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The Dynamics and Energization of the Ring Current During Substorms: A Synoptic 3D View from Cluster and IMAGE/HENA

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On a number of occasions, the Cluster fleet traversed the ring current while IMAGE remotely obtained time sequences of substorm injections into the ring current region. These conjunctions have enabled us to resolve the temporal and spatial ambiguities in substorm dynamics, and to explore the types of acceleration and transport responsible for the enhancements of energetic particle pressure in the ring current, and to provide a more complete view of the 3D current system driven by the ring current particle pressure. Here we present new results of such a cross-scale analysis of substorm injections during 18 and 20 April 2002.

We first interpret the in-situ ion measurements from Cluster/CIS together with global ENA images of the substorm injection in the 27-39 keV range to derive the global motion of the injection front and associated boundaries. We find what resembles a "sloshing" motion consistent with the earthward motion from a dipolarization of the field, a subsequent inflation of the field by the injected ring current particle pressure, a in- and outward motion of the inner edge of the ring current, and motion of the outer edge that restores the field to its pre-injection position.

Second, we present the 3D large-scale pressure-driven current system derived from the HENA images on 20 April 2002 and discuss the global context of the local measurements of current density applying the curlometer technique to cluster magnetic field measurements [Vallat et al., Annales Geophysicae, 23, 1849–1865, 2005]. The results are compared to the "snapshots" from the TS07d global empirical magnetic field model.

Third, we discuss the possible energization mechanisms by analyzing the spectral evolution of both protons and O+ obtained globally by HENA as well as locally by Cluster over the 10-200 keV range. The spectral analysis show possible indications of non-adiabatic acceleration of the O+, consistent with the expected non-adiabatic acceleration in the inductive electric field from the magnetic field dipolarization [Jones et al., doi:10.1029/2006JA011607, 2006; Fok et al., doi:10.1029/2006JA011839, 2006].