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Energization of ionospheric oxygen ions in the inner magnetosphere on a substorm time scale

Kunihiro Keika[1]; Pontus Brandt[2]; Harald Frey[3]; Shinichi Ohtani[2]; Masahito Nose[4]
[1] NJIT; [2] JHU/APL; [3] UCB/SSL; [4] DACGSM, Kyoto Univ.

Ionospheric O+ ions are widely recognized as one of the primary species in the magnetosphere under geomagnetically active conditions. Energized O+ ion population (1–200 keV) makes a significant contribution to plasma pressure in the inner magnetosphere and, in turn, the ring current. O+ energization causes ring current evolution, which produces considerable magnetic field distortion (known as a geomagnetic storm), magnetosphere- plasmasphere-ionosphere coupling, and the stability and nature of the radiation belts. In this study, we examine the temporal variations of energy spectra of energetic neutral atoms (ENAs) during substorms that occur in the storm main phase. ENAs are detected by the High Energy Neutral Atom (HENA) imager onboard the Imager for Magnetopause-to-Aurora Global Exploration (IMAGE) satellite. The ENA energy used in the present study ranges from 10 keV to 198 keV for hydrogen and from 29 keV to 222 keV for oxygen.

Case studies of storm-time substorms on 21 October 2001 and on 19 March 2002 showed that (1) the oxygen ENA flux displays 20 to 30-min bursts during all five substorms, while the hydrogen ENA flux did not increase or less significantly increased than the oxygen flux; (2) the temporal evolution of energy spectra is mass dependent for all substorms; and (3) for two of the substorms, the oxygen flux ratio between before and after a substorm increases with increasing energy, indicating the hardening of an O+ energy spectrum. The results suggest that O+ non-adiabatic acceleration with regard to the first adiabatic invariant did occur during the two substorms. For the rest three substorms, we believe that enhancements of cold/thermal O+ population prior to the substorm injections play an important role in the overall O+ energization.

In order to discuss relative importance of O+ non-adiabatic acceleration and preconditions, we examine correlations of oxygen ENA flux increases and spectral evolution with substorm strength, the spatial scale of substorm activity, and solar wind conditions. Substorm strength and the spatial scale of substorm activity will be determined from auroral brightness measured by IMAGE/FUV, dipolarizations observed by GOES, and magnetic field variations on the ground.