Tutorial on High Latitude Electrodynamics

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Outline

1. Definition of High Latitude Electrodynamics
2. Generation of High Latitude Electric Fields
3. High Latitude Current Systems
   1. Pedersen Currents
   2. Hall Currents
   3. Field Aligned Currents
4. List of Measurement Techniques
In space physics, we define high latitudes as those regions including and poleward of the auroral zone.
In this talk, we are especially interested in the E region ionosphere (90 – 120 km).
In electrodynamics, we study changing electric fields, currents, and conductivities. Here we look at one form of Ohm’s law.

We are going to look at conductivities and electric fields in the high-latitude ionosphere in order to learn something about the current systems that you can find there.
Sun
1. UV Radiation
2. SW Electrons and Ions
3. IMF for Energy Coupling

Earth
1. Internal Magnetic Field - Magnetosphere
2. Neutral Atmosphere
Start by looking at convection... a process that generates $E$. 
DRIVES Ionospheric Convection
These streamlines represent the motion of the footprints of the magnetospheric convection AND the motion of the plasma. In the ionospheric region, the ions and electrons of the plasma are pulled along by the motion of the field lines.
Vortical convection separates the electrons from the ions, and creates a polarization electric field which points to negative charges.
Vortical convection separates the electrons from the ions, and creates a polarization electric field which points to negative charges.
Conductivity is a tensor... the conductivity does not behave the same in all directions. Contrast to block of copper.

It is easiest to look at the conductivities and currents when they are organized relative to magnetic field direction.
Current Systems

Field-Aligned (Birkeland) Currents
Pedersen currents
Hall currents

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Pedersen currents are strongest near 125 km altitude.
Pedersen Currents

\[ J_p = \sigma_p E_\perp \]

- Flows in the direction of the electric field that is perpendicular to the magnetic field.
- Created by the acceleration of ions and electrons after a collision (Feels \( F = qE \)).

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Hall Currents are strongest near 105 km altitude.

\[ J_H = \sigma_H \mathbf{B} \times \mathbf{E}_\perp \]

- Flows perpendicular to both electric and magnetic fields in the opposite direction of the plasma flow.
- Created by uneven response to the \( \mathbf{E} \times \mathbf{B} \) drift. (Ions are big, collide with neutrals, therefore go slower than electrons.)

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Electrojets (Hall Currents)

Also, auroral precipitation enhances conductivity and creates the “Auroral Electrojet.”

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Field-Aligned Currents

\[ J_\parallel = \sigma_\parallel E_\parallel B \]

Observed During Southward IMF

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Currents flow along field lines. Pedersen currents are strongest near 125 km altitude. Hall Currents are strongest near 105 km altitude.

PC Index - The PC-index has been introduced by Troshichev et al. [1979, 1988] as an index for monitoring geomagnetic activity over the polar caps caused by changes in the interplanetary magnetic field (IMF) and solar wind.

AMIE - Assimilative Mapping of Ionospheric Electrodynamosics
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Thank you!
Questions?

Recap of Outline:
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