

Forum Notes March 4, 2002
Day 1 - Glenn Mason is chair

1:45 Plenary Breakout Sessions - Heliospheric Physics

Science Goals and Objectives

Ongoing and Future Missions (Laundry List)

- ACE
- Wind
- Ulysses
- Voyager
- IMP8
- Cassini
- SOHO

Future

- Stereo
- Messenger
- Triana

Planned

- Solar Probe
- Solar Orbiter (with ESA)
- Interstellar Probe

LWS Missions

- Far Side
- Inner Heliospheric Mapper

Themes List

- 1.Origins of Fast of Slow Solar Wind
- 2.Heating of the Corona
- 3.Structure and Dynamics of Heliosphere
- 4.Acceleration of Energetic Particles
- 5.Intersction of the Solar wind with the ISM
- 6.Solar Wind Structures such as CIRs and CMEs
- 7.Solar Wind Dynamics
- 8.Turbulence: Cause and Effects
- 9.Properties of the LISM and interaction with Heliosphere
- 10.Effect of the Changing Sun on interactions with the LISM
- 11.Relationship of Energetic Particles to Properties of Heliospheric Boundaries
- 12.Mapping of Energetic Particles to Solar Wind Sources
- 13.Dust Environment of the Solar System, Interaction with the Solar Wind, Energetic Particle Production
- 14.Coronal Composition
- 15.Relationship of Corona Composition and Composition of Sources
- 16.Composition of Solar System and Relationship to Composition of the LISM
- 17.Transport and Scattering of Energetic Particles throughout the Heliosphere
- 18.Our Position in the Galaxy and Implications of Heliospheric Observations for Galactic Evolution
- 19.Galactic Cosmic Rays
- 20.Particle Acceleration and Transpot and Relationship to Flares and CMEs
- 21.Implications of Global Heliosphere Structures for Life and Society
- 22.PaleoHeliosphere
- 23.Influence of Heliosphere on Magnetosphere and Upper Atmosphere of Earth and Other Planets
- 24.Comet Science
- 25.Extrasolar Astrospheres
- 26.Solar Variability and Activity on all timescales and Its Implications for Heliospheric Variability
- 27.Xray production due to Solar Wind Interaction with Neutrals
- 28.Physics of Collisionless Shocks and Heliosphere as a Natural Plasma Lab
- 29.Neutral Particles and Pickup Ions in the Heliosphere

OBJECTIVES AND RFAs

#	Science Objectives of the Space Science Enterprise	Research Focus Areas Specific to Sun Earth Connections
1	Understand the structure of the universe, from its earliest beginnings to its ultimate fate.	
2	Explore the ultimate limits of gravity and energy in the universe.	
3	Learn how galaxies, stars, and planets form, interact, and evolve.	1.
4	Look for signs of life in other planetary systems.	
5	Understand the formation and evolution of the solar system and earth within it.	
6	Probe the origin and evolution of life on earth and determine if life exists elsewhere in our solar system.	1.
7a	Explore the fundamental physical processes of plasmas in the universe.	1.
7b	Understand the changing flow of energy and matter throughout the Sun, heliosphere, and planetary environments.	1.
7c	Define the origins and societal impacts of solar variability.	1.
8	Chart our destiny in the solar system.	

OBJECTIVES

Topic 1. Origin of the Solar Wind

Topic 2. Structure and Evolution of the Heliosphere and other Astrospheres

Topic 3. Interaction of the Heliosphere with Galaxy

Topic 4. Origin, Acceleration, and Transport of Energetic Particles

Topic 5. Fundamental Space Plasma Physics

Topic 6. Interaction of Heliosphere with Earth, Planets and Other Celestial Bodies

Science Questions

Topic 1. Origin of the Solar Wind

- What heats the corona?
- What accelerates the solar wind?
- What are the sources of solar wind?
- What differentiates the fast and slow solar wind?
- What is the dynamic link between magnetic fields of the Sun and sources of plasma flows, energetic particles and transients?
- What is the relationship between compositions of the solar wind and corona?
- What is the source and cause of solar wind variability?
- What is the origin of fluctuations and turbulence in the solar wind?

Topic 2. Structure and Evolution of the Heliosphere and other Astrospheres

- What causes galactic cosmic ray modulation?
- How do CMES, CIRs, Shocks and Magnetic Clouds Propagate and Interact?
- What is the evolution of the heliospheric magnetic field through multiple solar cycles?
- What are the nature and sources time and spatial variations of solar wind?
- What are the temporal and spatial variations of heliospheric dust and grains?
- What mitigates thermodynamic and energy change of the solar wind?

Topic 3. Interaction of the Heliosphere with Galaxy

- How big is the heliosphere?
- Does the heliosphere have a Bow Shock?
- Does the solar wind terminate with a shock?
- Just outside the heliosphere,
 - what is the Magnetic Field?
 - what is the galactic cosmic ray spectrum?
 - what are the properties of the matter?
- Is the heliopause stable and how is it affected by the reversal of the solar magnetic field?
- How does solar activity modulate interaction of the heliosphere with the galaxy?
- What is the effect of incoming galactic matter on global heliospheric structure?

Topic 4. Origin, Acceleration, and Transport of Energetic Particles

- How do collisionless shocks generate energetic particles?
- Why are non-thermal tails ubiquitous?
- What are the processes and differences between acceleration in CMEs, CIRs, solar wind, corona, and solar flares?
- How do energetic particles escape from closed structures on the Sun and how do they move through the heliosphere?
- What are the sources of energetic particles, inner source and interstellar source pickup ions and ACRs; how and where are they accelerated?
- How do the spectra and composition of energetic particles vary in the heliosphere?

Topic 5. Fundamental Space Plasma Physics

- How do magnetic fields reconnect in space plasmas?
- What is the energy partition and interaction in multicomponent plasmas?
- How does turbulence affect heating transport and energetic particles?
- What causes turbulence in space plasmas?
- How do plasmas interact with neutral matter?
- What is the interaction between shocks and energetic particles?

Topic 6. Interaction of Heliosphere with Earth, Planets and Other Celestial Bodies

- How does solar wind get in to the magnetosphere?
- How does the solar wind drive magnetospheric activity?
- How does the heliosphere mitigate the persistence and evolution of life?
- Search for molecules and the building blocks of life from comets and interstellar dust
- How does the heliosphere mediate space-weather?
- How do small bodies contribute to the inner source of pickup ions?
- How does solar wind interact with unmagnetized bodies and ionospheres?

Measurement Strategy

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LWS Missions

- Far Side
- Inner Heliospheric Mapper

Near Term (2003- 2008)

- ACE - 2010
- Wind - > 2010
- Ulysses - 2008
- Voyager - 2015 (in heliosphere till 2004 ?)
- IMP8 - not dead yet
- Cassini - 2005 (orbit insertion - out of the solar wind)
- SOHO - > 2010
- Genesis - through 2004

Mid-Term (2009-2014)

- Stereo
- Messenger
- Triana
- Solar Probe
- Solar Orbiter (with ESA)
- Interstellar Probe

Missions From Prior Roadmap (2000)

Heliospheric Imager and Galactic Gas Sampler (HIGGS)
Inner Heliospheric Constellation
Solar Flotilla
Interstellar Trailblazer
Outer Heliosphere Radio Imager
Particle Acceleration Solar Observatory
Solar Farside Observer
Solar Polar Imager

Currently Presented Missions

HELIX (Heliospheric Explorers)
Interstellar Pathfinder
Telemachus (Ulysses successor)
Solar Polar Pathfinder
Particle Acceleration Solar Observatory
Solar Imaging Radio Array
Solar Probe
Space Weather Diamond (4 spacecraft within 0.2 AU of Earth)
ASCE (Advanced Solar Coronal Explorer - spectrographic remote sensing)
Far Side/MASSE
LWS Sentinels
Turbulence Mission??

Technology

HEUVI (Heliosphere Extreme Ultraviolet Imager)

Long Term (2015-2028)

Compelling Measurements and Needs

- Exploring the Inner Heliosphere
- Probe the Outer Heliosphere
- Polar Orbiter

OBJECTIVES

Topic 1. Origin of the Solar Wind

Near Term 2003 - 2008: Current Missions

*Mid Term 2009 - 2015: Solar Probe - Close Solar Flyby ,
Probe Evolution of Polar Regions
Hi-Res Fields and Particles
Coronal Spectroscopy*

Long Term 2016 - 2028: High Corona Magnetic Fields Imaging

Topic 2. Structure and Evolution of the 3D Heliosphere and other Astrospheres

Near Term 2003 - 2008: Current Missions

*Mid Term 2009 - 2015: Heliospheric Constellation
Multipoint Inner Heliosphere Measurements
Imaging Transients on Largest Spatial Scales*

*Long Term 2016 - 2028: Maintain and Renew Heliospheric Flotilla
Next Solar Max Observations - Advanced Technology*

Topic 3. Interaction of the Heliosphere with Galaxy

Near Term 2003 - 2008: Current Missions

*Mid Term 2009 - 2015: Remote Sensing of the Termination Shock and Sampling of Galactic
Matter*

Direct Probe of the LISM

Long Term 2016 - 2028: Probe the Far ISM

Topic 4. Origin, Acceleration, and Transport of Energetic Particles

Near Term 2003 - 2008: Current Missions

*Mid Term 2009 - 2015: Coordinated Measurements of Inner Heliosphere (0.02 AU and 0.5 AU),
Near Heliosynchronous Orbiter
Solar Max Observations
Shock Acceleration ~ 3 AU*

Long Term 2016 - 2028: Hi Lat GCRs

Solar Max (Cycle 25) Observations - Advanced Technology

Topic 5. Fundamental Space Plasma Physics

Near Term 2003 - 2008: Current Missions

Mid Term 2009 - 2015: Four-point Hi-Res Heliospheric Measurements (100 km - 0.2 AU)

Long Term 2016 - 2028: nanosat constellation observations

Topic 6. Interaction of Heliosphere with Earth, Planets and Other Celestial Bodies

Near Term 2003 - 2008: Current Missions

Mid Term 2009 - 2015: Multipoint Near-Earth measurements

In-situ measurement of comet tails

Long Term 2016 - 2028: Upstream Monitoring of planets

Unifying Themes

Paleo - Heliosphere and Astrospheres .. tie in to Stellar Evolution (Maunder Minimum etc ..)

Links from solar - heliosphere

Links from Heliosphere-magnetosphere

L1 for sale?

LWS - modeling .. are deterministic approaches relevant?

Explosive Release of magnetic energy .. reconnection

Magnetic Fields in Space Plasmas

Large-scale Currents

Microscale influence on mesoscale and macroscale phenomena

thematic approach

Complexity and highly non-linear phenomena

Wave-particle interaction

turbulence

collisional to the collective

Astrophysical Laboratory

Transitions, Shocks and Boundaries

Coordinated Remote and In-Situ High Corona Observations

Laboratory physics

Heliospheric Technology Roadmap

- Long Duration Propulsion
- Architecture to support Long life
- Instrumentation to do heliospheric Science
- Autonomy
- Telemetry Needs (Kband?)
- Power Sources in Deep Space (Higher Efficiency Solar Cells)
- Thermal Issues at High Temperature
- Interaction of Tech (nuclear) and science
- Constellation Issues - Coordination in Deep Space
- Miniaturization
- Ground Data System

Priorities

- In-space propulsion
- Telemetry

Heliospheric EPO

Seeing the Invisible

Flotilla of Spacecraft

Space Propulsion Systems

Voyager hits the wall (the edge of the solar system)

Spacecraft in Extreme Environments

Cosmic Radiation

Solar Sailing

Space Weather

Evolution of CMEs in outer Heliosphere

Interactive use of space-data .. Discovery activities

Visiting our Star

How do we do EPO?

Imaging stuff (pictures of the heliosphere)

Interaction of the Heliosphere with the Planets

Cosmic Bubbles (comets and planets)

Planetary evolution driven by Heliosphere

Participants

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LWS presentation by Kitner

SECAS said to develop a scientific understanding that leads to operational stuff

400 Million per discipline for LWS.
Sentinels, Inner Sentinels, Far Side.

Discussion of RFAs.

New RFAs

(a) Understand the transport of mass energy and magnetic fields within the Sun and into the solar atmosphere (inner boundary of the heliosphere)

-helioseismology

-CME origins (also LWS)

Missions: SDO, Farside Polar Imager (High Latitud Heliosphere), Stellar Imager, RAM/ESSO, MTRAP, Solar-B, NICO

(b) Determine through direct and indirect measurement the origins of solar wind, solar energetic particles and transient behavior

© Reveal the Dynamic Heliosphere in Space and Time

Determine through direct and indirect measurement the origins of solar wind

Reveal the Dynamic Heliosphere in Space and Time

Considerations

New Frontiers

- Solar Probe
- ☞Interstellar Probe

STPs

- ☞Ulysses Successor, Into the Third Dimension (Ulysses Follow-on with lower period)
Get 2 spacecraft
- HIGGS (Heliospheric Imager and Galactic Gas Sampler) Outer Heliosphere (HIGGS, beyond 4 AU, perhaps to 15 AU)
- ☞Voyager Successor ... intermediate inclination

LWS

- Inner Heliospheric Sentinels , Inside One AU (HELIX, Inner Sentinels)
- ☞Turbulence Constellation (spaceweather diamond)

Will Cost

- (1)Ulysses Successor
- (2) HIGGS
- (3) Inner Heliospheric Sentinels

Will Not Cost

- (1)Voyager Successor
- (2) Turbulence Constellation

Determine through direct and indirect measurements the origins of the solar wind, its magnetic field, and energetic particles

Determine the evolution of the heliosphere on its largest scales