Energetic electron, proton/hydrogen, and secondary electron interactions with ambient neutral species (N2, O or O2) make them the primary source of auroral emissions. Coupling, Energetic and Dynamics of Atmospheric Regions (CEDAR)/Phase III recently stated that proton studies offer an excellent means for investigating magnetospheric storms and magnetosphere-ionosphere coupling processes. Emissions from electron and proton aurora have been and continue to be observed from satellites (e.g., the Global Ultraviolet Imager (GUVI) aboard the NASA Thermosphere Ionosphere Mesosphere Energy and Dynamics (TIMED) and the Special Sensor Ultraviolet Spectrographic Imager (SSUSI) onboard Defense Meteorological Satellite Program (DMSP) satellites) and from ground-based observations. Examples of important features found in auroral emission spectra (80-800 nm) are the band systems for N$_2$ Lyman-Birge-Hopfield (LBH), N$_2$ Vegard Kaplan (VK), N$_2$ 2nd Positive Group (2PG), N$_2$ 1st Positive Group (1PG), and N$_2$+ 1st Negative Group (1NG). There is also a wealth of atomic lines, such as the O lines 98.9, 102.7, 130.4, 135. 6 nm. H emissions (H-Ly-alpha (121.6 nm), H-alpha (656.3 nm), and H-beta (486.1 nm)) from the excited H atoms resulting from the proton charge exchange with N$_2$, O or O$_2$ are a unique signature of the proton precipitation. It is crucial to separate electron and proton components of the precipitation in order to correctly assess ionosphere conductivity, heating, and composition changes. A review of emission cross sections for proton impact shows a dearth of data - the cross sections are either not reliable or undetermined. The lack of proton excitation cross sections seriously hinders remote sensing methods designed to specify energy deposition and ionization for proton-aurora that can possess significant energy fluxes depending on geomagnetic activity and location. The objective of this proposed laboratory program is to measure absolute UV and optical emission cross sections for proton impact on N$_2$, O, and O$_2$ from emission thresholds to 40 keV (a typical range in proton-aurora) for the following: (1) N$_2$ for Lyman-Birge-Hopfield (LBH) band system (100-280 nm), N I lines (120.0-175), First Negative band of N$_2^+$ (391.4 nm), and First Positive band of N$_2$ (visible 400-800 nm), (2) H for H-Ly-alpha (121.6 nm), H-alpha (656.3 nm) and H-beta (486.1 nm), and (3) O$_2$ and O for O I (98.9, 102.7, 130.4, 135.6 nm) and O$^+$ (463.9-469.6 nm).
Joachim Birn/Los Alamos National Laboratory
The Magnetsphere Under Low Mach Number Solar Wind

Low Alfvén Mach number solar wind produces a low thermal Beta magnetosheath downstream of the Earth’s bow shock. In a low Beta magnetosheath magnetic forces become dominant and the properties of the magnetosheath - magnetosphere interaction are altered. This is an overlooked effect which has implications of great importance. Recent observations have shown that such solar wind properties lead to intense, asymmetric magnetosheath flow accelerations. And such solar wind is associated with global sawtooth oscillations of the magnetosphere. This proposal focuses on the physics of the solar wind - magnetosphere coupling via the magnetosheath during low Alfvén Mach number solar wind. Four specific topics are addressed:
(1) Characterization of asymmetric fast flow accelerations in the magnetosheath as a function of upstream conditions;
(2) Investigation of the impact of asymmetric magnetic forces and flows on the shape and structure of the magnetopause;
(3) Investigation into the cause of anomalous magnetic field stretching of the dayside magnetosphere associated with sawtooth oscillations;
(4) Investigations of the dynamic effects of the extended stretching.
Data from key magnetospheric and solar wind science missions (Cluster, geosynchronous data, ACE) and local and global MHD simulations will be used.
This proposal directly contributes to NASA’s Strategic Goal 3.2: "Understand the Sun and its effects on Earth and the solar system."

Athanasios Boudouridis/University of California, Los Angeles
Comparison Of Dayside And Nightside Reconnection Changes Resulting From A Sudden Enhancement In Solar Wind Dynamic Pressure

Magnetic reconnection at the dayside magnetopause is the main process by which mass, energy, and momentum from the solar wind enter the terrestrial magnetosphere. Magnetic reconnection at the nightside energizes magnetotail plasma and closes the lobe open flux, thus completing the cycle that initiates and sustains magnetospheric convection. Understanding the drivers of reconnection in the magnetosphere is one of the primary goals of magnetospheric physics. It has long been recognized that the Interplanetary Magnetic Field (IMF) is the most influential factor in initiation of reconnection in the magnetosphere. Recent evidence has shown that the solar wind dynamic pressure plays also an important role in enhancing both dayside and nightside reconnection. Super Dual Auroral Radar Network (SuperDARN) observations show that solar wind pressure fronts induce significantly enhanced ionospheric convection in the dayside ionosphere. In parallel, Defense Meteorological Satellite Program (DMSP) precipitating particle measurements and POLAR Ultra-Violet Imager (UVI) images have demonstrated that sudden solar wind pressure increases also significantly affect the size of the polar cap. The polar cap is observed to shrink after an increase in solar wind pressure, especially on the nightside, suggesting an enhancement of magnetotail reconnection. MHD models of the interaction of the magnetosphere with solar wind pressure fronts have managed to reproduce the enhancement of dayside reconnection, but have failed so far to account for
the observed closing of the polar cap on the nightside and the suggested magnetotail reconnection increase. We propose to evaluate the relative strengths of the observed dayside and nightside reconnection enhancements after abrupt increases in solar wind dynamic pressure. For this purpose we will use SuperDARN observations of ionospheric convection within both the dayside and nightside polar cap ionosphere, including near the magnetic separatrix. We will evaluate changes in ionospheric convection after pressure enhancements for a number of selected events with appropriate radar coverage. We will use POLAR UVI images and/or concurrent DMSP particle measurements to determine the location of the open-closed field line boundary, estimate changes of convection in its vicinity, and consequently assess changes in the strength of reconnection on the dayside and nightside.

We plan to answer the following questions:
1) What is the relative effect of a solar wind pressure front on the dayside and nightside ionospheric convection?
2) What are the timescales of the observed variations on both sides?
3) How do the observed changes depend on the background IMF?
4) How does the reconnection response to a pressure change depend upon the existence and strength of a concurrent IMF change?
5) How do the day and night reconnection changes compare to each other and to the measured cross-polar-cap potential?
6) Can we identify a functional form connecting all three?

Anthony Chan/Rice University
Radiation Belt Modeling And Data Assimilation

The primary objective of the proposed effort is to significantly advance our understanding of the physical processes responsible for the storm-time variations of Earth's radiation belts.

We propose to use our existing dynamic radial diffusion model and also to develop new multidimensional radiation belt models. The new models would be based on numerical solution of stochastic differential equations (SDEs), which are mathematically equivalent to radiation belt Fokker-Planck transport equations. The SDE methods have significant advantages over standard finite-difference methods currently in use, including the ability to robustly and efficiently handle off-diagonal diffusion terms and complicated boundary conditions. We also propose to perform data-model comparisons using phase-space density data and Kalman-filter data assimilation methods. The data-model comparisons will be carried out in collaboration with Dr. Josef Koller of Los Alamos National Laboratory.

The proposed work is expected to contribute substantially to the primary NASA Research Objective to "understand the fundamental physical processes of the space environment," particularly the Earth's radiation belts. Because radiation belt particles are harmful to spacecraft and to humans in space, the proposed work would also contribute significantly to the NASA Research Objective to "develop the capability to predict the extreme and dynamic conditions in space in order to maximize the safety and productivity of human and robotic explorers."
**Mark Conde/University of Alaska**  
**Development Of A New Chemical Release Technique For Measuring Neutral Wind Velocity Gradients In Earth'S Auroral Thermosphere**

This is the lead proposal of a collaborative project with Clemson University that will explore the origins and consequences of small-scale wind gradients in Earth’s auroral thermosphere. Differential equations describing the time evolution of thermospheric wind and temperature fields also contain spatial derivatives of these same quantities. However, almost nothing is currently known about how these latter terms actually behave in the thermosphere at the relevant spatial scales. For example, recent results from the HEX rocket missions at Poker Flat showed strong spatial gradients in lower thermospheric winds during very quiet conditions, but no such gradients when the aurora was active. This finding directly contradicts current assumptions about how these wind gradients ought to behave.

To investigate this puzzle, we propose to develop a new way for a single sounding rocket to deploy into the thermosphere a complete three-dimensional “constellation” of around 60 independent wind-tracer clouds. The constellation would span around 100 km in diameter and, for the science of interest here, would extend from 110 km to 180 km in altitude. For other investigations, the bottom altitude could be dropped to as low as 80 km if required.

To enable this deployment, we will develop a compact and lightweight ejectable subpayload, carrying around 300 ml of liquid trimethyl aluminum in a sealed ampule. Visible tracer puffs would be formed in the atmosphere by exploding, under timer control, a few wraps of detonator cord wound around the ampule. This would shatter its envelope, and fragment the enclosed liquid into fine droplets that would quickly flash-vaporize in the low ambient pressure.

While deployment of the full 3D constellation is our eventual goal, work proposed here only extends to developing the subpayloads and testing them on two very simple sounding rocket flights, each deploying 16 ampules. Nevertheless, we discuss in detail how the full constellation could be deployed in subsequent missions, to demonstrate the feasibility of our overall objective.

The contribution to basic science of exploring this unknown regime of thermospheric weather is self-evident. More specifically, studying thermospheric wind gradients is of particular relevance to the Geospace Science program which, motivated by NASA’s Strategic Sub-Goal 3B, seeks to understand the fundamental processes occurring in the Geospace environment - of which Earth’s thermosphere is a key component.

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**John Dorelli/University of New Hampshire**  
**Understanding The Lifecycle Of Flux Transfer Events At Earth'S Dayside Magnetopause**

We propose a three year research program to study the generation, evolution and fate of Flux Transfer Events (FTEs) at Earth's dayside magnetopause. The program will make use of global resistive magnetohydrodynamics (MHD) simulations (using the
OpenGGCM code maintained at the University of New Hampshire's Space Science Center) to make predictions which are directly testable by spacecraft observations. In addition to making use of previously published analyses of observed magnetopause transients to test our simulations, we will perform new analyses using data from NASA's upcoming THEMIS mission (scheduled to launch later this year). Our research will focus on three basic questions: 1) How are FTEs generated? (e.g., Where do FTEs form? Are FTEs generated spontaneously or in response to solar wind triggers? Can solar wind pressure pulses produce a magnetopause response which might be mistaken by spacecraft probes as a signature of transient reconnection? How does the resistive tearing mode work in the inherently three-dimensional topology of Earth's dayside magnetopause? What is the effect of the global MHD resistivity model on FTE formation?) Q2: How do FTEs evolve on the magnetopause? (e.g., Once an FTE forms, what is its trajectory on the magnetopause? How long are FTEs? What is the magnetic topology of an FTE, and how does it change as the FTE evolves?); Q3: What is the ultimate fate of FTEs? (e.g., How far from their points of origin do FTEs travel? Do they eventually dissipate? If so, what is the dissipation mechanism, and how does it depend on the resistivity model in global MHD? How do FTEs interact with the polar cusps, if at all.

Our proposed research program is timely for two reasons: 1) present day computational resources are such that global MHD simulations can achieve spatial resolutions and Lundquist numbers comparable to more local simulations which have been used to test the various conceptual models of FTEs which have appeared in the literature; 2) the NASA THEMIS constellation will, by design, determine, via three solar wind probes (one in the foreshock, one in the "pristine" solar wind upstream of the foreshock, and one in the magnetosheath) and two magnetopause probes, the relationship between FTEs (and other magnetopause transients) and upstream solar wind conditions. Thus, for the first time, we are in a position to quantitatively address the physics of time-dependent magnetic reconnection in global resistive MHD models which fully resolve the subsolar magnetopause current sheet in the high Lundquist number limit. Moreover, with the launch of THEMIS, we will be in a better position than ever before to put our simulations to the test.

Jesper Gjerloev/Johns Hopkins University
Critical Test Of The Directly Driven Current System Concept

Summary
The rationale for the proposed research is based on the need to understand the response of the magnetosphere-ionosphere (M-I) system to southward turnings of the Interplanetary Magnetic Field (IMF). We will focus on periods of loading that is the period following a southward turning of the IMF and before the introduction of the substorm current wedge. During this period there is typically an imbalance between the magnetospheric energy input and output. This results in energy storage in the magnetotail as identified by a change in the magnetic field configuration. The objectives that will be addressed by the proposed study are:
1) What is the spatiotemporal behavior of the ionospheric currents on the dayside and on the nightside?
2) What is the spatiotemporal behavior of the field-aligned currents? Where and when are the ionospheric currents coupled to the magnetosphere through field aligned currents?
3) What is the characteristics of the current flow at the terminators (ionospheric currents as well as FAC's)? Are the dayside and nightside ionospheric currents coupled?
4) How is solar wind energy input related to magnetotail stretching/relaxation, the ionospheric currents and FAC's?

Our approach is to exploit considerable quantities of data from past and present space missions and ground-based facilities in newly developed analysis techniques to improve our understanding of a key portion of the magnetosphere-ionosphere current system. Solar wind data, magnetospheric observations, low altitude satellite measurements and ground data will be utilized to investigate the response of the magnetosphere-ionosphere system to solar wind transitions. Statistical average models will be deduced by a spatial and temporal organization of the data. We will use the magnetic latitude, magnetic local time and terminator location. Special emphasis on the terminators will provide knowledge of the coupling between the sunlit and dark ionosphere.

The recommended priorities of the heliophysics community are discussed in the decadal rapport for space physics, The Sun to the Earth - and Beyond: A Decadal Research Strategy in Solar and Space Physics. Of five main challenges the third states: "Challenge 3: Understand the space environments of Earth and other solar system bodies and their dynamical response to external and internal influences". The proposed study will address exactly this question by a careful analysis of the ionospheric electrodynamics and relating these to the solar wind driver and the magnetotail configuration.

Mary Hudson/Dartmouth College
Radiation Belt Electron Transport At Ultra-Relativistic Energies

The trapping of solar energetic protons to form new radiation belts is common around solar maximum in conjunction with the arrival of CME-generated interplanetary shocks which accelerate the proton source population to multi-MeV energies. This source population undergoes gradient curvature drift at velocities comparable to the impulse propagation speed associated with magnetopause compression (magnetosonic speed ~ 1000 km/s). Less common, but important for persistence and distinction between sources and energy dependent source mechanisms, is the formation of a > 10 MeV enhanced trapped electron component in the slot region around L = 2-3, where there is a depletion of relativistic electrons at lower energies due to wave-particle interactions. Once formed, such ultra-relativistic populations are long-lived because of the time scale for collisional and wave-particle induced pitch angle scattering and loss to the atmosphere, with the March 24, 1991 injection lasting for years (Looper et al., 2005).

More recent examples of ultra-relativistic electron injections have been found when simultaneous solar wind data was available (unavailable for March 1991). These will be modeled using a combination of MHD-test particle simulations and comparison with a radial diffusion model which includes losses. Recent advances in full Lorentz trajectory modeling of solar energetic electron access and trapping in 3D will be included, along with guiding center equatorial plane modeling of outer zone electron transport to lower L, accelerating electrons while conserving their first invariant. A plasmasphere will be
included in the MHD modeling to provide more accurate inner magnetosphere density structure which affects both transport and losses. Results will be compared with measurements from SAMPEX in a low altitude polar orbit, with additional measurements from Highly Elliptical Orbiter spacecraft (1994-026, with a 12 hour period covering L-values out to geosynchronous); with measurements from the Compact Environmental Anomaly Sensor (CEASE), launched on June 7, 2000 aboard the Air Force TSX-5 satellite into Low Earth Orbit (410 x 1710 km, 69o inclination); and with unique measurements from RHESSI, designed to image the sun in X-ray from a 600 km, 38 degree inclination orbit which extends up to L=2.7, providing electron spectral information up to 20 MeV.

This study will provide theoretical/modeling insight and techniques that can be directly applied to key LWS Radiation Belt Storm Probe scientific studies of relativistic electron sources and acceleration processes. The much more comprehensive RBSP data can then be directly incorporated into the formalism which we propose to develop and test with existing data sets.

**Konstantinos Kalogerakis/SRI International**

**Deactivation Of Highly Vibrationally Excited OH By Oxygen Atoms: Key Rates For Extracting Chemical Heating From Saber Observations**

SRI International proposes laboratory measurements of the removal rate constants of OH(v) by O and O2 at mesospheric temperatures. These measurements are essential in the modeling of atmospheric OH emissions and the determination of the chemical heating rate from measurements by the SABER instrument aboard the TIMED satellite.

Our recent studies have provided the first laboratory measurements on the interaction of OH(v = 9) with O and first quantitative measurements for N2 at room temperature, and the temperature dependence of the process OH(v = 3, 4) + O2. The rate constant for total removal of OH(v = 9) by O is more than an order of magnitude faster than that of O2 and N2, and thus O atoms strongly influence the intensity and the vibrational distribution extracted from the OH(v) emission at high altitude.

We propose to measure the temperature dependence of the rate constants for OH(v = 7, 9) removal by O and O2 at mesospheric temperatures, so that the rate data can be directly applicable to the OH emission region. We will use a combination of experimental approaches we have previously developed at SRI.

Accurate rates for the deactivation of the high-v states of OH at mesospheric temperatures are necessary to interpret the SABER data and determine the heating efficiency of the H + O3 reaction, a key factor in photochemical models of the upper atmosphere.

The proposed work contributes to the following NASA Objectives listed in The NASA Science Plan (2007), Table 2.1: (1) Understand the fundamental physical processes of the space environment from the Sun to Earth, (2) understand the role of oceans, atmosphere, and ice in the climate system and improve predictive capability for its future evolution, and (3) understand and improve predictive capability for changes in the ozone layer, climate forcing, and air quality associated with changes in atmospheric composition.
**Paul Kintner/Cornell University**  
*Development Of Inexpensive, Robust, Civilian Dual-Frequency Gps Technology And Instrumentation For Space Flight Experiments: Microgps*

The goal of this proposal is to develop robust, low-cost, remote-sensing GPS instrumentation that is responsive to the anticipated scientific objectives of candidate future geospace science missions, specifically inexpensive, lightweight, and low power dual-frequency GPS receivers that can be used in space flight applications. The new technology is made possible by new signals and codes that will become available with the GPS Block IIR-M and IIF spacecraft that will transmit two civilian codes on two frequencies: L1 and L2. Sixteen of the Bock IIR-M and IIF satellites are scheduled to be launched before 2010. These new signals enable more accurate and higher resolution measurements of tropospheric and stratospheric temperatures, ionospheric density profiles, and total electron content which open a window of applications to stratospheric, mesospheric, thermospheric, and ionospheric science questions. This new technology will enable critical measurements on candidate geospace science missions such as Geospace Electrodynamical Connections (GEC), Ionospheric-Thermospheric Storm Probes (ITSP), Ionosphere, Thermosphere, Mesosphere (ITM) Waves, and Tropical ITM Coupler. This proposal requests funding to develop a prototype, self-contained dual-frequency GPS receiver that includes design and implementation of the following elements: (1) a dual-frequency RF down converter for L1 and L2 with an A/D converter, (2) a DSP-based software receiver, and (3) integration onto a single board. This new receiver will be smaller, lighter, and use less power than current dual frequency GPS flight receivers. The state of this technology at Cornell University is a TRL level of 3-4. After the successful conclusion of this project the TRL level will be 5, suitable for proposing as an instrument in future Heliosphere missions. These new capabilities address three research focus areas (RFA) in the NASA Heliophysics Roadmap 2005-2035: RFA F.3, RFA H.2, and RFA J4.3.

**James LaBelle/Dartmouth College**  
*Correlated High-Frequency And Auroral Roar Measurements, 2. (CHARM-2)*

Plasma waves such as Langmuir, upper hybrid, and whistler waves, are prevalent throughout space plasmas. They can play a significant role in energy exchange between particle populations through wave-particle interactions, and they often provide local or remote sensing of plasma processes through measurements of cutoffs and resonances. For these reasons investigations of wave and wave-particle interaction physics are a high priority relevant to NASA's Heliophysics Division Research Focus Area of "Open the Frontier to Space Environment Prediction." Langmuir waves occur in many regions of the magnetosphere, solar wind, and ionosphere where electron beams are present, including along auroral field lines at rocket altitudes. Recent theoretical advances in Langmuir wave physics make predictions about the relation between wave E-fields and electron phase-space bunching associated with wave excitation or damping. We propose to test these predictions using a state-of-the-art wave particle correlator. Another ubiquitous space plasma process is mode conversion radiation whereby electrostatic waves excited by unstable particle distributions convert to radiation. Examples include
continuum radiation in Earth's magnetosphere and at other planets, many types of solar radio bursts, and auroral emissions including "roar," an emission near electron cyclotron harmonics generated at 275--600 km. Two previous rockets serendipitously measured "roar" source regions but not the resulting radiation. We propose to detect the radiation using a state-of-the-art digital receiver, and even if the sources themselves are not penetrated, these measurements will still give improved understanding of the emitted power, the mode conversion efficiency, and source locations and sizes. The results of these experiments will significantly improve confidence in theoretical treatments of Langmuir wave physics and mode-conversion radiation, an objective which has broad applicability to space plasmas and which can be best achieved with an instrumented rocket launched into the aurora from Alaska.

Guan Le/NASA Goddard Space Flight Center
Space Technology 5 Constellation Measurements Of Field-Aligned Current Variability

The Space Technology 5 (ST5) Project is part of the NASA's New Millennium Program (NMP). It is a constellation of three micro-satellites launched on March 22, 2006, operated successfully for its nominal 90-day mission, and completed decommissioning on June 30, 2006. Although the short 90-day mission is designed to flight validate new technologies, the constellation mission returned unprecedented measurements as they flew in formation and made simultaneous multi-point measurements of the magnetic field through dynamic ionospheric current systems. ST5 provided for the first time simultaneous multi-point measurements of field-aligned currents at low altitudes, which allow us to separate temporal and spatial variations of these currents. The data allow us to measure important physical parameters of field-aligned currents that cannot be unambiguously determined by single spacecraft, such as current sheet motion and thickness, electric current density, and temporal stabilities. The ST5 data will results in refined descriptions of field-aligned currents. Herein, we propose a three-year new project to disseminate fully calibrated ST5 magnetic field data to the community and to determine physical properties of FACs by separating spatial and temporal variations using the multi-point measurements. The main science objective of the proposed project is to understand the variability of field-aligned currents and its solar wind control using the unique data set of ST5 multi-point magnetic field measurements. The goal is to obtain a refined description of field-aligned currents that can be applied to future space weather modeling. Specifically, we propose to: (1) Quantify unambiguously the speed, the thickness, and electric current density of the field-aligned currents; (2) Determine how the solar wind conditions control the properties of the field-aligned currents; (3) Determine the temporal variability of the field-aligned currents in ~ 1 s - 10 min time scales; (4) Determine where and when thin and intense current filaments occur and if they are temporal or spatial variations.
Marc Lessard/University of New Hampshire
Rocket Experiment For Neutral Upwelling (RENU)

This proposal, entitled "Rocket Experiment for Neutral Upwelling (RENU)", M. Lessard
(Univ of New Hampshire), PI, is submitted to the ROSES-2007 Geospace Low Cost
Access to Space Program (NNH07ZDA001N-GEO) and is a multiple investigator
sounding rocket project for investigating neutral upwelling in the cusp with co-
investigators K. Lynch (Dartmouth College), P. Kintner (CornellUniv), J. Clemmons
and J. Hecht (Aerospace), and G. McHarg (Air Force Academy). We propose a FY
2010 launch in the winter of 2009/10 from the Andoya Rocket Range. RENU will transit
the cusp region during a neutral upwelling event, equipped with a suite of instruments
that will build on previous observations of this phenomena, as well as acquire new types
of data to provide a fresh perspective on this problem.
The RENU experiment is designed to provide new physical insight into the physical
processes associated with the upwelling of thermospheric gas in the Earth's magnetic
cusp. This phenomenon was first reported by Luhr et al., 2004 and was thought by those
authors to be due to small-scale Joule heating in the cusp. Since that report was
published, however, several other ideas have emerged which offer plausible explanations
for this phenomenon. The main objective of RENU is to distinguish the relative
contributions of each process. The competing mechanisms are:
1. Large-scale convection, with its associated Joule heating, may heat the neutral gas,
although the published results indicate that this process is likely not adequate.
2. Soft electron precipitation, whether originating from the magnetosheath or in
conjunction with Alfvénic aurora, may establish ambipolar electric fields, lifting ions
upwards and dragging neutrals in the process, or heat the neutral population directly.
3. Alfvén waves (i.e., Alfvénic aurora), may provide energy via Joule heating in a
manner similar to large-scale convection, although on much smaller scales.
4. Small-scale currents (observed by CHAMP and modeled by A. Otto) may drive
upwelling via ohmic heating, although this requires very strong currents, the order of
100's of micoramps per square meter or more, not observed very often in the cusp.
The RENU mission will address these issues by making measurements that are
complementary to existing data. Those measurements were performed on the CHAMP
orbiting platform, which does not have a full ionosphere/thermosphere diagnostic
package. RENU will complement those observations by making more comprehensive
measurements and by employing a trajectory that is primarily vertical. These
measurements include neutral, electron and ion temperatures as well as electric and
magnetic fields. These data will also be supported with auroral images acquired onboard
the payload.

Kan Liou/The Johns Hopkins University Applied Physics Laboratory
Study Of Diurnal, Seasonal, And Solar Cycle Variations In Auroral Conjugacy

Auroral display is a fundamental map of the Sun-Earth connection. Studying auroral
morphology and characteristics provides a means to understand this connection and
coupling between these distinct systems. Owing to geophysical constrain, there is a
paucity of information about the aurora Australis; current knowledge of the aurora is based primarily on Northern Hemisphere observations. Studying and comparing aurora Australis with aurora Borealis can improve our understanding of the auroral processes. The primary objective of this proposal is to address three outstanding questions: (1) What is the role of ionospheric instability effect in the equinoctial preference of geomagnetic activity? (2) Is the auroral sunlight effect ionospheric or magnetospheric? and (3) What is the extent of auroral conjugacy resulting from the effect of solar EUV illumination and Earth's nondipole magnetic field? These questions can be addressed more convincingly by considering the two hemispheres as a whole system. We will analyze more than 7-years' worth of near-global, multi-spectral FUV auroral images acquired from TIMED/GUVI and DMSP/SSUSI from both hemispheres. The major advantages of this proposal are (1) the use of a large number of near-global auroral images with unprecedented spectral and spatial resolution from the lesser-known Southern Hemisphere and (2) the quantitative inversion of images made at certain wavelengths can reveal characteristics of these precipitating particles such as their energy and the power they deposit in the upper atmosphere; case studies involving the TIMED GUVI imager have demonstrated the accuracy and utility of these inversions. The objectives of the investigation are consistent with the Sun–Solar System Connection Program Roadmap 2005-2035: "Open the Frontier to Space Environment Prediction: Understand the fundamental physical processes of the space environment - from the Sun to Earth, to other planets, and beyond to the interstellar medium." as quoted from 2005 Senior Review Report and also directly relevant to the Geospace Science program's target issue "Understand the response of the magnetosphere and the atmosphere to external and internal drivers (Goal II:SEC 1.c)."

Robert Lysak/University of Minnesota
Theoretical Studies Of Ulf Waves In The Magnetotail

Ultra-low-frequency (ULF) waves play a key role in the reconfiguration of the magnetotail, especially during magnetospheric substorms. Despite their potential importance, there has been little study of the propagation of these waves in a realistic geometry. Our main objective is to extend existing ULF wave models to include a proper magnetotail geometry, coupling the slab-like geometry of the tail itself with the dipolar geometry of the inner magnetosphere. We will build on two main models: a linear wave code in inhomogeneous dipole coordinates that treats the inner magnetosphere, and a fully nonlinear MHD model that treats the tail. Using these codes, we will investigate waves that are produced during magnetic reconnection and other tail dynamical processes and how they couple to the inner magnetosphere and ionosphere. We will also investigate the role these waves may have on the reconnection process itself. This research will support the nation's overall space weather effort, as well as addressing NASA strategic goal 3B and in particular research objective 3B.1 in studying fundamental plasma physics processes in the Earth's space environment and its application to other magnetospheres, e.g., Jupiter.
We propose study of several potentially important influences on the rate of magnetic reconnection. The distinguishing feature is that we address the reconnection problem in the presence of broad band finite amplitude fluctuations, i.e., turbulence. Most magnetized plasmas in space physics are affected by reconnection, and these systems often include turbulence of sufficient amplitude to contribute to the dynamics. Consequently, the context of the present research is relevant to solar, heliospheric and magnetospheric physics. We proceed numerically, using accurate spectral method codes, and Particle-In-Cell hybrid kinetic plasma codes, and ask: (i) How does the magnitude of the Hall effect term in Ohm's law influence the rate of reconnection? (ii) How does the magnitude of background MHD-scale turbulence influence the rate of reconnection? (iii) How do variations of the resistivity (Parker-Sweet reconnection rate) and guide field strength, affect the above issues? and (iv) To what degree do the answers to (i)-(iii) depend upon whether the numerical experiments are carried out with Hall-MHD or with PIC-hybrid codes?

We will address these questions using well-established and highly accurate spectral method 2.5 D and 3D compressible Hall MHD codes, and 2.5D hybrid codes (fluid electrons, PIC ions). We plan a systematic four dimensional parameter study, varying Hall parameter, turbulence level, guide field strength, and Reynolds numbers, as well as relevant resolution studies and control cases. This subject addresses 2006 NASA Strategic Goals, especially Subgoal 3B: Understand the Sun and its effects on Earth and the solar system, and further, 3B.1. Progress in understanding the fundamental physical processes of the space environment from the Sun to Earth to other planets, and beyond to the interstellar medium. It also addresses the Heliophysics Research Focus Area: Open the Frontier to Space Environment Prediction: Understand the fundamental physical processes of the space environment. and specifically area F1: Understand magnetic reconnection as revealed in solar flares, coronal mass ejections, and geospace storms, as given in the recent 2005 Heliophysics Roadmap.

The proposed work is relevant to: (1) Recent Geospace missions such as Polar, Wind and Cluster that have revealed key signatures of reconnection, (2) The upcoming Magnetospheric Multiscale Mission (MMS) mission that intends to provide conclusive answers to central questions concerning reconnection's influence on Solar wind-Magnetosphere couplings. (3) The Geospace Environmental Modeling (GEM) reconnection challenge that led to considerable advances in understanding the role of kinetic physics in the reconnection process.

A new multi-fluid version of the Lyon-Fedder-Mobarry (LFM) global magnetospheric model will be used in conjunction with the Rice Convection Model (RCM) to determine the impact of ionospheric heavy ion outflows on the evolution of the stormtime
magnetosphere. The project will focus on the following three areas: 1) the composition and dynamics of the near-earth magnetotail and plasma sheet, 2) effects of heavy ions on global convection and current systems, and 3) the day side magnetopause processes, including the development of boundary oscillations. To this end, we will utilize the recently developed multi-fluid extension to the LFM model coupled to the RCM model of the inner magnetosphere, combined with a set of empirical models of ion outflows. Thus both the electrodynamic and mass coupling between the magnetosphere and ionosphere will be simulated, which is crucial for an accurate description of the stormtime magnetosphere. This investigation contributes directly to achieving NASA's Research Objectives 3B.1, 3B.2, and 3B.3. The science questions raised and addressed in this project benefit directly NASA future mission planning (MMS, GEC, and TWINS missions, and LWS Radiation Belt and IT Storm Probes) as well as missions already in operation (Polar, Cluster, THEMIS). This project makes an important advance in global magnetospheric modeling by including heavy ion dynamics, proper description of the inner magnetosphere region, and a realistic representation of the ionospheric ion source.

Shin-ichi Ohtani/The Johns Hopkins University Applied Physics Laboratory
Statistical Characteristics Of Plasma-Sheet Ions: Storm-Time Equatorial Distributions

The ultimate goal of this project is to provide a better understanding of plasma-sheet ions as an imminent source of the storm-time ring current. The maximum storm intensity is well correlated with the plasma-sheet ion density, which strongly depends on the IMF orientation. O+ ions are an important constituent of the storm-time ring current, and the O+ flux significantly increases during storm-time substorms, which can be attributed to the energization and injection of pre-existing O+ ions in the near-Earth plasma sheet. Here the pre-storm O+ population should be dependent on ionospheric conditions and therefore on solar phase. Thus, for better understanding the characteristics of plasma-sheet ions in terms of storm dynamics, it is crucial to carefully consider various external and internal factors.

In this project we will observationally address the following questions:
1. How do the distributions of the ion density, temperature, pressure in the plasma sheet change during the course of magnetospheric storms? How do they depend on the external driver (e.g., the IMF BZ polarity of magnetic clouds)?
2. How are the O+ pressure and temperature distributed in the plasma sheet at geomagnetically quiet time? How do they depend on the solar phase?
3. How do the storm-time distributions of plasma-sheet O+ pressure and temperature differ from the quiet-time distributions? How do they change during the course of magnetospheric storms?
4. How differently are O+ and H+ ions are distributed in the plasma sheet? How does the O+-to-H+ pressure (energy density) ratio depend on solar phase, location, storm intensity, and storm phase?

We will address each question by examining the synoptic distribution of relevant parameters, which we will deduce from measurements made by the Geotail EPIC/STICS (9-210 keV) and LEP (32 eV - 39 keV) instruments in the near-Earth (r = 9-31 RE) tail. The data has been collected for more than one solar cycle. For Question 1 we will
examine the equatorial distributions of the total ion density, temperature, and pressure. We will examine CME-driven storm events separately from CIR-driven events, which will be further divided in terms of the polarity of the IMF BZ change. Based on the total pressure distribution we will also address the storm-time tail current distribution. For Question 2 we will examine the equatorial distributions of the O+ temperature and pressure at geomagnetically quiet time for different solar phases. A regression analysis will be carried out with respect to F10.7 for spatially binned measurements. The result will be used as a reference for addressing Question 3. For this question we will examine how the O+ pressure and its equatorial distribution change during the course of magnetospheric storms. Based on the result we will also address the ionospheric area of the O+ outflow (i.e., cusp vs. nightside auroral zone) and the so-called two-step storm development. For Question 4 we will not only compare the H+ and O+ distributions but also examine the O+-to-H+ energy density ratio. By addressing these four questions we will provide a synthetic perspective of plasma-sheet ions as a source of the storm-time ring current. The results should also be useful for setting outer boundary conditions for modeling efforts of the storm-time ring current.

Each of the proposed tasks is straightforward, and it does not require any major development of software. The Geotail data set has been proven in both quality and quantity. Therefore the associated risk is extremely low, and this project is highly feasible.

This project is in accord with the NASA's Strategic Goal. Its results will contribute to a better understanding of the storm-time ring current dynamics, which is crucial for the science goal of the NASA's RBSP mission. The characteristics of plasma-sheet ions are important for tail reconnection, which is the primary target of the THEMIS and MMS missions.

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**Nojan Omidi/Solana Scientific Inc.**

**Impact Of Emic Waves On Precipitation Of Ions And Relativistic Electrons**

Electromagnetic ion cyclotron (EMIC) waves play a significant role in the non-adiabatic dynamics of ring current ions and relativistic electrons. We propose a three year research program to investigate the properties and the effects of EMIC waves. Specifically, our emphasis is on plasma acceleration and loss processes which are mediated through nonlinear wave-particle interactions. The primary tool of investigation is the electromagnetic hybrid code in which ions are treated kinetically while the electrons form a massless fluid. To investigate the effects of EMIC waves on the dynamics of relativistic electrons, test particle calculations using the electromagnetic fields obtained from the hybrid simulations are planned. To achieve our objectives, we have devised a plan of study which addresses the following questions: (i) What are the effects of multiple ion species and other plasma parameters on generation and nonlinear evolution of EMIC waves? (ii) What are the effects of density gradients associated with the plasmapause or plumes on EMIC waves and their nonlinear evolution? (iii) How does wave propagation in the presence of density and magnetic field gradients influence wave growth and saturation and spectral properties? (iv) What is the response of relativistic electrons to the presence of EMIC waves? These objectives are directly relevant to the NASA strategic goal 3.B to "Understand the Sun and its effects on Earth and the solar system" and the
research objective "to understand the fundamental physical processes of the space environment" stated in Mission Directorates 2007 Science Plan. These objectives also address major science questions to be investigated by NASA's two Radiation Belt Storm Probes (RBSP) and provide a theoretical background for the analysis and interpretation of the fields and particle data from these spacecraft.

David Ortland/NorthWest Research Associates
Model Studies Of Gravity Wave And Tide Dynamics In The Mesosphere And Lower Thermosphere

The study proposes to examine the dynamics of gravity waves in the Mesosphere and Lower Thermosphere by performing high-resolution model experiments that resolve gravity waves with horizontal scales of a few hundred kilometers and vertical scale of 2-3 km. These experiments will help us to understand how to constrain gravity wave parameterizations that are currently in use. We will use high resolution TRMM measurements of tropical convection to realistically force a spectrum of gravity waves. We will also examine the dynamics that control the variability in tidal amplitude. This includes the role that gravity waves may play in the variability as well as a detailed look at of the tidal component forced by ozone heating in the stratosphere. Understanding these dynamical issues will improve our ability to predict weather and climate in the space environment and deepen our understanding of the coupling between different regions of the atmosphere. Data assimilation techniques will be a necessary part of that predictive capability. This study will also develop techniques for assimilation of tide data into steady and time-dependent tide models. These techniques incorporate the dynamics investigated in this study in an essential way.

Philip Pritchett/University of California
Collisionless Magnetic Reconnection At The Magnetopause: Kinetic Determinants Of "How?, When?, And Where?"

The magnetopause serves as the primary coupling site between the solar wind and the magnetosphere, and it has long been established that (collisionless) magnetic reconnection is the dominant transport mechanism at the magnetopause for southward IMF. Despite significant advances in recent years in the understanding of the basic microphysical processes that drive reconnection, there are many crucial questions that remain unanswered as to how, when, and where reconnection operates at the magnetopause. Magnetopause reconnection is complicated by several unique configurational aspects: it operates between two topologically distinct regions (the shocked solar wind and the magnetosphere) with separate plasma properties, it is subject to direct influences from the solar wind in the form of imposed electric fields, guide magnetic field components, and velocity shears, and it operates amidst a plethora of plasma waves and turbulence that are either locally generated or transported through the bow shock. This proposal will employ large-scale, open geometry 2D and 3D particle-in-cell simulations supplemented by Vlasov theory to probe these characteristic features of magnetopause reconnection. The aim will be to bridge the gap between our understanding of basic reconnection theory in simple configurations such as the Harris
current sheet and the complex nature of reconnection at the magnetopause. Specific issues to be resolved include the effect of the asymmetric current sheet configuration on the underlying reconnection rate and structure of the diffusion region, the effect of guide field strength and orientation (i.e., the magnetopause clock angle) on the reconnection properties, the effect of velocity shear on reconnection near the cusps, the effects of magnetic field stochasticity and percolation on reconnection in 3D, the effects of magnetosheath turbulence on the magnetopause structure and time variability, and the role that nonresonant mode conversion at the magnetopause might play in driving reconnection. The results of the proposal will be directly relevant to the upcoming Solar-Terrestrial Probe mission Magnetospheric MultiScale (MMS), one of whose chief aims is to understand magnetopause reconnection. The investigations should also prove helpful to interpreting THEMIS observations during the initial "pearls on a string" orbit phase as the satellites swing through the dayside region.

Michael Shay/University of Delaware
Magnetic Reconnection In The Earth'S Magnetosphere: Diffusion Region Structure And Its Impact On Reconnection

Magnetic reconnection plays an important role in the Earth's magnetosphere, mixing solar wind and magnetospheric plasma and driving global convection. However, there are still very basic unanswered questions regarding reconnection in the magnetosphere. This proposal focuses on two of them: (1) What impacts the presence and structure of the newly discovered two-scale electron diffusion region during reconnection? (2) What controls the structure and properties of the non-MHD diffusion region during asymmetric reconnection? These questions will be addressed with kinetic particle-in-cell (PIC) simulations and two-fluid simulations of reconnection, whose results will be directly compared with observations of reconnection events in the magnetosphere taken from Polar, Cluster, and Themis data. The impact of this study will be to greatly enhance our knowledge of the diffusion region during reconnection in the Earth's magnetosphere, which plays a fundamental role in the interaction of the solar wind with the Earth's magnetosphere. This proposal, therefore, directly addresses Research Objective 3B.1 in NASA's Science Plan and is a necessary step towards Research Objective 3B.3. The proposed research is also critical for planning and instrument development for the Magnetospheric MultiScale mission (MMS), which is devoted to studying magnetic reconnection in the magnetosphere. The following key MMS science question is directly addressed in this proposal: What are the kinetic processes responsible for collisionless magnetic reconnection? The study of these kinetic processes must focus on the boundary layer where the frozen-in condition is violated (the diffusion region) because it is here that magnetic reconnection is enabled. Therefore, the structure of the diffusion region and its effects away from the X-line must be understood so that the design and implementation of the scientific instruments on MMS will be optimized for the expected signatures.
Anatoly Streltsov/Dartmouth College
Low-Altitude Plasma Electrodynamics Accompanying Intense Magnetotail Power Flows

We are proposing to investigate redistribution of the ionospheric and magnetospheric plasma by the intense, ultra-low-frequency (ULF) electromagnetic waves and the feedback of this plasma redistribution on the electrodynamic coupling of the magnetosphere-ionosphere (MI) system. Intense electromagnetic fields, currents, ion fluxes, and density structures are frequently observed by satellites, sounding rockets and ground radars in the auroral and subauroral magnetosphere. To understand a casual connection between these phenomena we would like to investigate the following questions: (1) Under what conditions do intense ULF electromagnetic waves produce significant disturbances of the plasma density and parallel ion motion in the Earth's ionosphere and magnetosphere? (2) How does the spatiotemporal features of these density disturbances depend on the frequency, amplitude, and transverse scale-size of the ULF waves, as well as on the other parameters of the magnetosphere and ionosphere? (3) What are the feedback effects of the restructuring of the ionospheric-magnetospheric plasma on the electrodynamic coupling of the ionosphere and magnetosphere at high latitudes?

The research will be based on numerical simulations of a family of numerical models describing non-linear coupling between shear and slow MHD waves in a multi-component, strongly inhomogeneous, magnetospheric plasma. These models will be implemented in two and three spatial dimensions and they will include effects of plasma microturbulence and the ionospheric activity leading to a so-called ionospheric feedback instability. Recent successes in the numerical modeling of these geophysical processes achieved under the previous NASA ITM NNG04GE22G award will be extended in the proposed project.

The proposed research is directly related to the NASA's Research Objectives 3B.1 and 3B.3 described in the 2006 NASA Strategic Plan. In particular, this research will significantly contribute to understanding the fundamental physical processes of space environment from the Sun to Earth, and to developing the capability to predict the extreme and dynamic conditions in space. Also, the numerical models developed during this project can be used to interpret/analyze data from the current NASA missions such as FAST, Polar, Cluster, and THEMIS and to support the planning of future missions such as MMS and Geospace Electrodynamic Connections.

Yi-Jiun Su/University of Colorado
Generation Of Auroral Radiations Through Alfvénic Accelerated Electrons

The proposed investigation is to study the electron cyclotron maser instability which powers various radiation sources observed from magnetized planets, such as auroral kilometric radiation (AKR) from Earth's auroral region, Jupiter's decametric radiation (DAM), and solar microwave bursts associated with solar flares and active solar region. This mechanism is also believed to be important for planetary radio emission from the other outer planets as well as various stellar radio bursts. To date, the most successful
explanation for the generation of AKR is the cyclotron maser driven by an unstable shell electron distribution directly produced by static parallel electric fields in the upward current region of Earth's auroras. However, the generation mechanism of narrow-band short-burst radiations is still not well understood. Recently, we were able to successfully reproduce observed unstable electrons distributions, candidates for electron cyclotron maser, driven by Alfvénic perturbations with a gyrofluid model incorporating a test particle scheme. However, particles and waves were not self-consistently coupled together in these simulations. Moreover, the spatial scale of the simulation was too large to allow us to study the kinetic aspect of electron cyclotron maser. Hence, we propose to numerically investigate the cyclotron maser instability associated with Alfvénic accelerated electrons observed from the FAST satellite by utilizing a self-consistent 2D electromagnetic particle code. With in-situ observations, we will be able to provide observed electron distributions in the Alfvénic acceleration region as input parameters for our simulations. We intend to make progress toward answering the following questions: (1) Are the multiple-shell electron distributions and electron conics the common features at which short-burst radiations are observed simultaneously with Alfvénic perturbations? (2) What are the local plasma conditions? (3) What are the growth rates of maser instabilities from various observed electron distributions in the Alfvénic acceleration region? (4) How does the Alfvén wave driven cyclotron maser instability apply to the Jupiter's plasma environment? Can it explain the generation of Jovian S-bursts? The proposed study is directly relevant to the NASA Heliophysics research objective "Understand the fundamental physical processes of the space environment from the Sun to Earth, to other planets, and beyond to the interstellar medium." This proposed investigation will not only enhance our knowledge of the fundamental physics of auroral related processes on Earth, but will also serve to further our understanding of similar processes on other less explored planets. Results from this proposed simulation investigation will be sought for verification of such mission.

Richard Walterscheid/Aerospace Corporation
Wave And Wave Generated Events In The Upper Mesosphere And Lower Thermosphere And Their Effects On The Background Structure

The upper Mesosphere and Lower Thermosphere (MLT) is a region of the atmosphere where the mean-state is largely controlled by waves, and wave-driven process. Wave instabilities related to wave breakdown play a key role by inducing wave drag and mixing. Large amplitude wave events can cause widespread changes in the state of the atmosphere. Wave-wave instabilities may explain elevated power at high frequency and be related to occurrences of high frequency waves that cover large regions of the sky. Characterization of these processes is essential for a comprehensive understanding of the MLT. Here we propose a theoretical study supported by data analysis to address outstanding questions concerning the role of wave events and instabilities in the MLT. We propose to characterize the propagation of large amplitude waves and their effects on the background state, the conditions that favor convective, dynamical and wave-wave instabilities, and the excitation and evolution of events that suggest mesospheric bores. Certain wave events are important in that they are the signature of potentially catastrophic events at the Earth's surface. Waves excited by tsunamis seen in the
ionosphere or airglow may provide a measure of warning through use of an inexpensive array of instruments.

The specific objectives of this proposal are to assess
- The comparative importance of dynamic, convective and parametric instability in the degradation of large amplitude waves and the forcing of the mean state
- The generation of secondary waves by parametric and related instabilities
- The formation of phenomena suggestive of bores in the MLT
- The MLT signature of waves excited by tsunamis

To accomplish our goals we will use theoretical modeling supported by data analysis. We will use existing numerical models and extensive data sets at diverse locations. The G/SR&T program supports studies of the Earth's upper atmosphere through theory, simulation, modeling, and analysis of space data. The goals of this research are responsive to and support the NRA NNH07ZDA001N-GEO aims in the area of coupling between the ionosphere and thermosphere (events coupled to potentially catastrophic events at the Earth's surface), the conditions favoring Polar Mesospheric Cloud formation (through wave forcing of the high latitude polar mesosphere), the prediction of extreme conditions for space exploration and return (the entry and re-entry environments during extreme wave events). It also addresses the climate forcing by waves in the upper mesosphere and lower thermosphere. This proposal supports the goals of upcoming future space missions with Geospace focus including Geospace Electrodynamim Connections and Aeronomy of Ice in the Mesosphere and Coupled Ionized and Neutral Dynamics Explorer

This proposal addresses the NASA Thermosphere Ionosphere Mesosphere Energetics and Dynamics mission. Gravity waves have a profound effect on the state of the TIMED core region.

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**Qian Wu/NCAR**

**High Altitude Interferometer Wind Observation (HIWIND)**

We propose to build a balloon-borne Fabry-Perot Interferometer (FPI) to observe the daytime thermospheric winds over the polar cap and to answer the question: whether our current understanding of the thermosphere-ionosphere coupling is accurate and complete. It is believed that the polar cap thermosphere is strongly affected by the magnetosphere through ionosphere-thermosphere interaction. The thermosphere neutrals are dragged by the ions, which are driven by the cross-polar cap potential. The cross-polar potential is a direct result of the solar wind dynamo. The ion and neutral collision is an energy transfer process from the ionosphere to the thermosphere. Part of the energy is transformed to the neutral kinetic energy causing an increase of the neutral wind speed; other part of the energy is converted to the heat. Joule heating raises the thermosphere temperature, causes upwelling, and changes thermosphere composition and ion density. The high latitude ionosphere-thermosphere interaction has a great impact on the global thermosphere circulation. The lack of daytime thermospheric wind observations has left many uncertainties in theories and modeling results on the thermosphere-ionosphere coupling. Our proposal to provide daytime thermospheric wind measurements will help to answer some questions about thermosphere-ionosphere interaction. Such effort belongs to the NASA G/Space program. The G/Space program overview states: “The
goal of the G/Science program is to understand the space that surrounds and is influenced by the various solar system bodies. These studies range over regions that begin with the Earth’s upper atmosphere, including the mesosphere and thermosphere, and extend outwards through the ionosphere, into, and beyond the magnetosphere.”

To achieve a better understanding of ionosphere-thermosphere interactions, we must know the thermospheric winds for accurate estimation of the Joule heating. Ground based FPIs are able to measure the thermospheric winds during nighttime by monitoring nightglow from 250 km altitude with an accuracy of a few m/s. Ground based FPI measurements of daytime thermospheric neutral winds have extremely large errors due to the high background from the sunlight. Consequently, there are no northern polar cap thermospheric wind observations during summer. The seasonal ionosphere density difference can lead to difference in ionosphere thermosphere interaction. The proposed balloon-borne FPI will be able to fill in this critical data gap by providing the much needed summer polar cap thermospheric neutral wind data. A balloon-borne FPI will not be strongly affected by the scattering of the sunlight.

We plan to build the FPI and the gondola, fly the instrument out of Kiruna, Sweden for 4-5 days then analyze the data in this three project. We will focus on Joule heating, ion-neutral collision frequency, inter-hemispheric comparisons, and inter-seasonal comparison.

Yihua Zheng/The Johns Hopkins University Applied Physics Laboratory

Modeling Ring Current Dynamics With Self-Consistent Electric And Magnetic Fields

The ring current constitutes a critical and active element of the inner magnetosphere. It plays a pivotal role in the dynamics of the inner magnetosphere, magnetosphere-ionosphere coupling, plasmaspheric interaction with hot plasmas and radiation belt dynamics.

We propose to develop a self-consistent physics modeling approach for the ring current region and the underlying ionosphere by coupling a bounce-averaged kinetic ring current model (CRCM) with a three-dimensional (3-D) plasma force balance code. The resulting model will achieve self-consistency in both magnetic and electric fields, and at the same time provide full pitch angle information of the ring current plasma.

Our objective is to make good progress in furthering our physical understanding of the ring current (primary) and the coupled ionosphere (secondary) by answering these three questions:

a. What is the role of the self-consistent feedback between electromagnetic fields and plasmas in the global dynamics of the ring current, such as its pressure and pressure/flux/temperature anisotropy?

b. What is the global, 3-D distribution/structure and evolution of the inner magnetosphere electromagnetic fields and how does the ring current affect their dynamic evolution?

c. How does self-consistency in fields and plasma affect the coupled ionosphere in terms of region 2 field-aligned currents and ionospheric ion drifts?

Methodology:

1. Implement two-way coupling of the CRCM and the 3-D force balance code.
2. Perform both global and in-situ comparisons between model results and data, constraining model parameters and validating model results.

3. Extract 3-D maps of plasma, electric field and magnetic field, both on an event basis and statistical (parameterized by solar wind/IMF parameters and/or magnetospheric activity indices).

The completion of this project will bring our understanding of the coupled inner magnetosphere and ionosphere system to a higher level. This project will lead to global self-consistent three-dimensional distributions of plasma, E and B fields in the inner magnetosphere, which will be provided for community use. The fundamental physics problems that we aim to address in this proposal span over many disciplines and can be applied to other planetary magnetospheres.

The expected outcome of this project will be a better and quantitative assessment of the ring current and the underlying ionosphere. It is directly relevant to NASA Strategic Subgoal 3B: “Understand the Sun and its effects on Earth and the solar system”. It is also in-line with the NASA Science Outcomes 3B.1, that is, to make “Progress in understanding the fundamental physical processes of the space environment from the Sun to Earth, to other planets, and beyond to the interstellar medium”. The expected results of this proposal will also help define scientific objectives of the future NASA mission RBSP and will directly benefit the existing NASA missions TWINS and THEMIS.