

Physical Models of the Radiation Belts

We propose creating a GEM focus group dedicated to the investigation of physical processes active within the radiation belts, with the goal of providing quantitative descriptions of the dynamics of the trapped radiation environment within the framework of first-principles physical models and in situ observations. This Radiation Belt Modeling Focus Group (RBMFG) will concern itself with identifying and quantifying the contributions and effects of various sources of heating, transport, and loss of radiation belt ions and electrons, and developing global and local models of the radiation belts. These efforts will complement the existing NASA RBSP mission planned for launch in 2012. RBMGF will provide context for understanding RBSP observations, and will leverage new results from the RBSP mission in terms of advancing radiation belt modeling capabilities by quantifying input conditions, validating model results, and identifying missing physical processes.

Science Questions and Activities.

- *What are the quantitative effects of ELF/VLF waves on radiation belt acceleration and loss?* This question will be addressed through efforts to develop statistical models of ELF/VLF using in-situ observations of waves, and by quantifying scattering rates by different types of waves. The results of model simulations will be compared with in-situ observations of precipitating and trapped fluxes as well as balloon and ground observations of precipitating particles.
- *What are the quantitative effects of transport via interaction with ULF waves?* Activities relating to this question will include particle tracing and diffusive simulations of the radiation belts, with the aim of properly quantifying diffusive transport of MeV particles. Analysis of ground-based and in situ observation of ULF waves will be undertaken in this effort, as well as modeling the excitation of ULF waves due to solar wind driving and inner-magnetospheric plasma instabilities.
- *What is the role of coherent, non-diffusive processes on the belts?* Prompt injection of MeV particles during storm sudden commencement can have a profound impact on the belts; injection of keV particles during substorms can provide source populations for acceleration to radiation belt energies. This work will contrast these effects with diffusive and acceleration of particles, and will examine the effects of large-amplitude waves that act outside the quasilinear diffusion approximation.
- *What role do seed populations play in the dynamics of the radiation belts?* This work will examine the role of keV seed populations on the evolution of the radiation belts, and will involve in situ and modeling studies of the access of these particles to the inner magnetosphere and their subsequent acceleration.
- *Why do some storms produce increases in the radiation belt fluxes while others produce no net change?* This effort will combine quantitative insight from efforts described above into working models of the radiation belts. Coupling existing codes to account for the range of different physics and validation studies for selected events will be a key part of this work.

Goals and Deliverables.

This focus group will work on answering the fundamental questions outlined above, with the goal of advancing physical models of the radiation belts and making them available for the analysis of results from the upcoming NASA's Radiation Belt Storm Probe (RBSP) mission. The efforts of this group will focus on modeling energy, pitch-angle, and particle transport; we will also involve a wide range of observations including ground observations of waves, balloon

observations of precipitating particles, and in-situ observations of ULF/VLF/ELF waves and energetic electron and ion fluxes. International researchers from France, the UK, Canada, China, Italy, and Russia will be strongly encouraged to participate.

Relation to Existing Focus Groups.

This focus group is intended to fill a niche within GEM that is not addressed by any active focus group, but will seek to work with and leverage results from existing GEM efforts. The RBMFG will largely work within the Inner Magnetosphere and Storms GEM Research Area, but will actively contribute to other GEM Research Areas.

Space Radiation Climatology. This focus group endeavors to investigate the radiation belts from an empirical/observational point of view, while explicitly excluding radiation belt physics discussions. The RBMFG will work with the radiation climatology focus group, using associated observational efforts to validate and constrain physics-based models developed under the RBMFG, and in return will provide a global context and physical understanding for the empirical efforts of the climatology group.

Near Earth Magnetosphere: Plasma, Fields and Coupling The results of this focus group, will be used for modeling electric and magnetic fields which have a significant effect on the dynamics of the radiation belt particles. The developed understanding of the processes governing the acceleration and transport of the seed populations for the radiation belts will be incorporated into or coupled with the radiation belt models. Plasma sheet particles also provide free energy for various plasma waves responsible for the acceleration and loss of energetic electrons and ions in the inner magnetosphere.

Diffuse Auroral Precipitation. Many of these scattering mechanisms associated with diffuse auroral precipitation originate in wave-particle interactions that also have an effect on high energy radiation belt electrons, e.g. whistler-mode chorus. The RBMFG will work with the diffuse aurora focus group, applying advances in understanding the morphology and effect of these waves on charged particles to the acceleration, transport, and loss of radiation belt particles.

Plasmasphere-Magnetosphere Interactions. The cold plasmas of inner magnetosphere have a profound effect on wave growth and characteristics in the radiation belts and ring current. The RBMFG will apply advances in understanding the dynamics of the plasmasphere and the wave modes associated with this cold population to understanding and quantifying the subsequent effects on radiation belt particles.

Modes of Solar Wind-Magnetosphere Energy Transfer. Particle injections via substorm, SMC, and sawtooth activity may provide seed populations for subsequent acceleration to MeV energies in the radiation belts, as well as producing temperature anisotropies associated with waves driven by plasma instabilities. These efforts may be applied RBMFG activities in terms of providing wave characteristics and initial and boundary conditions for inclusion in radiation belt models.

CoChairs. This GEM focus group will be organized by Yuri Shprits (UCLA) and Scot Elkington (LASP, University of Colorado), with input from other members of the radiation belt research community.

Term of effort. The GEM Radiation Belt Physics Focus Group should encompass the term of the RBSP mission (tentatively 2012-2014), with subsequent time to allow for model implementation of advances brought by the RBSP science observations. We propose a focus group term that begins in 2010 and extends through 2014.