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Current sheet collapse and reconnection at ion-inertia scale

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The neutral current sheet model of substorms in the near-Earth space and in other astrophysical environments provides a coherent picture of how the stored magnetic energy is converted to the fast plasma flows and high-energy particles. Merging of the opposite magnetic field lines is thought to be responsible for the fast and efficient energy release. However, the triggering of such events, and the mechanism of collisionless reconnection remain a challenging and fundamental issues. In the last decade it became evident that for the Earth magnetosphere the ion inertia scale of several hundred km and a whistler dynamics associated with it play a crucial role. Extensive numerical studies based on various plasma models [1] revealed that non-ideal Hall term in the Ohm's law which describes decoupling of electron fluid from ions opens up a number of new processes that remained beyond the classic MHD approach.

In the present work reconnection physics at ion-inertia scale is analyzed in Electron Magneto-Hydro-Dynamics frame. A new class of collapse-like solutions is demonstrated. It describes an intense current embedded into the equilibrium sheet which, being driven by in-plane Hall currents, collapses at the neutral line [2]. Evolution ends by a fast and disruptive restructuring of current sheet from a stretched X-line to a typical X-point configuration. At electron-skin scale a static reconnection solution describing the structure of fields and currents near X-point is derived. It explicitly demonstrates how collisionless reconnection might work without any kinetic effects. A role of collisions is investigated as well. Obtained relation shows that even exceedingly low collision rates of space plasmas are enough to restrict maximum current density by quite finite albeit large values.

Analysis is carried out treating ions as immobile. For the non-linear solutions a local approximation is employed as well. Because this and other approximations used

to derive analytical solutions are not strictly justified, obtained results are verified by a direct comparison with a two-fluid 2D numerical simulation. The designed code is able to encompass a really large, up to five orders of magnitude, range of spatial scales. In the numerical simulation a response of equilibrium system to the boundary perturbation is investigated. It shows triggering of the collapse process and formation of the X-point which supports a global quasi-steady reconnection pattern. Characteristic spatial and time scales, current and field structures are found to be in a good agreement with analytical solutions.

1. J. Birn et al *Geophys. Res. Lett.* **32**, L06105 (2005)
2. I. F. Shaikhislamov *Plasma Phys. Controlled Fusion* **47,** 1 (2005)