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Impulsive enhancements of oxygen ions in the inner magnetosphere: Van Allen Probes RBSPICE observations

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We investigate enhancements of O^+ ions in the inner magnetosphere (L<6) during magnetic storms. Previous in-situ and remote-sensing observations by several investigators have confirmed that the O^+ pressure increases on a substorm time scale (<10 min) rather than on a storm time scale (>hours). Such temporally impulsive enhancements can be caused by adiabatic, impulsive transport and/or non-adiabatic acceleration. The relative significance of these two processes, however, remains an open question and might even vary from event to event. We perform a case study of the 6 June 2013 storm, during the main phase of which the RBSPICE instrument onboard the Van Allen Probes spacecraft observed short time-scale (<10 min) enhancements of energetic (>50 keV) proton and oxygen ion fluxes.

The ion injection event occurred at ∼2000 UT in the course of the main phase which started at about 16 UT. The Van Allen Probes A and B were located at (X, Y, Z)$_{SM}$ = (-5.4, 1.5, 0.6)RE and (X, Y, Z)$_{SM}$ = (-5.3, 2.1, 0.7) RE, respectively. The flux enhancements display only small energy dispersion, indicating that the westward edge of the injection region was close to the spacecraft but at a later MLT. The duration of the flux enhancements differ between the two spacecraft; the flux at ∼100 keV continued for ∼5 min and ∼10 min at spacecraft A and B, respectively. The difference in the end time of the flux enhancements enables us to estimate the ion drift speed to be ∼0.4 RE/min, suggesting that the eastward edge of the injection region was <1 RE eastward of spacecraft A. We thus estimate the spatial scale of the injection region to be <1 RE in the MLT direction. We also compare energy spectra (phase space density vs. mu, the first adiabatic invariant) to identify whether ion acceleration is adiabatic or not. The energy spectral slope for both ion species did not change during the injection event. The oxygen spectra were also shifted toward higher PSD by a factor of ∼3.

The results suggest that both ion species were accelerated adiabatically and that oxygen ions increased in density. We conclude that, for this storm event, energetic (ring current) oxygen ions in the inner magnetosphere were enhanced by adiabatic, fast transport of oxygen-rich plasma sheet plasma and/or adiabatic heating of preexisting cold/warm oxygen ions due to temporally impulsive, spatially localized electric field fluctuations.

Keywords: ring current, oxygen ions, injections in the inner magnetosphere, magnetic storm and substorms, Van Allen probes RBSPICE