Observational study on mass and charge dependence of plasma energization in the inner magnetosphere and near-Earth magnetotail

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The ion pressure in the Earth's inner magnetosphere is generally dominated by a few to a few 100s keV protons. Oxygen ions of ionospheric origin, O^+, can make a significant contribution to the ion pressure during geomagnetically active periods. Our previous study showedclear oxygen-proton differences in energy spectra in the outer part (L>5) of the ring current region. The results indicate the occurrence of mass-dependent or selective acceleration in the inner magnetosphere and/or near-Earth magnetotail. The present study extends analysis toward ions with different mass and/or charge states. We primarily use data from the MEP-i (Medium-Energy Particle experiments - ion mass analyzer) on board the Arase spacecraft, particularly when the Arase apogee was positioned on the night side during magnetic storms. MEP-i measures ions with energies of ~10 to 180 keV/q and distinguishes between different ion species.

Energy spectra of singly-charged ions (H^+, He^+, O^+) show mass dependence, with He^+ and O^+ having harder spectra than H^+. The spectral slope of doubly-charged ions (He^{++}, O^{++}) is steeper for H^{++} than O^{++}. For ions with the same mass, singly-charged ions show harder spectra than doubly-charged ones. The results indicate that energization processes in the near-Earth magnetotail are more dependent on mass than charge. This suggests that the ion energy gain in the magnetotail is not determined by a complete displacement across the global electric field potential only. An important factor is likely the limited spatial scale of the electric field associated with narrow flow channels during magnetic field reconfiguration (dipolarization), which has been reported comparable to gyro-radii of heavy ions.

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