

PHYSICS OF THE EARTH'S RING CURRENT: IMPORTANT PROBLEMS AND NEW CHALLENGES

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The ring current is a key current system in the inner Earth's magnetosphere and a defining element of magnetic storms. It consists of ions and electrons with energies from 1 keV up to hundreds of keV. The ring current dominates the energy content of the inner magnetospheric plasma, and therefore is the primary factor in altering the electric and magnetic fields in this region of geospace. Observations and simulations indicate that the ring current is the main source of the Dst index during intense magnetic storms. There are two primary external drivers of the ring current to consider: the source population and the sunward force within the magnetosphere. For the former, there are questions about solar wind entry mechanisms into the magnetosphere, ionospheric outflow rates and acceleration in the magnetosphere, and the recirculation of magnetospheric plasma back into the magnetotail. For the latter, there are issues regarding the distribution of the convection electric field in the magnetosphere, electric potential saturation, and the relative role of convection versus substorm inductive electric fields in supplying plasma to the inner magnetosphere. A defining feature of the ring current is that, during magnetic storms, it is not a ring, but rather a highly asymmetric crescent of pressure. The existence of this partial (rather than symmetric) ring current leads to the distortion of the magnetic and electric fields in near-Earth space and therefore to nonlinear feedbacks on the ring current itself. This influence of the ring current on its further development is a critical unknown that is just beginning to be explored by the magnetospheric physics community. In addition to these issues, there are still concerns about the dominant loss mechanisms of the ring current. In particular, there is debate about when flow-out loss to the magnetopause is larger than charge exchange loss within the magnetosphere. Recent studies have clarified this, but questions remain about when and how these two loss mechanisms relate to the ring current drivers and morphology. Ring current is a catalyst of many space weather phenomena. There is uncertainty, however, in predicting the strength and morphology of the ring current because it depends on the nonlinear combination of several source populations and physical mechanisms. Large-scale, systematic investigation of the physical processes controlling the flow of particles into and through the inner magnetosphere, based both on the observations and modeling is needed to quantify the mechanisms responsible for the sources, dynamics, and decay of the ring current.