickness is close to gyro-diameter of ions crossing the layer, namely, of ion-kinetic scale. The broadened thickness is larger in the negative shear ($\mathbf{B} \cdot \mathbf{\Omega}$ <0) case than in the positive shear ($\mathbf{B} \cdot \mathbf{\Omega}$ >0) case, where $\mathbf{\Omega}$ is the vorticity at the layer. This is because the convective electric field, which points out-of (into) the layer for the negative (positive) shear case, extends (reduces) the gyro-diameters. Here, note that the positive (negative) shear case corresponds to the duskside (dawnside) boundary of the Earth's and Mercury's magnetospheres under northward IMF conditions. Next, we found that the KHI linear growth rate depends on not the initial shear layer thickness but the broadened thickness, since the kinetic equilibrium and associated shear layer broadening are accomplished before the KHI onset. These results strongly imply that a clear dawn-dusk asymmetry of the wavelength of the fastest KH mode, which depends on the shear layer thickness, is expected to appear only in Mercury-like ion kinetic-scale situations.