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Bursty electron precipitation by very-oblique whistler-mode waves

Longzhi Gan*[1], Anton Artemyev[2], Wen Li[1], Xiao-Jia Zhang[2], Qianli Ma[1,3], and Vassilis Angelopoulos[2]
(1) Boston University, Boston, MA, USA
(2) Earth, Planetary, and Space Sciences, University of California, Los Angeles, CA, USA
(3) Atmospheric and Oceanic Sciences, University of California, Los Angeles, CA, USA

Whistler-mode chorus waves play important roles in energetic electron dynamics in Earth's radiation belts. Specifically, theoretical and numerical studies have shown that intense chorus waves can produce bursty electron precipitation within very short timescales, through nonlinear wave-particle interactions. In this presentation, we study a conjunction event observed by the twin Electron Losses and Fields Investigation (ELFIN) Cubsats, and the Time History of Events and Macroscale Interactions during Substorms (THEMIS) satellite, which suggested the important role of oblique chorus waves in the bursty electron precipitation. On January 07, 2021, intense electron precipitation flux for energies near 100 keV was observed by ELFIN-B at a low altitude. The THEMIS-E satellite, located at the conjugated point near the magnetic equator, observed highly oblique whistler-mode chorus waves simultaneously. Based on the observed parameters, we perform the test particle simulations for electron energies from 1 keV to 1 MeV, and equatorial pitch angles from 0º to 90º. Flux ratio, defined as the ratio between precipitated electron flux and perpendicular electron flux, is calculated from the simulation results. The time averaged flux ratio spectrum versus electron energy is compared to the ELFIN observation. Tracing of the precipitated electrons in the model shows that Landau trapping by the oblique chorus waves can accelerate electrons with energies of several keV to 10s of keV, while transporting them into the loss cone. Landau trapping can also accelerate electrons up to 100 keV. The electron equatorial pitch angles decrease close to the loss cone during the same Landau trapping process. Higher-order resonances with the oblique chorus waves further scatter these electrons into the loss cone, enhancing the precipitation near 100 keV. Our study shows that the combination of nonlinear Landau trapping and higher-order pitch angle scattering can drive the fast and intense electron precipitation flux with energies around 100 keV. The results further demonstrate the importance of nonlinear wave-particle interactions for energetic electron precipitation into the Earth's upper atmosphere.