Global Simulation of Electron Cyclotron Harmonic Wave Instability in a Storm-time Magnetosphere

Xu Liu*[1], Lunjin Chen[1], Miles A. Engel [2], and Vania K. Jordanova [2]

[1] William B. Hanson Center for Space Sciences, University of Texas at Dallas, Richardson, Texas, USA

[2] Los Alamos National Laboratory, Los Alamos, New Mexico, USA

Electron Cyclotron Harmonic Wave (ECH) is an electrostatic emission between electron cyclotron harmonic bands, naturally found in the Earth's magnetosphere. Such emission is dominant for precipitating energetic electron in the magnetotail. Magnetospheric ECH wave is excited by the loss cone distribution of hot electrons $(1-10s\ keV)$, Statistically, its intensity is stronger at nightside and dawnside than at dayside and duskside, and increases with the geomagnetic-activity level. In this study, we, for the first time, simulate the global ECH wave evolution during a geo-storm (March 16^{th} to March 18^{th}, 2013). We use Ring current-Atmosphere interaction Model and Self-Consistent Magnetic (RAM-SCB) Model to simulate electron distribution in the equatorial plane from $3R_E$ to $6R_E$, where R_E is Earth radius, and then use linear growth rate formula of ECH wave to evaluate ECH instability. We find our simulated results are consistent with the statistical observation. ECH wave growth rates are much more enhanced at nightside and dawnside, compared with those at dayside and duskside. During a weak activity prior to the storm, the unstable region of ECH wave locates at $> 4R_E$ to $6R_E$, and the instability is moderate at nightside and dawnside. Just before the geo-storm (quiet time), the unstable region moves to $5 \sim 6R_E$, and the ECH instability becomes very weak. During the main phase of the storm, the unstable region can extend to lower altitude ($3R_E$ to $6R_E$), and the ECH instability is strongest and can extend to dayside. During the recovery phase, the unstable region returns to $5 \sim 6R_E$, and only midnight instability is strong. The inner boundary of unstable ECH wave region is coincident with the plasmapause location during the storm, because the drifting path of energetic electrons, which store free energy fro ECH waves, is well confined outside the plasmapause. Our work greatly advance our understanding of the ECH spatial and temporal evolution during storm times, and is an important step to build a storm-time physical model for ECH waves and their wave normal angles, which is valuable for radiation belt modeling work.