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The coalescence of MHD-scale Kelvin-Helmholtz vortices; Two-dimensional two-fluid simulations including finite electron inertia

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The Kelvin-Helmholtz instability (KHI) has been considered as one of the most important processes in space plasma system involving shear flow. In understanding the structure of an MHD-scale KHI in the non-linear stage, the coalescence of KH vortices should not be neglected. In this study, we show the new results that the coalescence process of KH vortices is affected largely by in-the-plane magnetic component.

When MA$>$5, KHI grows as a highly rolled-up vortex overcoming in-the-plane magnetic field tension. Here, MA is the Alfven Mach number of the velocity jump for in-the-plane magnetic field. In this situation, multiple highly rolled-up vortices coalesce into larger vortices. In addition, since in-plane magnetic tension suppresses such coalescences, there is a threshold in the degree of swelling of the vortex.

On the other hand, when (2$<$)MA$<$5, KHI is too weak to produce a highly rolled-up vortex. In this situation, although KHI alone can not lead to coalescence of vortices, only in the cases in which in-the-plane magnetic component is anti-parallel across the shear layer (the anti-parallel case) there is coalescence of KH vortices; In this case, magnetic reconnection induced by the flow of KHI assists the KHI to grow as a highly rolled-up state. The magnetic structure of the rolled-up vortex is same as that of the magnetic island and rolled-up vortices can coalesce just like the coalescence of magnetic islands. In addition, since in-plane magnetic field does not suppress the coalescence of magnetic islands, there is no threshold in the degree of swelling of the vortex.