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Vlasov simulations of auroral flux tubes

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Electric fields that are parallel to the earth's magnetic field are known to exist in the auroral zone, where they contribute to the acceleration of auroral electrons. Thus, parallel electric fields form an integral part of the auroral current circuit. Transverse electric fields at high altitude result in parallel electric fields as a consequence of the closure of the field-aligned currents through the conducting ionosphere (*L. R. Lyons*, JGR, vol. 85, 1724, 1980). These parallel electric fields can be supported by the magnetic mirror field (*Alfvén and Fälthammar*, Cosmical Electrodynamics, 2nd ed., 1963).

The current-voltage characteristics of an auroral flux tube has been studied using stationary kinetic models (*Knight*, Planet. and Space Sci., vol. 21, 741-750, 1973). 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). In the upward current region, 20-50% of the total potential drop has been identified as localised. How the rest of the potential is spread out as function of altitude is not yet known from observations (*Ergun et al.*, J. Geophys. Res., vol. 109, A12220, doi:101.1029/2004JA010545, 2004).

We have performed Vlasov simulations, using a model that is one-dimensional in configuration space and two-dimensional in velocity space. In the upward current region, most of the potential drop is found in a thin, stationary, double layer. The rest is in a region, which extends a few earth radii above it. The current-voltage characteristic approximately follows the Knight relation. The altitude of the double layer decreases with an increasing field-aligned potential drop.

In the downward current region, the voltage is significantly lower than in the upward current region for the same value of the current. Double layers have been observed also in the downward current region (*Andersson et al.*, Phys. Plasmas, vol. 9, 3600–3609, doi:10.1063/1.1490134, 2002). It has been shown that the double layer position is stationary only when electrons are accelerated into the stronger magnetic field (*Song et al.*, Physica Scripta, vol. 45, 395–398, doi:10.1088/0031-8949/45/4/019, 1992), whereas in the downward current region the polarity of the voltage is such as to accelerate electrons towards weaker magnetic fields. We use Vlasov simulations to follow the motion of the double layer in this region and to examine the current-voltage relationship.