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Vlasov simulations of magnetic field-aligned potential drops

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In the auroral zone, electrostatic fields that are parallel to Earth's magnetic field are known to exist and to contribute to the acceleration of auroral electrons. Parallel electric fields can be supported by the magnetic mirror field, creating potential drops extending over great distances (*Alfvén and Fälthammar*, Cosmical Electrodynamics, 2nd ed., 1963).

The current-voltage characteristics of the auroral current circuit was studied by *Knight* (Planet. and Space Sci., vol. 21, 741-750, 1973) using a stationary kinetic model. Later, fluid and hybrid models have been used in the study of potential drops and of Alfvén waves and their relation to the formation of potential drops (*e.g., Vedin and Rönnmark*, JGR, vol. 111, 12201, 2006).

Recent observations have shown that field-aligned potential drops often are concentrated in electric double layers (*e.g. Ergun, et al.*, Phys. Plasmas, vol. 9, 3685-3694, 2002). Vlasov simulations of the part of the flux tube where most of the auroral acceleration takes place have recently been performed (*Main, et al.*, PRL, vol. 97, 185001, 2006).

We present results from Vlasov simulations using a model that is one-dimensional in configuration space and two-dimensional in velocity space. We verify the model by comparison with a double layer experiment in the laboratory, and the model is then applied to the auroral field lines.

A flux tube is modelled from the equator to the ionosphere. The spatial grid is non-uniform, finer close to the ionoshere and coarser near the equator, in order to improve computational efficiency. We can run the simulation on a coarser spatial grid and with a longer time step by introducing a relative dielectric constant ϵ_r such that $\epsilon = \epsilon_0 \epsilon_r$, because $\lambda_D \sim \sqrt{\epsilon_r}$ and $\omega_p \sim 1/\sqrt{\epsilon_r}$ (*Rönnmark and Hamrin*, JGR, vol. 105, 25333–25344, 2000). We start with a large ϵ_r value, filling the simulation region with plasma from the ends. We then conduct a series of simulation runs, successively decreasing ϵ_r toward realistic values. Thus, we arrive at a solution, without relying on assumptions about the distribution function in the interior of the simulation region.