Highly structured and dynamic outer electron belt
Outstanding questions

- Which physical processes produce radiation belt enhancement events?
- What are the dominant mechanisms for relativistic electron loss?
- How does the inner magnetospheric plasma environment control radiation belt acceleration/loss?
Outline

- What are they talking about?
- What are they fighting for?
- Why is it so hard?
- What would help?

- Breakout sessions
- Student sponsored tutorial
What are they talking about? (1)

- Adiabatic and non-adiabatic processes  Need B-model!
- L shell (L and L*)  Need B-model!
- Phase space density (PSD)  Need B-model!

![Graph 1](Huang, 2007)

![Graph 2](Green and Kivelson, 2004)
What are they talking about? (2)

- Waves in the magnetosphere
  - Need B and E-models!
  - Local stochastic acceleration
    - Local heating, break 1\textsuperscript{st} or 2\textsuperscript{nd} invariant
  - ULF wave resonant
    - Radial diffusion, break 3\textsuperscript{rd} invariant
  - VLF waves
    - Pitch angle diffusion, break 1\textsuperscript{st} or 2\textsuperscript{nd} invariant

After Summers et al., 1998
What are they talking about? (3)

- **Diffusion theory**: time evolution of a distribution of particles whose trajectories are disturbed by innumerable small, random changes.
  - Has to break one or more invariants
  - Has to remove the adiabatic motions
More on diffusion matters

- Diffusion coefficients
  - Radial diffusion ($D_{LL}$)
  - Pitch angle diffusion ($D_{\alpha\alpha}$)

\[
\frac{\partial f}{\partial t} = \frac{\partial}{\partial L} \left[ D_{LL} \frac{1}{L^2} \frac{\partial}{\partial L} \left( L^2 f \right) \right], \quad D_{LL} = \frac{\langle (\Delta L)^2 \rangle}{2}
\]

\[
\frac{\partial f}{\partial t} = \frac{1}{\sin \alpha} \frac{\partial}{\partial \alpha} \left[ D_{\alpha\alpha} \sin \alpha \frac{\partial f}{\partial \alpha} \right]
\]

Walt, [1994]

Horne et al. [2003]
Importance of B and E field models

- VERY IMPORTANT!!!
- Field models determine almost everything
- Model validation

Empirical model

Tsyganenko model

LFM MHD code

Global MHD simulation

Dipole field
What are they fighting for?

Balance between everything...

- Particle acceleration mechanisms
  - Internal and external heating mechanisms
  - Shock acceleration
  - Substorm injection
  - Recirculation, Jovian source, Cusp diffusion, SEP event
- Loss
  - Pitch angle diffusion
  - Coulomb collision
  - Magnetopause shadowing
- Transport
  - No-so-perfect field models
What are they fighting for?

Balance between everything...

- Particle acceleration mechanisms
  - Internal and external heating mechanisms
  - Shock acceleration
  - Substorm injection
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  - No-so-perfect field models

Reeves, 2007
Why is it so hard?

- **Observational difficulties**
  - Lack of measurements
  - Energetic particles are hard to measure
  - Converting particle flux to PSD is tricky
    - Because of not-so-perfect magnetic field model

- **Modeling difficulties**
  - Not-so-perfect magnetic and electric field model
    - Field configurations and wave fields
  - Limited understanding of wave-particle interactions
  - Limited computational resource
What would help?

- Better understanding of
  - Inner magnetospheric structure and dynamics
  - Wave-particle interactions
- Multi-spacecraft mission
  - Radiation Belt Storm Probes (RBSP)
  - Demonstration Science Experiments (DSX)
- Physics-based Modeling
  - Include all physical processes
Space Radiation Climatology

- Goal: produce data-assimilative models of the magnetically trapped plasmas and radiation belts.

- IM tutorial talk: Friday morning by Paul O’Brien, Aerospace, title: “Space Radiation Climatology: A New Paradigm for Inner Magnetosphere Simulation and Data Analysis”

- Four breakout sessions on Thursday and Friday
  - Intro to focus group
  - Radiation Belt Data and Simulations
  - Ring Current/Plasmasphere Data and Simulations
  - Strategy and planning session
Student sponsored tutorial talk

- **Harlan Spence**, Boston University
- Title: Radiation Belt Redux: Science Objectives of the RBSP Mission
- Tuesday morning