Physics of multi-step Hall effect in the nonuniform and anisotropically conducting Ionosphere

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In the Earth's ionosphere, nonuniform and anisotoropic electroconductivity distribution causes strongly complex but organized current system by the incidence of electric fields from magnetosphere and atmospheric dynamo origins. Total current distribution is determined by generation of polarization and inductive electric fields to satisfy the current conservation law total with generation of secondary currents.

Peculiarities of the Earth's ionospheric current system come from the existence of Hall effect. As in the same context as semiconductors, Hall voltages are generated by breaking of Hall current continuity and charge accumulation at the boundary regions. Secondary Hall current generated by this Hall voltage flows in the same direction of the primary Ohmic current, which is directly driven by the primary electric field (we call it Pedersen current). In the aurora regions, this secondary Hall current is enhanced several times by the primary Pedersen current, and by connecting to the field-aligned current system, it perhaps triggers sudden release of electromagnetic energy stored in the night-side magnetosphere (aurora substorm).

Furthermore, in the Earth's ionosphere, divergent type electric fields are incident on the ionosphere from the magnetosphere with field aligned-current, which generate source-free Hall current. When this divergent electric field is varying, Hall voltage is generated as inverse electromotive force for this source free Hall current changing. Secondary Hall current generated by this inverse electromotive force flows in divergent direction and is connected to the field aligned current system, and then absorb electromagnetic energy for being of source-free current in the ionosphere.

In this paper, we will discuss about such multi-step Hall effects: it is a quite general mechanism to realizing mode converted current system by the primary Hall effect.