Wave-Particle Interactions in the Earth's Magnetosphere

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Morphological structures of the magnetosphere such as the third radiation belt (or "storage ring") have been a major observational achievement of the RBSP program (renamed the "Van Allen Probes" mission in November 2012). A goal of that program has been to understand more thoroughly how ultra-relativistic electrons are accelerated deep inside the radiation agents due to various wave-particle interactions. Van Allen Probes studies have demonstrated that electrons up to energies over 10 megaelectron volts (MeV) can be produced over broad regions of the outer Van Allen zone on timescales of minutes to a few hours. The key to such rapid acceleration is the interaction of "seed" populations of ~10 to ~20 keV electron (and subsequently higher energies) with electromagnetic waves in the lower band whistler-mode chorus frequency range. Extended studies of Van Allen Probes data show that "source" electrons (in a typical energy range of one to a few tens of keV energy) produced by magnetospheric substorms play a crucial role in amplifying the chorus waves in the magnetosphere. It is repeatedly observed that these chorus waves then rapidly heat and accelerate the tens to hundreds of keV seed electrons that are injected by substorms into the outer Van Allen zone. Thus, we often see that geomagnetic activity driven by strong solar storms (coronal mass ejections, or CMEs) almost inexorably leads to ultra-relativistic electron production through the intermediary step of waves produced during intense magnetospheric substorms. More generally, wave-particle interactions are of fundamental importance over a broad range of energies and in virtually all regions of the magnetosphere. We provide in this presentation a summary of many of the wave modes and particle interactions that have been studied in recent times.

References

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