Rapid energization of oxygen ions in the inner magnetosphere during a substorm

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Observations have shown that energetic oxygen ions are rapidly enhanced in the inner magnetosphere during a substorm. Two distinct processes have been suggested to explain the enhancement. The first one is transport from the near-earth plasma sheet, and the other one is local acceleration. We traced oxygen ions under the electric and magnetic fields that are self-consistently obtained by the global MHD simulation developed by Tanaka et al. (2010, JGR). The oxygen ions are initially placed at (-7, 0, 0) Re with an equatorial pitch angle of 60 deg near the substorm onset. The simulation results show that oxygen ions appear to be significantly accelerated by large-amplitude, quasi-periodically oscillating electric field. The amplitude of the electric field reaches ˜10-20 mV/m, and the oscillation is attributed to a force imbalance between the JxB force and grad-P force (Ebihara and Tanaka, 2012, submitted to JGR). Oxygen ions with initial energy of 1 eV are immediately accelerated to 7 keV within ˜17 sec, and to ˜20 keV within a half bounce period (a few minutes). Oxygen ions with initial energy around 1 keV reach the innermost point to the Earth, that is, L˜6, and are accelerated to ˜4 keV within a half bounce period (˜5 minutes). These results may support Nose et al.'s (2010, JGR) idea that pre-existing thermal oxygen ions contribute to the oxygen-rich ring current.