The Acceleration of Electrons in the Magnetotail and their Auroral Signatures

Maha Ashour-Abdalla[1,2], *Meng Zhou*[3], *Mostafa El-Alaoui*[1], *David Schriver*[1], *Robert Richard*[1] and *Raymond Walker*[1,4]

[1]Institute of Geophysics and Planetary Physics, University of California at Los Angeles, 405 Hilgard Avenue, Los Angeles, California 90095-1567 U.S.A.; mabdalla@igpp.ucla.edu, mostafa@igpp.ucla.edu, dave@igpp.ucla.edu, rrichard@igpp.ucla.edu, rwalker@igpp.ucla.edu

[2]Department of Physics and Astronomy, University of California at Los Angeles, 405 Hilgard Avenue, Los Angeles, California 90095-1547 U.S.A.; mabdalla@igpp.ucla.edu

[3]Institute of Space Science and Technology, Nanchang University, P.R. China 330031; monmentum82@gmail.com

[4]Department of Earth and Space Science, University of California at Los Angeles, 405 Hilgard Avenue, Los Angeles, California 90095-1567 U.S.A.; rwalker@igpp.ucla.edu

Magnetic reconnection in a magnetized plasma represents a change in the topology of the magnetic field and is associated with a concomitant energization of charged particles that results in a conversion of magnetic energy into particle energy. In the Earth's magnetosphere, during southward interplanetary magnetic field, reconnection occurs first on the dayside then in the near Earth magnetotail. By using data from the THEMIS and Cluster missions together with global MHD and Large Scale Kinetic (LSK) particle simulations, we demonstrated that electrons were energized in two distinct regions: in the magnetotail: (1) a low energy population (up to a few keV) that arose in the reconnection region where particles were demagnetized and the magnetic topology changes and (2) a high energy component that was further energized by betatron acceleration within dipolarization fronts as they swept Earthward far from the diffusion region. In general it is concluded that particle energization in the Earth's magnetotail during substorms is not associated solely with the conversion of magnetic to kinetic energy within the reconnection region, but also arises in conjunction with macroscopic flows(Ashour-Abdalla et al 2011)

In this study MHD simulations are used to determine the global magnetospheric configuration during a substorm dipolarization event and electrons trajectories are then followed within the large scale fields. The electron energy flux at the equatorial plane is calculated at different times and locations and the results were validated using THEMIS observations. The precipitating electron energy flux in the auroral region was also calculated at different times. It is found that at times when the precipitating energy flux intensifies and moves to lower latitudes there is a direct correspondence with earthward movement of the dipolarization fronts. This is determined by first calculating the energy flux based on a spherical virtual detector located on the inner boundary of the simulation at $r = 2.8\ R_E$ and then mapping those energy flux values along dipolar field lines into the ionosphere. Polar plots display the energy flux of the precipitating electrons in the simulation from 0351 UT to 0404 UT. Early in the simulation at about 0353-354 UT, the simulated electrons enter the ionosphere in a narrow band at about 72 degrees latitude, duskward of midnight. By tracing field lines from the locations of maximum precipitating energy flux back into the magnetotail equatorial plane we found that the particles at 0353 UT originate from near the neutral line which was at x~-25 R_E in the magnetotail. At about the time (0357 UT) the dipolarization front was observed at THEMIS, the precipitating electrons intensify and moves to lower latitudes. The most intense electron energy fluxes in the ionosphere occur below 70 degrees latitude. The field lines from the most intense fluxes suddenly (within a minute) move to the vicinity of THEMIS (x~-10 R_E in the magnetotail). This is related to the motion dipolarization front in the MHD model. This behavior repeats at about 0359 UT, when the second dipolarization front engulfed THEMIS in the MHD simulations. The results show a direct connection between auroral precipitation and electron acceleration in the magnetotail due to reconnection and dipolarizations.

Ashour-Abdalla, M., M. El-Alaoui, M.L. Goldstein, M. Zhou, D. Schriver, R. Richard, R. Walker, M.G. Kivelson, and K.-J. Hwang (2011), Observations and simulations of non-local acceleration of electrons in magnetotail magnetic reconnection events, *Nature Physics*, doi:10.1038/NPHYS1903.

978-1-4244-6051-9/11/$26.00 ©2011 IEEE