BOSTON UNIVERSITY

Boston University College of Arts & Sciences
Center for Space Physics

2024—2025 SPACE PHYSICS SEMINAR SERIES

Cross-Scale Modeling of Storm-Time Radiation Belt Variability

Relativistic electrons in Earth's radiation belt exhibit large flux variations on rapid time scales of minutes to days during geomagnetic storms. The magnitude and extent of radiation enhancements are controlled by the shifting balance among multiple acceleration and loss mechanisms acting at different spatial and temporal scales. The mechanisms often occur simultaneously and are all strongly regulated by the storm-time electromagnetic fields and cold plasma density within the magnetosphere, increasing the complexity to disentangle their effects. Correlation between waves, background fields, and precipitation features, though, is limited to rare conjunction studies. As such, their relative importance to global dynamics of the belt still remains a major open question. Numerical simulations are in a unique position to help address disentangle the effects of each mechanism; however, it requires a first-principles model capable of capturing the multiscale nature of the problem.

In this presentation, we review results from our newly developed model of the storm-time radiation belts. The model incorporates electron wave-particle interactions with parallel propagating whistler mode waves into our global test-particle model of the outer belt. Electron trajectories are evolved through the electromagnetic fields generated from the Multiscale Atmosphere-Geospace Environment (MAGE) global geospace model. Pitch angle scattering and energization of the test particles are derived from analytical expressions for quasi-linear diffusion coefficients that depend directly on the magnetic field and density from the magnetosphere simulation. Using a study of the 17 March 2013 geomagnetic storm, we demonstrate that resonance with lower band chorus waves can produce rapid relativistic flux enhancements during the main phase of the storm. While electron loss from the outer radiation belt is dominated by loss through the magnetopause, wave-particle interactions drive significant atmospheric precipitation. We also show that the storm-time magnetic field and cold plasma density evolution produces strong, local variations of the magnitude and energy of the wave-particle interactions and is critical to fully capturing the dynamic variability of the radiation belts caused by wave-particle interactions. Finally, we will discuss the connection between mesoscale injections to the generation of transient precipitation features and their potential impact on radiation belt dynamics.

Thursday, November 7th

3:30 - 4:30 p.m.

725 Commonwealth Ave | Room 502

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