Project Details

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Selection Year: 2007
Program Element: Independent Investigation

Topic: Investigate the Global Distribution, Sources and Effects of Large Electron Density Gradients at Middle and Low Latitudes

Project Title:
Relativistic Electron Losses in the Outer Radiation Belt Via Their Interactions With EMIC Waves

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Summary:
The dynamics of the radiation belts (RB) have received considerable attention in recent years because of their impact on our technology-based society and because of the fundamental and unresolved scientific questions about transport, acceleration and loss of these particles. During magnetic storms, under certain conditions, relativistic electrons with energies ~1 MeV can be removed from the outer RB by Electromagnetic Ion Cyclotron (EMIC) wave scattering. Recent calculations suggest that pitch angle scattering via EMIC waves can compete with Dst effect as a mechanism for depleting relativistic electrons from the outer RB zone during the initial and main phases of a magnetic storm. These studies assumed only (or almost) parallel propagating EMIC waves. However there are growing theoretical and experimental evidence that such assumption could be severe and should be reconsidered in future studies of relativistic electron losses.

EMIC waves are generated by ion temperature anisotropy in the Earth s ring current (RC) and, therefore, the dynamics of RB, RC, and EMIC waves are intimately related. It is well known that the effects of EMIC waves on RC ion and RB electron dynamics strongly depend on such particle/wave characteristics as the phase-space distribution function, frequency, wave-normal angle, wave energy, and the form of wave spectral energy density. Therefore, the realistic characteristics of EMIC waves must be properly determined by modeling the RC-EMIC wave evolution self-consistently. This work is absolutely necessary to achieve the NASA LWS goal of predictive modeling of the growth and decay of the RB during the magnetic storms.

To quantify the EMIC wave effects on the RB losses, in order to properly address NASA LWS program concerns, a systematic and self-consistent studies of magnetosphere-plasmasphere-ionosphere RC/EMIC wave coupling are needed in order to provide EMIC waves forecast on a global scale and include corresponding wave-particle interaction processes in RB modeling. We propose a comprehensive theoretical study of EMIC waves and their interactions with relativistic electrons on a global scale based on our self-consistent RC/EMIC wave model that has been developed over the last five years [Khazanov et al., 2002-2006]. The central objectives of this proposal are:

(a) To investigate the resonance interaction of relativistic electrons with EMIC waves on a global scale in order to verify the efficiency of this channel of the RB losses;

(b) To modify our RC/EMIC wave model to include realistic configurations of magnetic and electric fields, and cold plasma electron and ion distributions;

(c) To validate the RC/EMIC wave model using appropriate wave data provided by EMIC wave experimentalists.

Publication References:

Summary: no summary

Reference: Gamayunov, K. V.; Khazanov, G. V.; (2007), Effect of oblique electromagnetic ion cyclotron waves on relativistic electron scattering: Combined Release and Radiation Effects Satellite (CRRES)-based calculation, Journal of Geophysical Research: Space Physics, Volume 112, Issue A7, CiteID A07220, doi: 10.1029/2007JA012300

Summary: no summary

Reference: Khazanov, G. V.; Gamayunov, K. V.; (2007), Effect of electromagnetic ion cyclotron wave normal angle distribution on relativistic electron scattering in outer radiation belt, Journal of Geophysical Research: Space Physics, Volume 112, Issue A10, CiteID A10209, doi: 10.1029/2007JA012282

Summary: no summary

Reference: Gamayunov, K. V.; Khazanov, G. V.; (2007), Crucial role of ring current H+ in electromagnetic ion cyclotron wave dispersion relation: Results from global simulations, Journal of Geophysical Research: Space Physics, Volume 113, Issue A11, CiteID A11220, doi: 10.1029/2008JA013494

Summary: no summary

Reference: Gamayunov, K. V.; Khazanov, G. V.; Liemohn, M. W.; Fok, M.-C.; Ridley, A. J.; (2009), Self-consistent model of magnetospheric electric field, ring current, plasmasphere, and electromagnetic ion cyclotron waves: Initial results, Journal of Geophysical Research, Volume 114, Issue A3, CiteID A03221, doi: 10.1029/2008JA013597