Vlasov simulations of auroral processes
Herbert Gunell¹, Johan De Keyser¹, and Ingrid Mann²,³

¹Belgian Institute for Space Aeronomy, Avenue Circulaire 3, B-1180 Brussels, Belgium
²Eiscat Scientific Association, P. O. Box 812, SE-981 28 Kiruna, Sweden
³Umeå University, SE-901 87 Umeå, Sweden
herbert.gunell@physics.org

Geometry
We model an auroral flux tube from a source at the magnetospheric equator to the ionosphere, as is illustrated in Fig. 1a. Our model applies to the centre of the arc, where the electric and magnetic fields are parallel. Off centre, the perpendicular electric field component causes plasma to drift along the arc with a drift velocity \(v_D = B \times E / B^2\) (Fig. 1b), and therefore our model is valid in the drift frame. In that frame \(E_z = 0\). Satellite crossings of the auroral cavity show that \(E_z\) field falls in thin layers at the edges of the cavity with small or zero field inside (Hall et al., 2003).

Upward current region
An example of distributions and fields is shown in Fig. 2 for the case when 3 kV was applied over the system. An electric double layer forms near \(z = 5 \times 10^3\) m, and electrons are trapped between it and the magnetic mirror.

Downward current region
We applied 100 V over a flux tube, with a polarity that would lead to upward acceleration of electrons. A discharge source on the left hand side represents the magnetosphere, and a Q-machine source on the right hand side corresponds to the ionosphere (Gunell et al., 2003b). The mirror ratio is 25.

Simulated experiments
We have run computer simulations of a proposed laboratory experiment that could be used to model auroral acceleration. A discharge source on the left hand side represents the magnetosphere, and a Q-machine source on the right hand side corresponds to the ionosphere (Gunell et al., 2003b). The mirror ratio is 25.

Conclusions
• We use a 14D electrostatic Vlasov simulation code to study the physics of auroral flux tubes Gunell et al. (2003a).
• For an example of the simulation program is available at http://www.herbertgunell.se/software.php.

In the upward current region, a stable and stationary double layer is formed by the majority of the voltage, and the current-voltage relation approximately follows the Knight relation.

• Electrons are trapped during the formation of the potential profiles.
• Also in the downward current region double layers form. These are non-stationary, moving towards higher altitudes (cf. Song et al., 1992).

• Similar to observations in the downward current region [Anderson et al., 2002] waves are seen near the double layer, and there are electron holes on the high potential side of the double layers.

• The voltage in the downward current region is much smaller than that in the upward current region when these carry the same current, even when the density of the ionosphere is reduced.

• It is possible to simulate auroral flux tubes in the laboratory, using a discharge source and a Q-machine source to model the magnetosphere and the ionosphere. Ion acoustic waves are more prominent in the experiment due to the low temperature of the ions from the discharge.

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References
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