

EVOLUTION OF ELECTRIC FIELDS IN THE AURORAL RETURN CURRENT REGION OBSERVED BY CLUSTER NEAR PERIGEE

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EVOLUTION OF ELECTRIC FIELDS ACCELERATING ELECTRONS AWAY FROM THE AURORAL IONOSPHERE

What is new?

Auroral crossings by Cluster at high altitude ($4.4 R_E$) -- when the s/c were aligned like pearls-on-a-string -- have allowed the first detailed studies of the temporal evolution of electric potential structures that accelerate electrons away from the auroral ionosphere.

Why Cluster?

To reveal the nature of such acceleration structures it is necessary to understand their temporal behavior, which cannot be resolved from single satellite measurements (e.g. Freja, Polar, FAST).

Time-scale of evolution

The time-scale of evolution (a few 100 seconds) is similar to formation time of ionospheric density holes caused by the upward escape of electrons indicating a close relationship

Auroral Return Current - Density Holes - Black Aurora

The upward escaping electrons: 1) carry the return current; 2) produce density holes and sometimes 3) the optical phenomenon Black Aurora, like a photographic negative of the aurora

Possible impact on the discrete aurora

A common current system links the downward return current with the upward current of the aurora. The evolution of the ionospheric density hole and acceleration structure above it represents a growing load in the downward leg of the auroral current circuit with possible impact on the visible aurora

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WHAT DRIVES THE AURORA?

Earth's Shield

The Earth's magnetic field forms a giant shield to the solar wind particles (mostly protons & electrons) that stream through the solar system at supersonic velocities (300 km/s)

'Solar Windmill'

Part of the kinetic energy of the solar wind particles impinging on Earth's magnetosphere, is transformed into electrical energy, driving currents in the power lines (geomagnetic field lines) down to Earth's polar ionosphere

Currents flowing into / away from Earth

Currents flowing into Earth must be balanced by currents flowing away from Earth. This applies to large-scale (auroral oval) as well as to small-scale (auroral arc) current systems

Auroral Current Circuit

Driven by an external generator and consists of an upward and a downward current (connected to the aurora and black aurora, respectively) closed in the ionosphere by a horizontal ion current.

Aurora a Universal Phenomenon

Occurs on magnetized planets with an atmosphere, such as on Jupiter, Saturn, Uranus

Everyday Analogy

The aurora, caused by high-energy electrons impinging on the upper atmosphere, can be compared with TV-pictures generated by electron beams hitting the TV-screen.

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SUMMARY

- ; A positive electric potential structure is detected by Cluster in conjunction with upward accelerated electrons at the border between two different plasma source regions
- ; The increase in the electric potential agrees with the energy increase of the electrons; the evidence is a positive U-shaped potential structure increasing in magnitude & width
- ; The total downward current associated with the structure remains constant, but the current sheet widens to enable collection of current carriers over a larger area
- ; The time scale of the evolution, a few 100 s, is similar to the evacuation time of ionospheric electrons, forming a growing load in the downward leg of the auroral current circuit with possible impacts on the aurora
- ; Cluster observations from other events showing the same features provide further support of these findings

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	<u>Aurora</u>	<u>Black Aurora</u>
occurs in a region of	upward current	downward current
carried by	downward electrons	upward electrons
originating from the	magnetosphere	ionosphere
accelerated by an	upward electric field	downward electric field
at altitudes	5000-8000 km	1500-3000 km
associated with a	negative electric potential structure	positive electric potential structure
producing in the ionosphere	electron density enhancements	electron density holes
and visible	auroras	black aurora
linked by	a common auroral current circuit driven by an external generator	

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