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Charge Separations in the Geomagnetosphere

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Charges and electric currents source the electromagnetic field, and therefore the distribution and motions of charges determine its form. Charge separations may appear in various plasma boundary layers due to the inertia of electrons and ions or the trapping of the magnetic field. Based on the electric fields observed by MMS four spacecraft, the gradient of the electric field, as well as the charge density, can be obtained. The analysis on the electric field data acquired during dayside magnetopause crossing events by the MMS constellation shows a charge separation in the magnetopause boundary layer and that the positive charges are accumulated on the magnetospheric side while the negative charges are accumulated on the magnetosheath side. The charge separations in dayside, dawn side and dusk side magnetopause have been systematically explored. Furthermore, the spatial distribution of electric charge density in the inner magnetosphere is derived and analyzed based on the electric field measurements from September 2015 to December 2020 by MMS satellites. It is revealed that, the inner magnetosphere accumulates positive charge at dusk side and negative charge at dawn side, both of which vary with the magnetic activities. The charge and the electric field distribution confirm the presence of the Alfvén layer for the first time. In the Alfvén layer, the charge distribution has dawn-dusk asymmetry. The positive charge density at dusk is much greater than the negative charge density at dawn. These observations and analysis results could shed light on the structure of the magnetosphere and the magnetosphere-ionosphere coupling during storms.