Kelvin-Helmholtz instability and vortices around unmagnetized planets: A numerical simulation

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Abstract

Results of 2D nonlinear numerical simulations of the magnetohydrodynamic Kelvin-Helmholtz instability are presented. We assume a boundary layer of a certain width, which separates the plasma in the upper from the plasma in the lower layer. Such a configuration is similar to the situation around unmagnetized planets, where the solar wind (upper plasma layer) streams along the ionosphere (lower plasma layer). At unmagnetized planets, the mass density increases toward the planet. We investigate the influence of a density increase toward the planet on the development and evolution of the Kelvin-Helmholtz instability and vortices.

The evolution of the Kelvin-Helmholtz instability can be divided into three different phases, namely a linear growth phase at the beginning, followed by a nonlinear phase with regular structures of the vortices and, finally, a turbulent phase with nonregular structures (see Figure 1 for an example).

The Kelvin-Helmholtz instability has been discussed as a loss process for ionospheric particles. The idea of the process is the following: Small perturbations on the boundary grow to waves, which eventually reach the nonlinear stage on their way along the boundary from the subsolar point to the terminator. Around the terminator, the evolved vortices might detach and form plasma clouds consisting of planetary ions. In this study, we address the question if the perturbations can reach the nonlinear phase, i.e. evolve into vortices, on their way along the boundary to the terminator and what spatial scales are involved. Furthermore, we roughly estimate the loss rate thought to emanate from the process of plasma cloud formation.
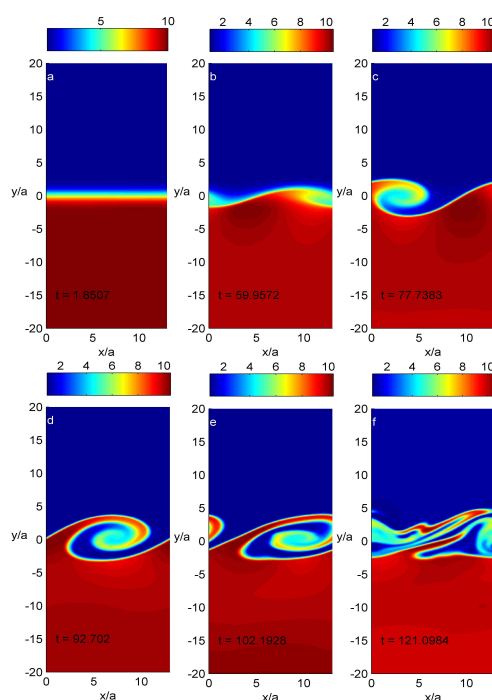

Figure 1: Time series of the density for an exemplary case.

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