Mass- and charge-dependent ion energization in the near-Earth magnetotail: Arase observations

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The ion pressure in the inner magnetosphere is generally dominated by protons with energies of a few to a few 100s keV. Oxygen ions of ionospheric origin, O^+, can make a significant contribution to the ion pressure during geomagnetically active periods. Our previous study (Keika et al., 2018, GRL) showed clear oxygen-proton differences in the contributing energies (energy ranges that makes the dominant contribution to plasma pressure) in the outer part (L larger than 5) of the ring current region. The results provided in situ evidence of the contribution from mass-dependent/selective acceleration processes to the energization of the outer part of the ring current.

The present study extends this analysis toward different ion species, that is, ions with different mass and/or charge states than H^+ and O^+. We primarily use data from the MEP-i (Medium-Energy Particle experiments - ion mass analyzer) on board the Arase spacecraft. MEP-i measures ions with energies of ˜10 to 180 keV/q and distinguishes between different ion species. We analyze the MEP-i data during the magnetic storms that occurred in May, July, and September 2017; the apogee of Arase was located on the night side. Contributing energies were higher for He^+ and O^+ than H^+. Energy density of O^+ was contributed from higher-energy (higher than 100 keV) ions as well as lower-energy ions. For doubly-charged ions, contributing energies were similar, ˜50-˜100 keV. O^{2+} energy density was also contributed from higher-energy (higher than 100 keV) ions. Contributing energies per charge are higher for lower-charge-state ions. The results indicate that energization processes in the near-Earth magnetotail are mass- as well as charge-dependent. 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 can be comparable to gyro-radii of heavy ions.