Session Summary – “Couplings Between Plasma Populations and Magnetic Field”

The sessions for this focus area, led by Sorin Zaharia and Colby Lemon, looked at the interaction between the plasma and the magnetic field in the inner magnetosphere.

Introductory presentations by Zaharia and Lemon summarized the tools used in investigating this coupling, from observations to empirical models and then focusing on numerical physics based models, which can a provide physical understanding of the causal chain of events. MHD models are fully self-consistent but not able to accurately describe the inner magnetosphere. Kinetic models (e.g. RAM, RCM, CRCM) have more physics, but are not as self-consistent; they use the slow flow approximation (valid in the inner magnetosphere on closed field lines) to reduce the phase space dimensionality from 6-D to 4-D (2 spatial + 2 velocity space) or 3-D (if isotropy is assumed). Recently self-consistency has been improved by calculating 3-D magnetic fields in force balance with plasma populations.

Invited presentations by Sazykin and Ebihara focused on aspects of B-field/plasma coupling in such models, i.e. the ability to portray features such as the substorm growth phase field stretching and the influence of self-consistency on pitch angle anisotropy.

A final presentation by Y. Zheng in the splinter session was followed by discussions, which led to defining what the main findings and outstanding issues in this area are.

Findings:

- Observations show that the magnetic field is significantly depressed vs. dipole in the inner magnetosphere during storms

- Simulations show that a strong ring current lowers the magnetic field; in its turn, the decreased field lowers the pressure (due to faster drifts) vs. simulations with a dipole

- The anisotropy is important; the Fermi acceleration is significantly enhanced during storms (due to shorter magnetic field lines), leading to butterfly-like PADs; anisotropy also leads to a difference in ENA intensity in polar vs. equatorial views.

- The storm-time induced electric field in the ring current region could be significant.

- Convection simulations that include plasma sheet show that plasma convection leads to a minimum in B_Z near $X = 12R_E$, until $pV^{5/3}$ is reduced by substorms or other processes.

Outstanding issues:

- Coupling to outer magnetosphere (IM models as modules inside global models) (RCM/ SWMF), in progress (RAM-SCB/SWMF, HEIDI/SWMF)

- Better self-consistency is needed; boundary dependence needs to be better quantified

- Modeling fast ($T < T_{bounce}$) events (e.g., 1-min. change of pitch angle seen by CLUSTER - Yamauchi); while RCM-E simulations (S. Sazykin) can model certain aspects of isolated substorms (as long as one stays away from the onset location), issues remain with how to include substorm effects (both field changes and particle injections) in models, and how to model substorms that occur during storms

- Better characterization of ion composition (can strongly influence plasma pressure)

- Understanding how fluctuating B (and E) fields impact the inner magnetosphere: effect of large scale, longer time (~ 5-min) induced E-field vs. faster variations

- Understanding the nature of instabilities that appear in simulations under strong driving, whether they are numerical or physical (e.g. ballooning, interchange, mirror).