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Concurrent observations of thin magnetospheric current layers, ionospheric field-aligned currents and naturally enhanced ion-acoustic lines

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Structures of small scales have been observed and received considerable attention in both the ionosphere as well as the magnetopause and the cusp region. The thin layers in the magnetosphere exhibit high currents and strong electric fields on scales where ion and electron motions are decoupled, and the region can be described by Hall MHD physics. These structures are believed to originate from reconnection diffusion regions. In the F region small scale field-aligned currents (FACs) with densities of hundreds of uA/m2 have been observed. Neutral density enhancements by a factor of 2 and more occur around these. Incoherent scatter radar, also in the F region, detect so-called naturally enhanced ion-acoustic lines (NEIALs) extending across scales of the order of only 1 km and less. NEIALs are typically associated with strong heating of ionospheric electrons and ion upflow.

We present observations from the four Cluster spacecraft, the CHAMP satellite, and the EISCAT Svalbard Radar suggesting that intense FACS and NEIALS are the ionospheric signatures of magnetospheric thin layers. Not only do the three phenomena nearly concur in space and time when projecting the location of the Cluster tetrahedron along the magnetic field to the ionosphere. The current density in the layer obtained from four space-craft measurements reaches 7 uA/m2 and this current becomes approximately a few hundred uA/m2 when flowing in the ionosphere which is the value derived from the CHAMP fluxgate magnetometer. The observed scales of the current structures are about 30 km in the exterior cusp and 1 km in the ionosphere which corresponds to the expectations. The most intense current at Cluster is downward, and in the radar spectra the ion-acoustic line corresponding to downward current is most enhanced.

We suggest that the microphysical structures which form when the interplanetary and geomagnetic fields merge extend over ten thousands of kilometers along the magnetic field and that they are imaged in the Earth's ionosphere. Feedback from the ionosphere to the reconnection diffusion region is important. Reconnection on the dayside magnetosphere is able to transfer energy to the ionosphere in very narrow regions and thus triggers localized heating of ionospheric electrons, thermospheric density enhancements and upflow of ions from the ionosphere.