Numerical simulations of the Kelvin-Helmholtz instability development in a bounded supersonic plasma flow

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In the frame of a semi-infinite flow model, the supersonic flows $M_S \equiv U / C_S > 2$ (U_0 – the flow speed, C_S – the ion sound speed) are well known to be stable (Miura & Pritchett 1982). However, the semi-infinite flow model is an appropriate approximation only of the oscillations with the wave length shorter than the flow thickness. Thus, in order to investigate the stability of the long wave oscillations, one has to allow for the finite thickness of the flow.

We have carried out a linear stability analysis of the flow of a finite thickness using two models: a three-layered slab flow model (Burinskaya et. al. 2011), and a cylindrical flow model (Shevelev & Burinskaya 2011). In both cases we have proved for the K-H instability to grow for a sufficiently large sound Mach numbers, $M_S \gg 2$.

Our recent studies are concentrated on a nonlinear evolution of the K-H instability. The process of a vortices formation is of a great importance in a momentum and density transport from the flow to the surrounding medium. To simulate evolution of the MHD K-H instability we have implemented a numerical algorithm based on HLL-like (Harten et al. 1983) scheme to calculate monotonic and high-resolution flux approximations and flux-corrected transport (FCT) approach (Zalesak 1979, DeVore 1998) to result in TVD close monotonic high-order scheme. Simple and robust computational code has given us an opportunity to examine the nonlinear stage of the K-H instability development initiated from the periodic perturbations or pure noise. We have accomplished a series of numerical simulation for the slab flow in a longitudinal magnetic field to study the K-H nonlinear dynamics.

References

Burinskaya T.M., Shevelev M.M., and Rauch J.-L., *Kelvin-Helmholtz Instability for a Bounded Plasma Flow in a Logitudinal Magnetic Field*, Plasma Physics Reports, v.37, pp. 43-55, 2011

DeVore C.R., *An Improved Limiter for Multidimensional Flux-Corrected Transport*, Naval Research Lab. Reports, No. 6440-98-8330, 1998

Grigorenko E.E., Burinskaya T.M., Shevelev M.M., Sauvaud J.-A., Zelenyi L.M., *Large-scale fluctuations of PSBL magnetic flux tubes induced by the field-aligned motion of highly accelerated ions*, Ann. Geophys, v.28, pp. 1273-1288, 2010

Harten A., Lax P.D., and van Leer B., *On Upstream Differencing and Godunov-type Schemes for Hyperbolic Conservation Laws*, SIAM Rev., v.25, pp.35-61, 1983

Miura A., and Pritchett P.L., *Nonlocal stability analysis of the MHD Kelvin-Helmholtz instability in a compressible plasma*, J. Gophys. Res., v.87, pp.7431-7444, 1983

Shevelev M.M., and Burinskaya T.M., *Kelvin-Helmholtz Instability of a Cylindrical Plasma Flow with an Arbitraty Temperature, Plasma Physics Reports*, v.37, pp. 1006-1019, 2011

Zalesak S.T., *Fully Multidimensional Fux-Corrected Transport Algorithms for Fluids*, JCP, v.31, pp.335-362, 1979