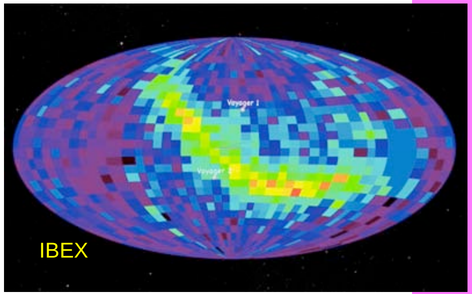
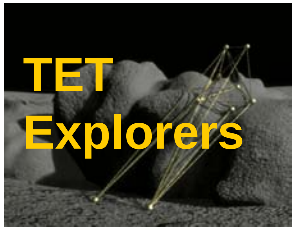


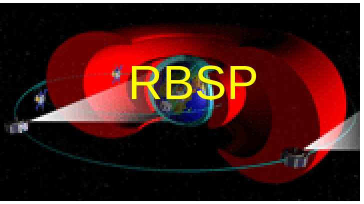
A SCIENCE OVERVIEW

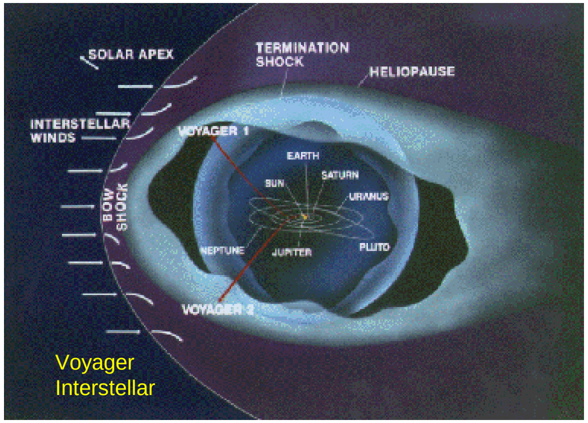
Steve Curtis

Code 690 All Hands

14 APRIL 2010







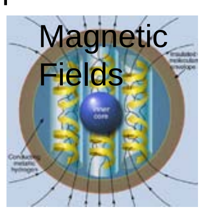
BUSINESS AREAS

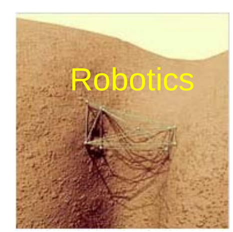
1. SOLAR SYSTEM MAGNETIC FIELDS The Planetary Magnetospheres Laboratory has been the source for flight magnetometers for nearly 4 decades. Magnetometers from the this Laboratory have flown to every planet in the Solar System , including the Earth's Moon.

2. SOLAR SYSTEM RADIO ASTRONOMY Radio Astronomy has been a key research area in the Planetary Magnetospheres Laboratory since the 1960's. The principal targeted research areas are planets and the sun together with its outer atmosphere known as the heliosphere.

3. PLANETARY DUST AND PLASMA PHYSICS Planetary dust and plasma interactions at the Moon and at Mars represents one of the key problems for the exploration of these bodies due to its adherence to and obstruction of surface operations. Planetary dust is also a key to understanding the formation and evolution of planetary surfaces. In the Planetary Magnetospheres Laboratory, building on the expertise in plasma interactions, research is being conducted on the nature of dust charging, which is central to dust dynamics, as well as the mitigation of dust by plasma interactions which may control not only electrostatic dust interactions but also van der Waal's force driven dust interactions.

4. SOLAR SYSTEM EXPLORATION Space Autonomous Systems In the research of the Planetary Magnetospheres Laboratory, as in all other areas of space research, there is an increasing need for intelligence, mobility, and adaptivity. This capability has become just as important as the need to new instruments, and in some ways is more important since if the payload can not be placed and operate where it is needed, the payload's research capability is of little consequence. The ability to place complicated instruments in difficult places in a cost effective manner in which they may have to act alone or autonomously, is of increasing importance.





PERSONNEL

- **Steve Curtis-** chief, planetary dust mitigation, solar system formation, autonomous architectures
- **James Daniel** - secretary, website,graphics

- **Jack Connerney** -planetary magnetometry
- **Ron Oliversen** -planetary astronomy, magnetometry
- **Jim Odom –** lead magnetometry technician
- **Dave Sheppard –** lead electronics engineer
- **Rick Schnurr –** overall magnetometry hardware lead
- **Pat Lawton** – magnetometer ground operations and data

- **Bill Farrell** -lunar dust characterization,planetary radio astronomy, search coils
- **Telana Jackson** - planetary and terrestrial dusty plasmas
- **Haydee Aquilar** – lead technician
- **Rosemary Killen** – planetary exospheres

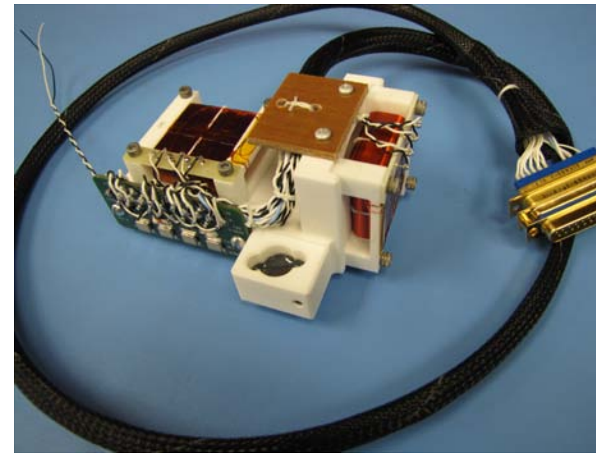
- **Bob MacDowall** - radio astronomy, solar and planetary, heliophysics magnetometry
- **Mike Collier**- lunar, NEO, planetary, interplanetary plasma environments

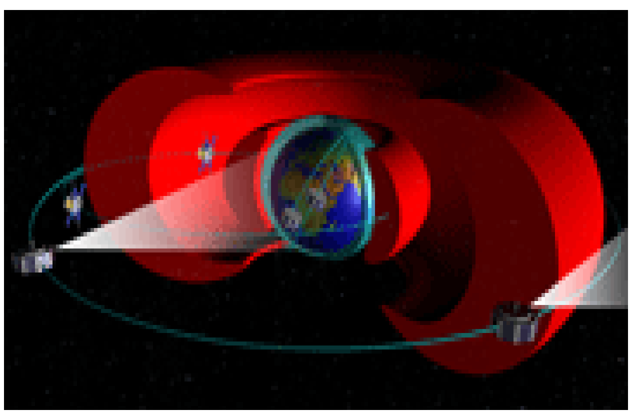
- **Joe Grebowsky** - planetary atmospheres and ionospheres
- **Jared Espley** - planetary atmospheres, ionospheres, magnetic fields

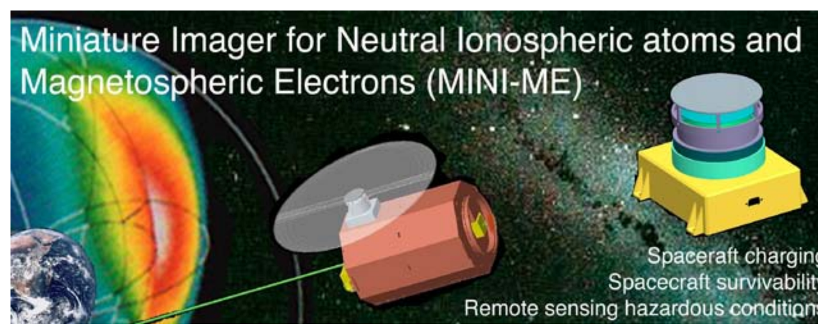
- **Cynthia Cheung** - flight science data systems, EPO
- **Fred Minetto** – dust/electron beam interactions, EPO, mag test site, autonomous architectures

on going flight instrument builds

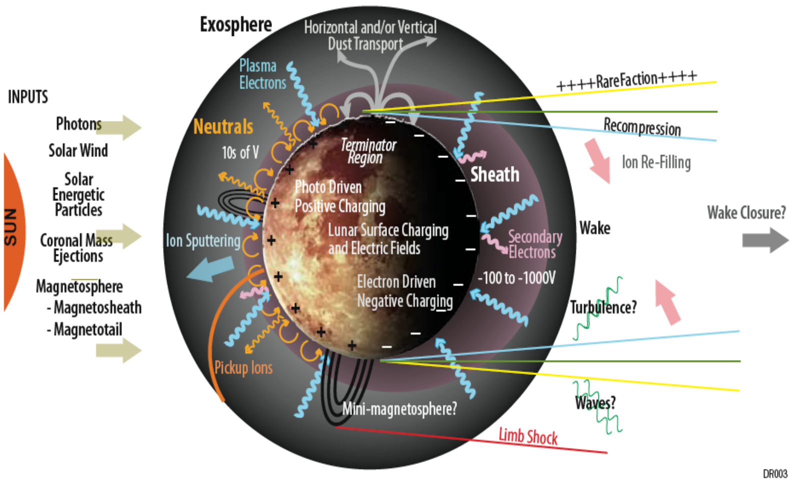
- Juno - magnetometer
- Radiation Belt Storm Probes - magnetometers
- MAVEN (Mars) – magnetometers
- DSX (DoD) – search coils
- FASTSAT – neutral atom imager







MAJOR ROLES ON NLSI RESEARCH TEAMS



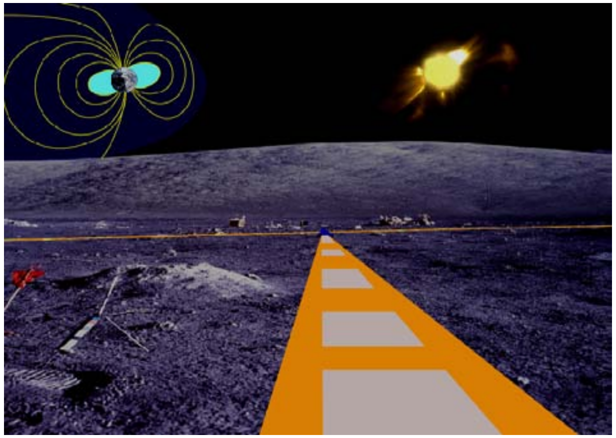
LUNAR (Lunar University Node for Astrophysical Research) PI: Jack Burns/ UC Boulder - Lunar Low Frequency Radio Astronomy – *Co-I: Bob MacDowall*

- Terrestrial –severe noise over nightside due to human sources , restricted by ionospheric absorption over day side
- Galactic “background” – complex spectrum; diffuse electron emission peaks ~3 MHz
- Example: Complete Jupiter radio observations at low frequencies

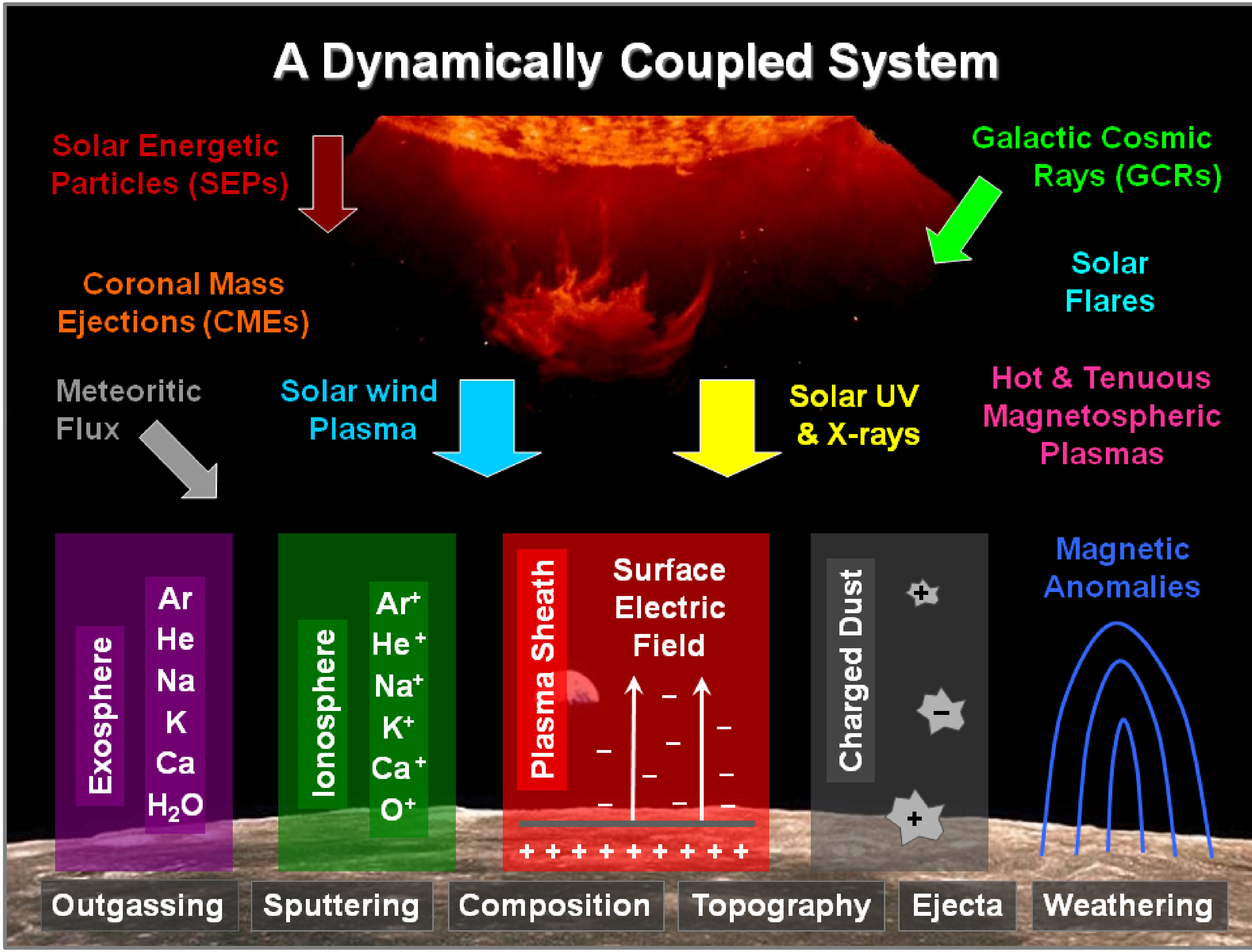
DREAM (Dynamic Response of the Environment At the Moon) – *PI: Bill Farrell*

DREAM is a theory, modeling, and data validation effort that will reveal, advance, and test extremes of the solar-lunar environmental connection. It will be a center of environmental knowledge to:

- Guide future missions
- Determine the viability of lunar observational platforms
- Provide critical information that will result in optimal decisions for safe and environmentally sound exploration
- Train the next generation of lunar scientists.

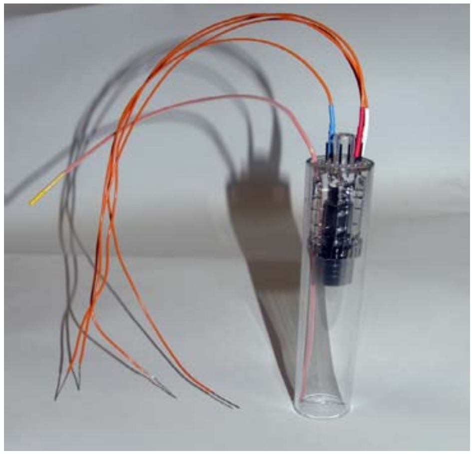


Roll-out Antenna



A Dynamically Coupled System
Solar Energetic Particles (SEPs)
Galactic Cosmic Rays (GCRs)
Coronal Mass Ejections (CMEs)
Solar Flares
Meteoritic Flux
Solar wind Plasma
Solar UV & X-rays
Hot & Tenuous Magnetospheric Plasmas
Exosphere
Ar He Na K Ca H_2O
Ionosphere
Ar^+ He^+ Na^+ K^+ Ca^+ O^+
Plasma Sheath
Surface Electric Field
Charged Dust
Magnetic Anomalies
Outgassing
Sputtering
Composition
Topography
Ejecta
Weathering

EXPERIMENTAL LUNAR RESEARCH



SPARCLED (Space Plasma Alleviation of Regolith Concentrations in the Lunar Environment by Discharge) – *PI: Steve Curtis*

Funded by ESMD ETDP

- Research and development of dust removal techniques for high vacuum lunar and for Mars environments.
- Developed dust containment instrument for the next series of tests being conducted at Kennedy Space Center May 2009. 1 Patent filed, 1 patent disclosed.
- Applications to accretion processes in early nebula of solar systems

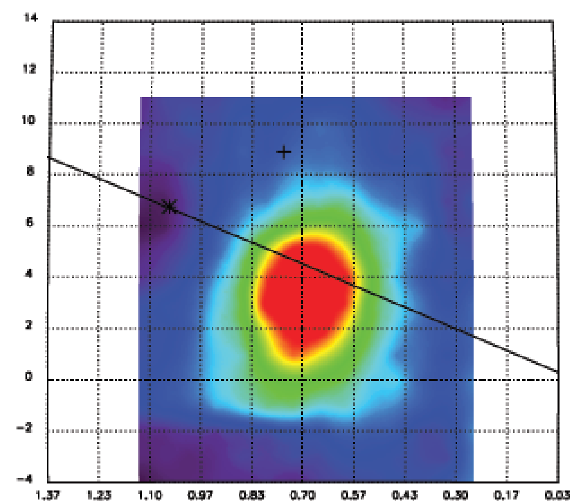
Figure 1: A cartoon depicting the geometry of the extended lunar sodium tail.

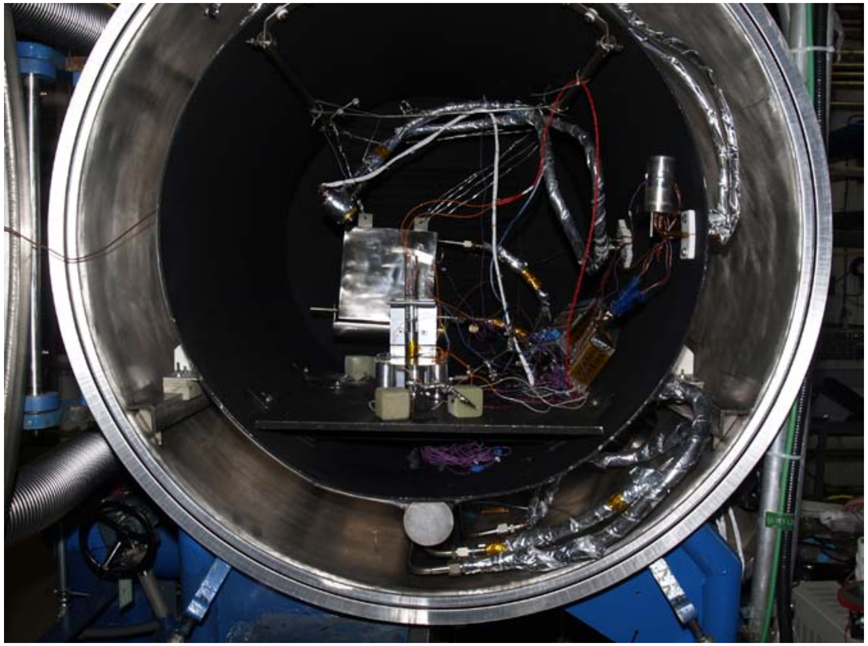
LUNAR SODIUM TAIL OBSERVATIONS

PI: Ron Oliversen in partnership with U. of Wisconsin

Funded by Planetary Astronomy

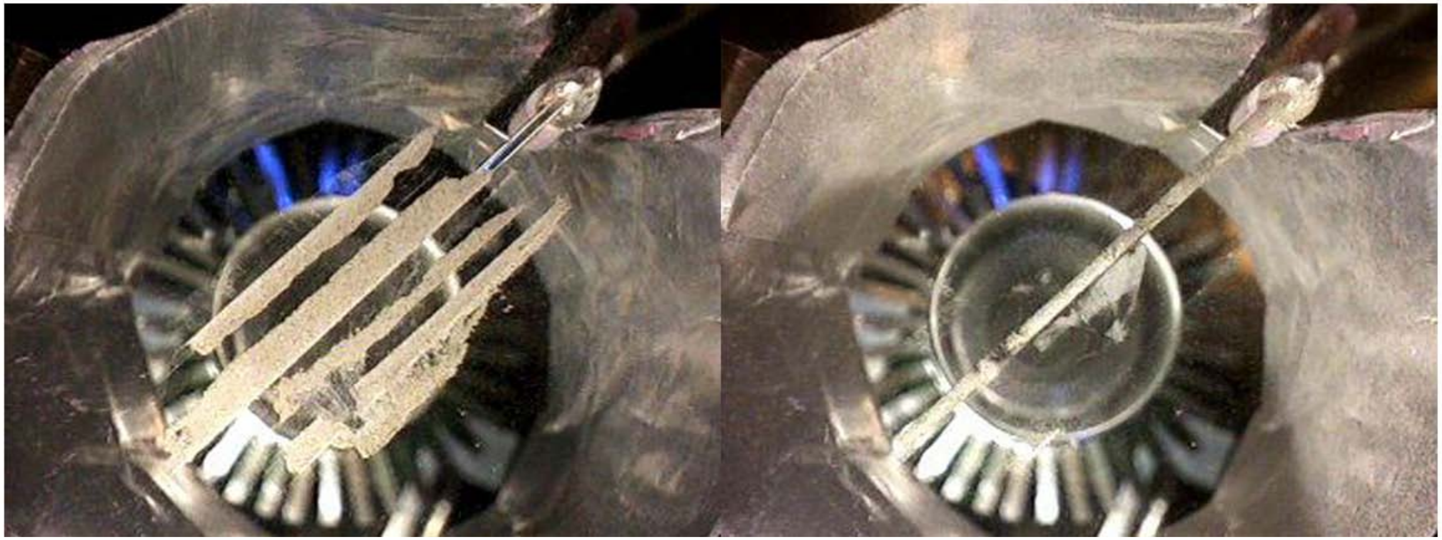
Follow the Sodium: Lunar sodium acts as a tracer of lunar environment dynamics, viewed along the comet-like sodium tail drawn out by solar radiation pressure.



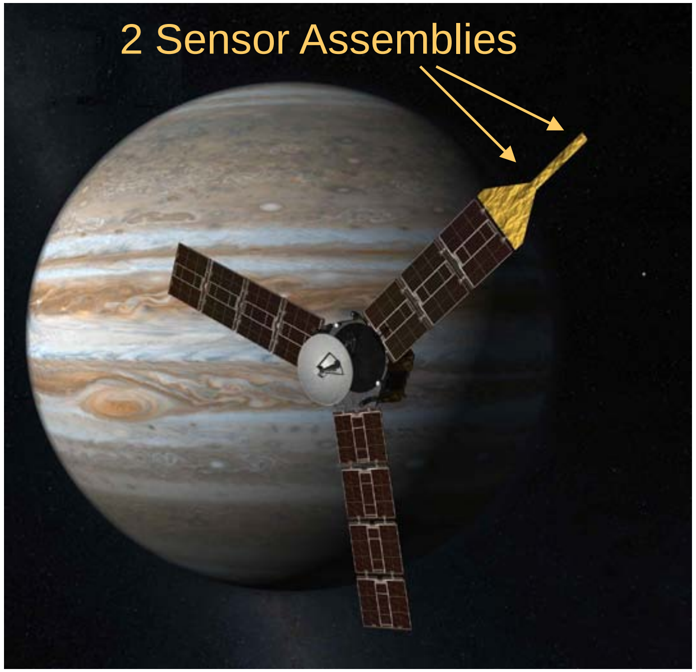


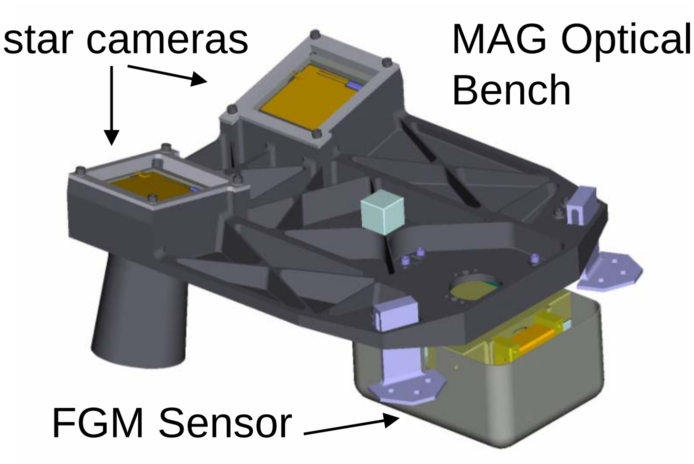
SPARCLED – Planetary dust manipulation by electron beams

Solving the solar system formation sticking problem



Juno MAG Investigation



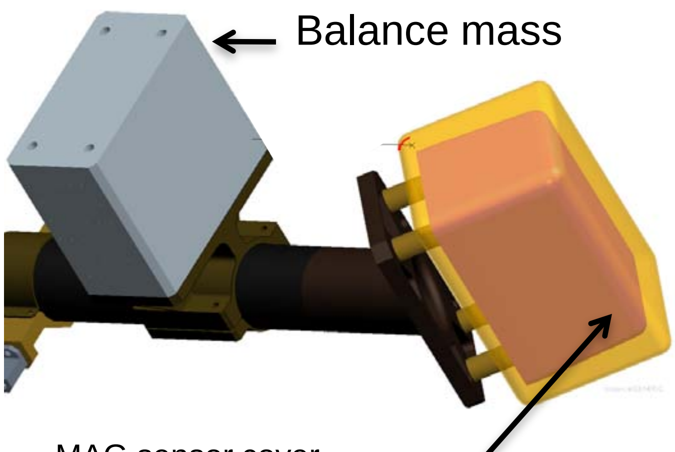


Personnel:
• Jack Connerney (Juno Deputy PI; Mag PI)
• Rick Schnurr (Lead Eng.); Oliversen (Inst. Mgr.) & Eng/Tech Support Staff: Sheppard, Odom, Hunsaker; Aguilar, Murphy, Lawton, Himes

Mission
• Juno – New Frontier Mission (PI: Bolton/SWRI)
• Launch August 2011; Earth Flyby October 2013; Jupiter Orbit Insertion August 2016
• Instrument ATLO need date July 2010

Status
• EM Tests completed (MHA Mag. Test Site)
• FM FGM Analog Boards & Sensors completed
• FM Mag Optical Benches delivered, in test
• FM ASC Star Cameras delivered
• MAG Integration begun, TRR completed
• MAG Instrument delivery to LM (July 2010)
• Magnetic control program oversight ongoing

Radiation Belt Storm Probes (RBSP) MAG



Personnel:
- MacDowall, Connerney, Oliversen (Code 695)
- Lead engineer – Rick Schnurr (Code 560)
- Eng/Tech Support Staff: Sheppard, Odom, Hunsaker; Aguilar (SAIC), Murphy (RSI), Himes

Mission
- Two multi-instrumented spacecraft to improve radiation belt time-variable models
- Orbit - elliptical (600 km – 6 Earth radii)
- Launch – May 18, 2012
- MAG is part of EMFISIS suite (U. Iowa)

Status

- EM2 tests completed 1/14/2010 at Iowa
- FM parts procured, flight sensors and analog boards in assembly, delivery June 2010
- Magnetic control program oversight ongoing

MAVEN MAG Investigation

Personnel:

- Jack Connerney (695); Jared Espley
- Eng/Tech support: Sheppard, Odom, Schnurr

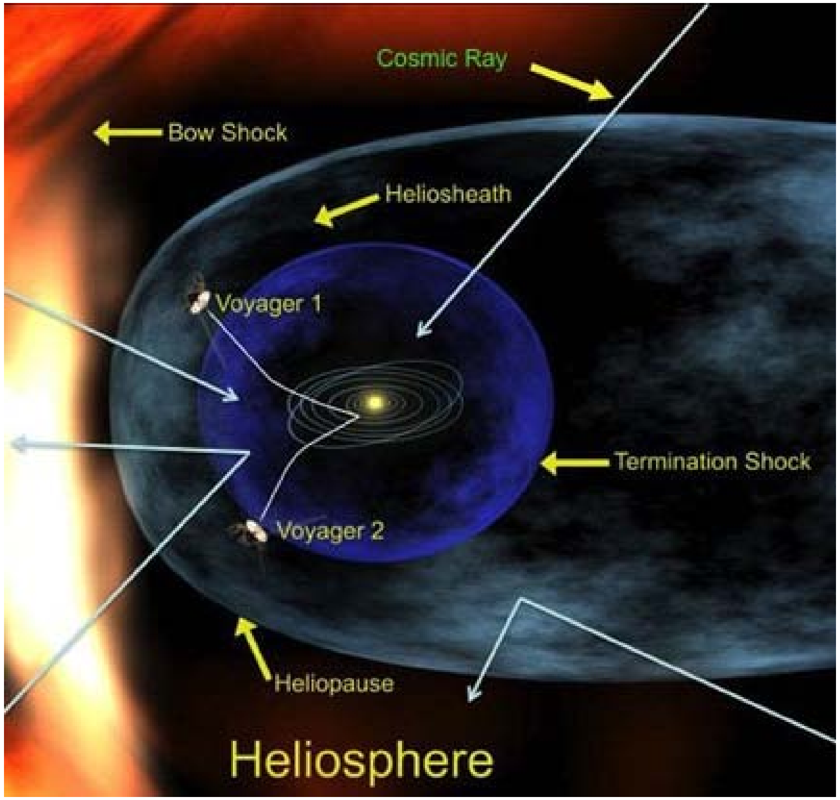
Mission

- Characterize atmosphere and escape processes; 4.5 hr elliptical orbit to 150 km alt.
- Measure vector magnetic field
- Characterize solar wind interaction
- Support particles & fields package

Status

- Pre – PDR; preliminary design stage
- MAG boom trade study
- Magnetics control program oversight

Voyager 1 & 2 MAG Investigation



V1 and V2 have crossed the Termination Shock (separates the supersonic Solar Wind and the subsonic Heliosheath).

Both S/C expected to enter the Interstellar Medium before 2020.

Personnel:
- Connerney (Code 695); Burlaga
- Ness (PI, Catholic University)
- Instrument was built by Mario Acuna

Mission: “Voyager Interstellar Mission”
- Explore the Heliosheath, Interstellar Medium and the Interaction between the Solar Wind and Interstellar Medium
- Orbit - see figure
  V1 is 10.5 billion miles from Earth
  V2 is 8.5 billion miles from Earth
- Launch – V1 September 5, 1977
  V2 August 20, 1977

Status
- Both of the (dual) magnetometers on V1 & V2 are operating satisfactorily.
- Data reduction is increasingly challenging, owing to the weak fields & ageing instrument.

MEx/MARSIS Participating Scientist

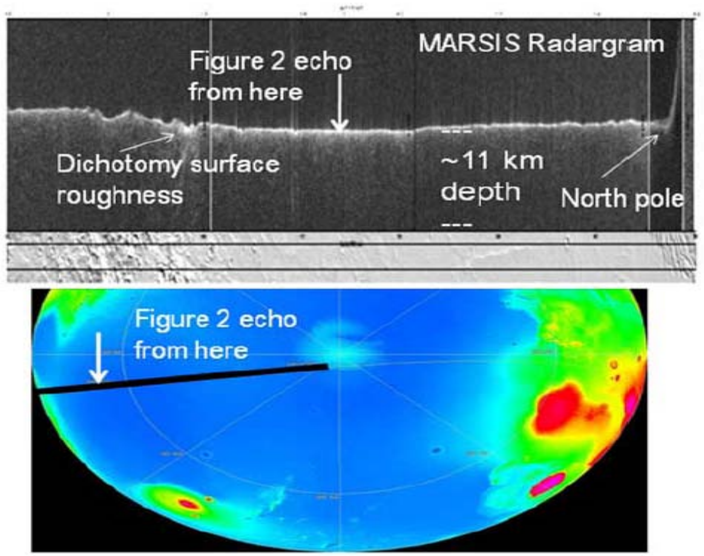
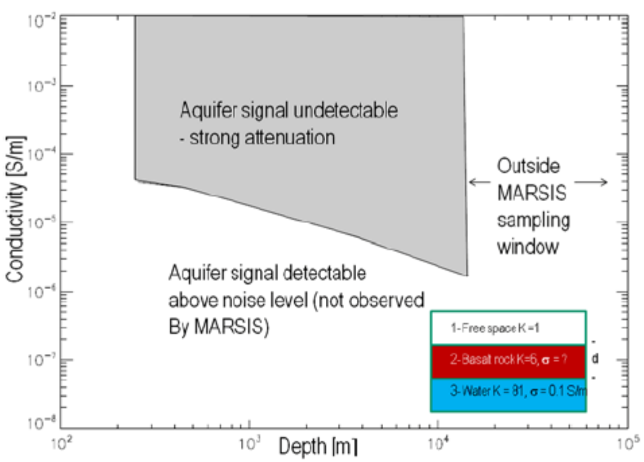
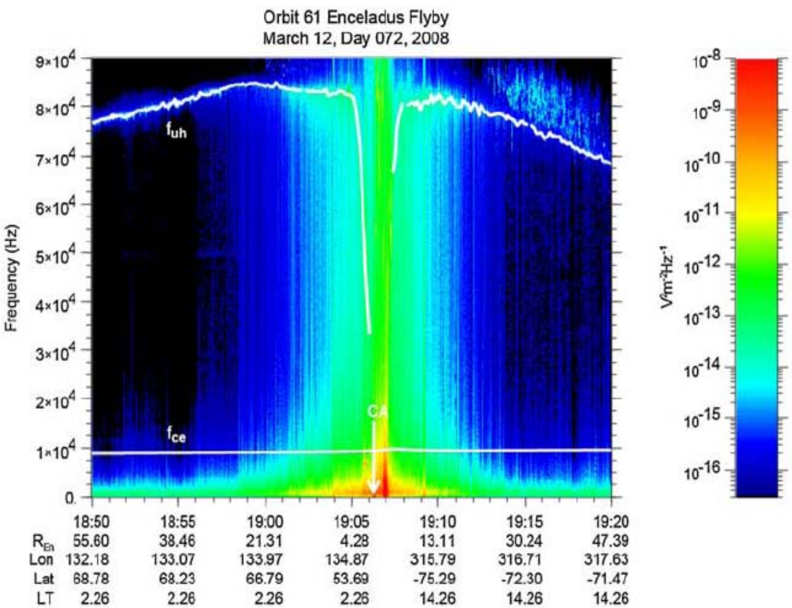


Figure 1. A MARSIS radargram from orbit 3869 and a map of the associated groundtrack. The spacecraft passes over the northern lowlands on the Martian nightside.



- **Personnel:** Farrell, Espley
- **Yr:** 6th
- **Funds:** Ramping down from ~$100k/yr to $50k in FY09
- Have a MIDP under review led by Duke to continue effort at ~$50k level
- **Pub # in last year:** 4
- **Finger-Touch Accomplishments:**
- Demonstrated that overlying crust can absorb signature of deep ground water table
- Espley coordinated a campaign to look for GPR signal losses during Martian meteor showers (worked with MEx, MERs, Meteor prediction teams)…great work!

Cassini/RPWS Co-investigators

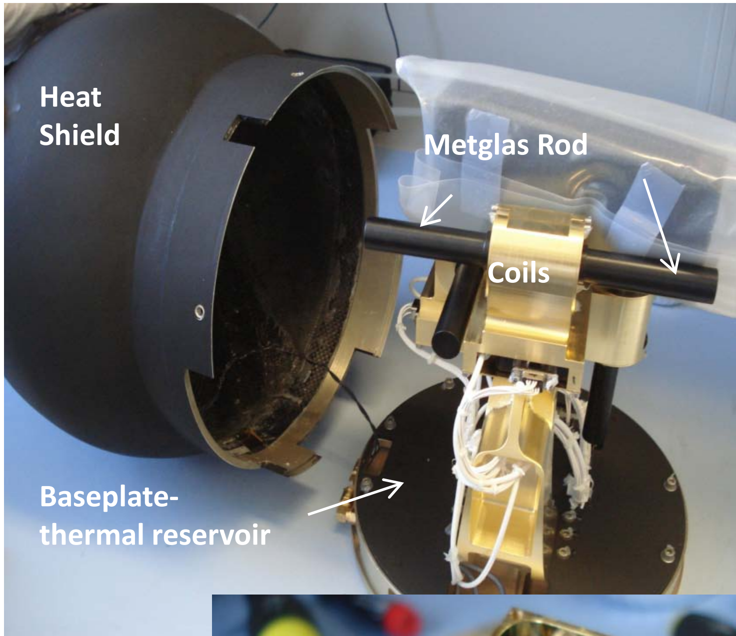


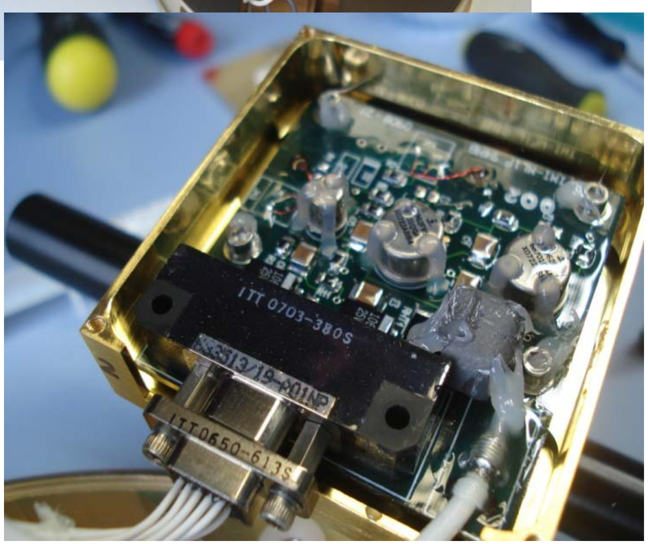
$$\partial(n_e v_e)/\partial s = v_e \partial n_e/\partial s + n_e \partial v_e/\partial s$$
$$= \nu n_{H2O} - k_r n_e^2 - k_d n_{H2O} n_e - \eta_d v_e n_e$$

Dominant term

- **Personnel:** Farrell, MacDowall
- RJM now replaces MLK as Cassini co-I, with PI Gurnett approval
- **Yr: ~**15th
- **Funds:** ~$150k/yr
- **Pub # in last year:** 2
- **Finger-Touch Accomplishments:**
- Demonstrated that the Enceladus plume behaves as collective dusty plasma system: Icy dust so abundant that they preferentially absorbs plasma electrons
- Developed 1-D fluid model of Enceladus plasma, photo-ion, dust interaction
- Continue to study SKR-derived rotation period anomalies

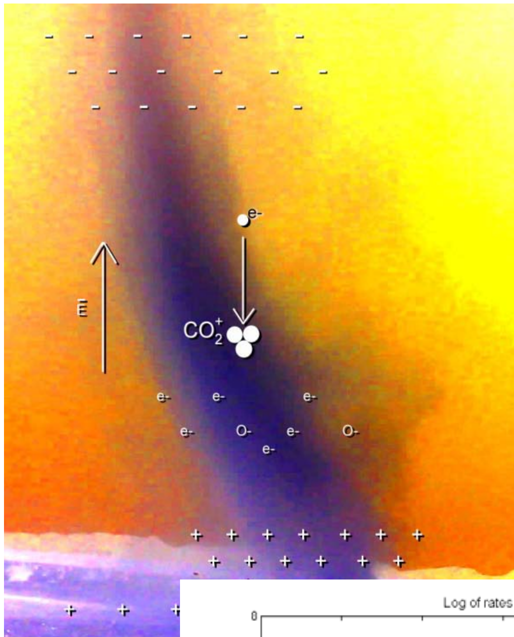
DSX/Triaxial Search Coil (TASC)

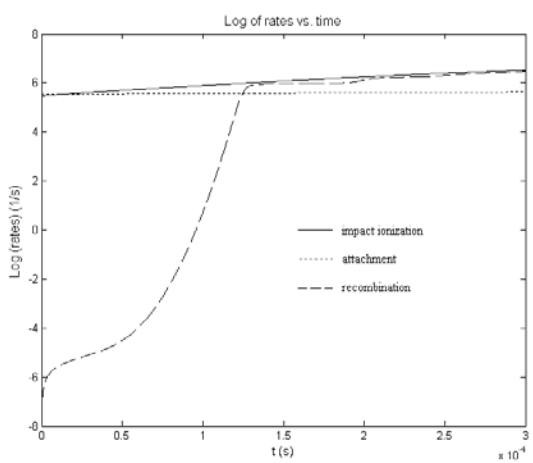




- **Personnel:** Farrell, Jackson [Aguilar (SAIC), Murphy (RSI), Singh (PC)]
- Preference for contractor support in build, away from 500
- **Yr:** 5th
- **Funds:** MIPR issued in FY09 for $150k
- **Progress & Issues:**
- Flight unit completed and mid-way through Env Testing
- In August, LMACT ‘fried’ primary board and compromised PA boards
- TASC was rebuilt with flt spare boards and back online in Sept
- LMATC has run out of funds – TASC is going separate path to delivery
- 2012 Launch with DMSP-19, to 12000 km altitude (in the radiation belts)

MFRP/Numerical Simulation of dust storms (SWRI)

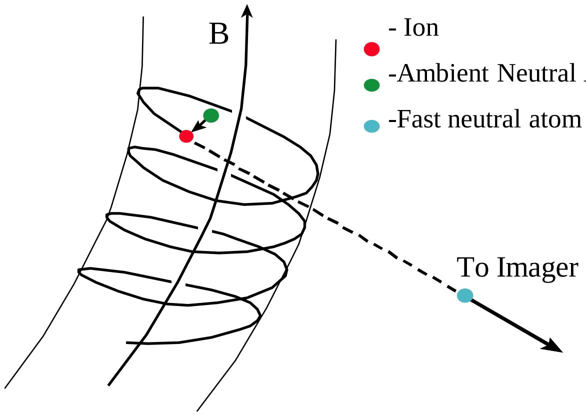




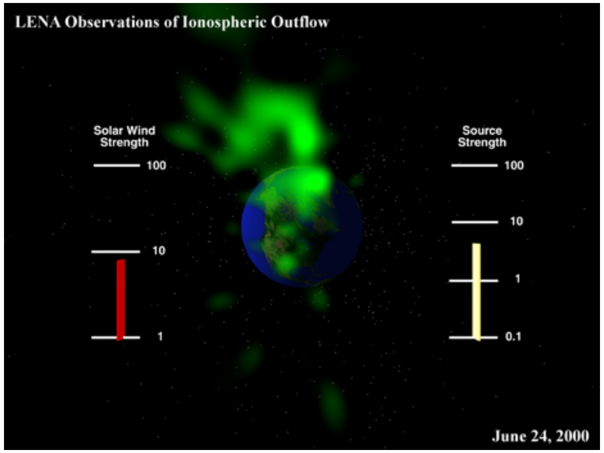
- **Personnel:** Farrell, Jackson
- **Yr:** 3rd & Final
- **Funds:** $40k
- **Pub # in last year:** 1 and 1 under review
- **Finger-Touch Accomplishments:**
- Jackson's 2008 thesis and 2009 graduation tied to this award
- Found that dust absorption can influence the development of a dust storm E-field
- Developed DDEAM: Dust Devil Electron Avalanche Model as thesis
- 9 coupled continuity OD equations that describes temporal evolution of dust-created electron avalanche
- Jackson is PI of 2009 MFRP proposal to continue model development

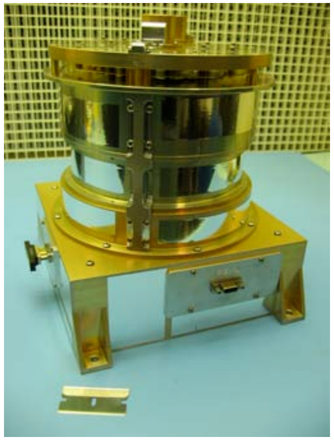
MINI-ME remotely senses magnetospheric plasma populations to improve space weather forecasting for operational use.

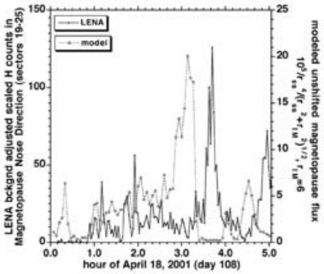
Remote Sensing of Ions



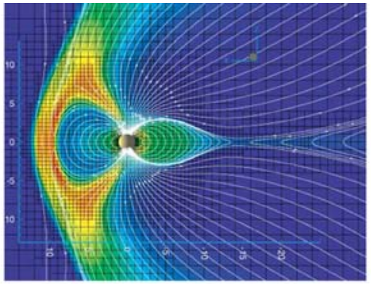
Charge transfer collisions



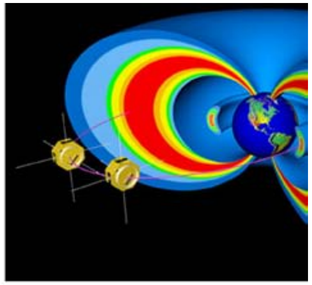




MINI-ME REMOTELY SENSES BOUNDARY BETWEEN SOLAR WIND AND MAGNETOSPERE →



EXISTING MODELS TAKE THIS AS INPUT →



SPECIFICATION OF SPACECRAFT CHARGING AND RADIATION ENVIRONMENT

PATENTS INTELLECTUAL PROPERTY

Search Coil Patent

Neural Basis Function Synthetic Neural System

Tet Synthetic Skeletal Muscular System

Stability Algorithm for Neural Entities (SANE)

Formulation for Emotion Embedding in Logic Systems (FEELS)

Stability Requirements Algorithm for Advanced Mobility (SCRAAM)

Field Reactive Amplification Controlling Total Adhesion Loading (FRACTAL) – Gecko adhesion release

Space·Plasma Alleviation of Regolith Concentrations in Lunar Environments (SPARCLE)

DISCLOSURES: SPARCLED, MOPED,DDEAM,ADAPTS