Hybrid Simulation of K-H Turbulence in the Presence of Flow

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We study the effect of inhomogeneous flow on the Kelvin-Helmholz instability and turbulence. The inhomogeneous flow includes both flow shear and flow curvature. The effect of flow curvature (second radial derivative of flow) is shown to have significant effect in controlling the turbulence level contrary to the usual prediction that flow shear (first radial derivative of flow) alone controls the turbulence level. The detail result of this simulation will be reported.

In this study of flow curvature effects, a two-dimensional hybrid model is used to simulate the Kelvin-Helmholtz instability (KHI). The hybrid model treats the ions as particles, and electrons as massless fluid. Pressure and resistivity are assumed as isotropic. A classical configuration for the study of KHI is investigated, i.e. transverse shear flow to uniform background magnetic field. This is thought as the most unstable situation in magnetohydrodynamic (MHD) theory. There are 50 super particles per cell in the current simulations, which number could be increased to as much as 200 in the future. The boundary is periodic along the flow direction and reflective in the perpendicular direction. The code was originally developed by the Los Alamos National Laboratory and has been successfully applied to the study of Kelvin-Helmholtz instability on the Earth's magnetopause. In this study, the code has been running on the Advanced Research Computing (ARC) platforms of Virginia Tech.

Four distinct shear profiles are simulated to investigate the effects of flow curvature on the growth of the KH instability: uniform flow, linear shear without curvature, quadratic profile with positive curvature, and quadratic profile with negative curvature.

By comparing plasma flows from the four simulations with the same amount of time of evolvement, it is visible that the KH vortex is most nonlinearly developed in the case of negative curvature. In the case of linear shear, the vortex is less developed, but coalesce of two adjacent vortices is about to occur. Two vortices can also be seen in the case of positive curvature. The uniform flow basically keeps stable.

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