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The role of the ring current in the Dungey cycle from the point of view of Stokes' theorem

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The well-known Dungey model of the solar wind - magnetosphere interaction has been revised to take into account the essentially non-stationary effects of magnetic reconnection. For this purpose we used the so-called magnetic contour method.

The magnetic contour is the following. A segment perpendicular to the magnetic field lines is chosen in the magnetosphere, and a field line is launched from each point of it until it intersects with the ionosphere, first at time t, and then at time (t+dt). The Stokes theorem is applied to the moving contour constructed in this way, which claims that the electromotive force (EMF) along the magnetospheric segment differs from the EMF along the projection of this segment in the ionosphere by the magnitude of the magnetic flux drawn by the moving projection during the time (dt).

Knowing the behavior of the projection of a segment in the ionosphere, which often manifests itself in the form of a moving arc, it is possible to obtain the distribution of the electric field in the magnetosphere. It is shown that in the zone of the developing Birkeland current loop of a substorm, a powerful electric field with an effective potential difference of several tens of kV is generated. Therefore, the arising Birkeland current loop of a substorm is the central element in the magnetosphere, responsible for the acceleration of charged particles. This current system amplifies the already existing ring current, and the closure of a part of it through ionosphere generates a zone 2 of field aligned currents. The movement of an expanding partial ring current around the magnetosphere together with the drift of charged particles transfers the magnetic flux from the night side of the magnetosphere to the day side. At the daytime magnetopause, reconnection is also responsible for the creation of the Birkeland current loop, but now the electric field arising in the loop zone slows down the particles of the ring current, and regions of ring current weakening are formed. The closure of these holes in the ring current leads to the transfer of magnetic flux from the day side to the night side, ensuring its balance.

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