
SHINE
WORKSHOP
2005
Program and Abstracts

Welcome to the SHINE 2005 Workshop!

Dear SHINEr,

Welcome to the 2005 SHINE workshop in Kona, Hawaii. We have more than 160 participants, an all time high. For the past two years, we have been providing the abstract book, which includes all the abstracts to be presented at the meeting as posters or talks. We hope that these abstracts will be useful in tracking down interesting topics and authors. The working group leaders and the steering committee members worked tirelessly in getting all the speakers to send their abstracts in. Nick Arge has done a great job in compiling the abstracts and printing them.

We are happy to see the continued growth of the student population: The number has more than doubled to 27 since 2002. The Student day program, like last year, will consist of tutorial talks on the subject matter of the working groups and student presentations. Thanks to Ben Lynch and Kathy Reeves for putting the student day program together with the help of the steering committee members. The NSF/SHINE grant was able to support most of the students to attend the 2005 workshop. We are grateful to the NASA/LWS program for providing additional student support, which became necessary because of the increase in the number of students and the high cost of the meeting location.

It has been a pleasure serving the SHINE community as the Workshop Coordinator for the past three years. I take this opportunity to thank several of my colleagues and students who helped a lot in putting the logistics of the workshop together: Ernesto Aguilar-Rodriguez, Sachiko Akiyama, Gregory Michalek, Sara Petty, Seiji Yashiro, and Hong Xie (from the Catholic University of America). Finally, we thank AFRL for providing financial support to print the abstract book.

Nat Gopalswamy
SHINE Workshop Coordinator
2005 June 21

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About the SHINE Group...

SHINE is an affiliation of researchers within the solar, interplanetary, and heliospheric communities, dedicated to promoting an enhanced understanding of the processes by which energy in the form of magnetic fields and particles are produced by the Sun and/or accelerated in interplanetary space and on the mechanisms by which these fields and particles are transported to the Earth through the inner heliosphere. Membership is open to all interested parties, and participation in SHINE activities by members of the international community is welcomed. SHINE research focuses in particular upon the connection between events and phenomena on the Sun and their relation to solar wind structures in the inner heliosphere. The goal of SHINE activities is to enrich and strengthen both physical understanding and predictive capabilities for these phenomena.

The goals of SHINE parallel those of NSF's GEM and CEDAR programs, and joint space weather studies are being planned with those organizations. However, since SHINE was initiated after the establishment of the interagency National Space Weather Program (NSWP), it is not a separate NSF entity and does not draw research support from designated NSF sources. Funding for participants in SHINE activities comes from the range of agency investments in the NSWP through other programs. NASA's Living with Star Program also supports student travel to the SHINE workshops.

All planning for SHINE activities is conducted via a steering committee, which holds regular telecons and meetings throughout the year. During the formative years of SHINE, the committee was composed of individuals motivated toward furthering its stated goals. The organizational structure was loosely modeled along the lines of GEM and CEDAR, and remained highly informal. With the passage of time and the advent of sustained specific funding from NSF, it was recognized by the 2001 Workshop in Snowmass that a more defined SHINE leadership was needed. The needs of the SHINE community is addressed most effectively by a small but flexible organization consisting of the Steering Committee.

Current (2005) Steering Committee:
Pete Riley (SAIC), Chair uk2@haven.saic.com
Nat Gopalswamy (NASA/GSFC), Workshop Coordinator gopals@fugee.gsfc.nasa.gov
David Alexander (Rice University) dalex@rice.edu
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SHINE 2005
Workshop Program

Working Groups: WG1 – Solar WG2 – Interplanetary WG3 – Energetic Particles

Sunday, July 10

SHINE student day – STUDENTS and INVITED SPEAKERS ONLY!

07:00	Breakfast	
08:30	Welcome/Opening remarks	Pete Riley
08:45	SHINE Logistics	Nat Gopalswamy
09:00	Instrument Review Talk: *The RHESSI (Ramaty High Energy Solar Spectroscopic Imager) Mission*	Bob Lin
10:00	Coffee Break	
10:30	WG1 Review Talk: *The Physical Origins of Coronal Mass Ejections*	Spiro Antiochos
11:30	Student Talk: *Supergranulation Waves in the Subsurface Shear Layer*	Christina Green
11:45	Student Talk: *Light Curves for a Loss of Equilibrium Model of Solar Eruptions*	Kathy Reeves
12:00	Group Lunch	
13:30	WG2 Review Talk: *Connecting Sun and Heliosphere*	Thomas Zurbuchen
14:30	Student Talk: *Identifying and Distinguishing ICMEs and Stream Interaction Regions (SIRs)*	Lan Jian
14:45	Student Talk: *Magnetic Clouds and Their Geoeffectiveness*	Cynthia Lopez-Portela
15:00	Coffee break	
15:30	WG3 Review Talk: *Explaining the Acceleration and Transport of Solar Energetic Particles*	Christina Cohen
16:30	Student Talk: *Heating in CME shocks*	Kelly Korreck
16:45	Student Talk: *Elemental abundance variations of solar energetic particles at low energies as measured by WIND/STEP over the last solar cycle*	Maher Al-Dayeh
17:00	Adjourn	
17:30	Group dinner	
21:30	Informal social time	

Monday, July 11 (Chair: Allan Tylka)

07:00	Breakfast	
08:30	Opening remarks	Riley/Gopalswamy
08:45	Agency talks: NSF	Paul Bellaire
09:00	Agency talks: NASA	Lika Guhathakurta
09:15	Agency talks: CCMC	Michael Hesse
09:30	Overview of Campaign Events	Dave Webb
09:45	Poster Overview	Joan Burkepile
10:15	Coffee break	
10:30	Description of working group (WG) sessions	
	WG 1: Solar	Plunkett/Abbett
10:45	WG 2: Interplanetary	Richardson/Roussev
11:00	WG 3: Energetic Particles	Desai/Giacalone
11:15	Invited paper: *The Importance of Subsurface Magnetic Field Structure and Evolution*	George Fisher
12:30	Lunch break	
14:00	Working Group Sessions	
	WG1: *The Evolution of Sub-Surface Magnetic Fields*	Abbett/Plunkett
	WG2: *Are CMEs Driving the Solar Wind at Maximum or Along for the Ride?*	Richardson/Roussev
	WG3: *Sources of Suprathermal Ions in the Solar Corona and the Interplanetary Medium*	Desai/Giacalone
15:15	Break	
15:45	WG sessions continue	
17:00	Welcome reception and Posters	

Tuesday, July 12 (Chair: Terry Forbes)

07:00	Breakfast	
08:30	Plenary: Working Group Summaries	WG Leaders
09:00	Invited paper: *Shocks and Particle Acceleration*	Marty Lee
09:45	Working Group Sessions	
	WG1: *Numerical Models of CME Initiation*	Plunkett/Abbett
	WG2/WG3: *Modeling and Observations of IP shocks, (I)CMEs and SEPs* – part 1	Richardson/Roussev
10:30	Coffee break	
10:45	WG sessions continue	
12:30	Lunch break	

14:00	Working Group Sessions	
	WG1/WG2: *Origin and Evolution of the Solar Wind*	Roussev/Abbett
	WG2/WG3: *Modeling and Observations of IP shocks, (I)CMEs and SEPs* – part 2	Richardson/Giacalone
15:15	Break	
15:45	WG sessions continue	
17:00	Poster session with refreshments	
19:00	Adjourn	

Wednesday, July 13 (Chair: Pete Riley)

07:00	Breakfast	
08:30	Plenary: Working Group Summaries	WG Leaders
09:00	Invited paper: *Particle Acceleration Near the Sun*	Bob Lin
09:45	WG1/WG2/WG3: SHINE Campaign Events:	
	1. *2003 Halloween Storms*	Jackson/ Plunkett
	2. *Progress and Challenges Towards Driving Solar Models with Observations from the SHINE Campaign Event Periods*	Arge/Abbett
	WG3: *Mechanisms of Particle Acceleration near the Sun*	Giacalone/Desai
10:30	Coffee break	
10:45	WG sessions continue	
12:30	Lunch, free afternoon	
18:00	Steering Committee, Working Group Leaders, Agency Representatives Dinner	

Thursday, July 14 (Chair: Christina Cohen)

07:00	Breakfast	
08:30	Plenary: Working Group Summaries	WG Leaders
09:00	Invited paper: *End-to-end Modeling of CMEs & SEPs*	Tamas Gombosi
09:45	Working Group Sessions	
	WG2/WG1/WG3: *End-to-End Modeling of CMEs & SEPs* – part 1	Roussev/Abbett
	WG1/WG3: *Radio Observations of CMEs & Particle Acceleration*	Plunkett/Giacalone
10:30	Coffee break	
10:45	WG sessions continue	
12:30	Lunch break	
14:00	Working Group Sessions	
	WG2/WG1/WG3: *End-to-End Modeling of CMEs & SEPs* – part 2	Roussev/Abbett
	WG3: *Effects of the Sun on the Outer Heliosphere*	Desai/Giacalone
15:15	Break	

15:45	WG sessions continue	
15:45	Steering Committee Meeting	
17:00	Poster session with refreshments	
19:00	Banquet	

Friday, July 15 (Chair: David Alexander)

07:00	Breakfast	
08:30	Reports from liaisons and related meetings:	
	GEM	Dave Webb
08:45	IHY	Dave Webb
09:00	WG summary reports, challenges, and discussion	WG Leaders
10:45	Discussion of plans for next year	Nat Gopalswamy
11:00	Adjourn	

SHINE 2005
Session Invited Speakers

MONDAY AFTERNOON: Working Group Sessions

WG1: The Evolution of Sub-Surface Magnetic Fields (Abbett & Plunkett)

Yuhong Fan - *The Sub-surface Evolution of Emerging Magnetic Fields*
Chip Manchester - *The Source of Magnetic Shear that Drives CMEs*
Junwei Zhao - *Sub-surface Dynamics and Structures of AR-8210*
Doug Braun - *Local Helioseismic Inferences of Sub-surface Magnetism and Dynamcs*
Aad van Ballegooijen - *The Role of Sub-surface Processes in the Formation of Coronal Magnetic Flux Ropes*

WG2: Are CMEs Driving the Solar Wind at Maximum or Along for the Ride? (Richardson & Roussev)

Ian Richardson - *Variation in Average Solar Wind Conditions During the Solar Cycle – Is There a Role for ICMEs*
Matt Owens - *Heliospheric Flux and ICMEs*
Janet Luhmann - *Solar Wind Sources – Where Are We Now?*
Sue Lepri - *The Nature and Variability of the Open Magnetic Flux in the Heliosphere From In-situ Observations and MHD Models*
Justin Kasper - *Coronal Regulation of the Solar Wind Helium Abundance Over the Solar Cycle*

WG3: Sources of Suprathermal Ions in the Solar Corona and the Interplanetary Medium (Desai & Giacalone)

Matthew Hill - *Suprathermal Ion Composition at Cassini from 1 to 9 AU*
George Ho - *Transient Shocks and Associated Energetic Particle Events Observed by ACE during Solar Cycle 23*
Thomas Zurbuchen - *Suprathermal Tails*
Nathan Schwadron - *Pre-accelerated seed populations of energetic particles in the heliosphere*
Len Fisk - *Statistical Acceleration in the Corona and Solar Wind*

TUESDAY MORNING: Working Group Sessions

WG1: Numerical Models of CME Initiation (Plunkett & Abbett)

Dana Longcope - *Energy Storage and Release in the Corona: The Role of Topology*
Daniel Spicer - *A Unified Picture of Coronal Mass Ejections*
Spiro Antiochos - *The Breakout Model for CME Initiation*
Terry Forbes - *The Role of Ideal-MHD Processes in CME Initiation*
Jon Linker - *CME Initiation in a 'Simple' Active Region*

WG2/WG3: Modeling and Observations of IP shocks, (I) CMEs & SEPs – part 1 (Richardson & Roussev)

Hilary Cane - *Using Energetic Particles to Understand the Interplanetary Characteristics of CMEs and Their Shocks*
Justin Kasper - *Characterizing Interplanetary Shocks at 1 AU*

TUESDAY AFTERNOON: Working Group Sessions

WG1/WG2: Origin and Evolution of the Solar Wind (Roussev/Abbett)

Len Fisk - *Diffusion of Open Magnetic Flux and Its Consequences*
Spiro Antiochos - *Constraints on Coronal Hole Topology*
Nathan Schwadron - *Relating the Sub-Parker Spiral Structure of the Heliospheric Magnetic Field to Dynamic Sources of Solar Wind*
Scott McIntosh - *Does the Chromosphere Have Heliospheric Impact?*

WG2/WG3: Modeling and Observations of IP shocks, (I) CMEs & SEPs – part 2
(Richardson & Giacalone)

Chip Manchester - *Post-Shock Compression and Forward-Reverse Shock Pair Resulting From CME Interaction With a Bimodal Solar Wind*
Jozsef Kota - *SEP Acceleration at CME-Driven Shocks: The Possible Role of Acceleration in the Sheath Between the Shock and the CME*
Adam Szabo - *Determination of the Properties of Interplanetary Shocks*

WEDNESDAY MORNING: Working Group Sessions

WG1/WG2/WG3: SHINE Campaign Events:

1. 2003 Halloween Storms (Jackson & Plunkett)

Nat Gopalswamy - *Overview of the October-November 2003 Solar Eruptions*
Bernard Jackson - *The Extent, Mass, and Energy of the October-November CME Events in the Interplanetary Medium*
Thomas Zurbuchen - *October-November 2003 Events: Plasma and Composition*
Richard Mewaldt - *Solar Energetic Particle Observations During the Large Solar Particle Events of October, November 2003*

2. Progress and Challenges Towards Driving Solar Models With Observations From the SHINE Campaign Event Periods (Arge & Abbett)

Ilia Roussev - *Progress and Challenges Towards Data-Driven Numerical Models of Solar Eruptions*
Zoran Mikic - *Progress and challenges in modeling the May 12, 1997 CME*
Richard Frazin - *Driving models with 3D tomographic reconstructions from white-light, EUV and magnetogram data*
Dusan Odstrcil - *Heliospheric Simulations of SHINE Events Using CME Cone Models*
Jonathan Krall - *Modeling the 2003 October 28-30 CME/ICME Event: Can We Predict These Things?*

WG3: Mechanisms of Particle Acceleration near the Sun (Giacalone & Desai)

Jim Miller - *Particle Acceleration and Atmospheric Response in Impulsive Solar Flares*
Yuri Litvinenko - *Particle Acceleration During Magnetic Reconnection in the Solar Corona*
Randy Jokipii - *The Mechanism of Acceleration of Energetic Charged Particles in Impulsive Flares*
Chee Ng - *Particle Acceleration at CME-driven shocks*
Vahe' Petrosian - *Cascade and Damping of Turbulence in Solar Flares: Plasma Heating and Particle Acceleration*

THURSDAY MORNING: Working Group Sessions

WG2/WG1/WG3: End-to-End Modeling of CMEs & SEPs – part 1 (Roussev & Abbett)

Janet Luhmann - *CISM End-to-End Space Weather Modeling Progress and Plans*

Robert Weigel - *Present Status and Future Challenges of Modeling the Sun-Earth System*

WG1/WG3: Radio Observations of CMEs & Particle Acceleration (Plunkett & Giacalone)

Tim Bastian - *Radio Emission from CMEs*

Stephen White - *Coronal Radio Bursts*

Hilary Cane - *Relationships between Solar Radio Emissions and Energetic Particle Events*

Mike Reiner - *Radio Observations Related to CMEs and to Particle Acceleration*

THURSDAY AFTERNOON: Working Group Sessions

WG2/WG1/WG3: End-to-End Modeling of CMEs & SEPs – part 2 (Roussev & Abbett)

Igor Sokolov - *Solar Energetic Particles: Acceleration and Transport in Realistic Magnetic Fields*

Gang Li - *How Particles Are Accelerated to High Energies in Large SEP Events – A Secret Recipe*

David Ruffolo - *Finite Time Shock Acceleration and Fits to ESP Ion Spectra*

Peter MacNeice - *Solar and Heliospheric Models at the CCMC*

WG3: Effects of the Sun on the Outer Heliosphere (Desai & Giacalone)

John Richardson - *The Solar Wind in the Outer Heliosphere*

Trevor Sanderson - *Mapping the Heliosphere: a New Look at Energetic Particle Increases at CIRs*

Devrie Intriligator - *Asymmetries in the Solar Wind from the Sun to the Outer Heliosphere*

Nathan Schwadron - *The Effect of Solar Photospheric Footpoint Motion on the Heliospheric Magnetic Field*

Plenary Talks

The importance of subsurface magnetic field structure and evolution

George H. Fisher, Space Sciences Laboratory, UC Berkeley

Where does the energy for solar flares and coronal mass ejections come from? Most of the time, we as solar and heliospheric physicists take the magnetic field evolution at the surface of the Sun for granted: Active regions emerge and disperse, complex magnetic topologies in the corona develop and evolve, and violent space weather events occur, all apparently driven by dynamics we observe at the Sun's surface.

Yet the evolution of the solar magnetic field at the surface is ultimately governed by forces acting on magnetic flux elements at and below the photosphere, in the solar interior. To fully understand the mechanisms that control magnetic fields in the solar atmosphere, we must understand how magnetic fields evolve in the solar interior.

In this talk, I will discuss what we have learned about magnetic field evolution in the solar interior, what aspects of the observations can be explained in terms of interior MHD models, what remains mysterious, and directions for future research.

Shocks and Particle Acceleration

M. A. Lee, UNH

After a very brief historical introduction to the acceleration of solar energetic particles (SEPs) by shock waves, the basic process of diffusive acceleration at a CME-driven shock to produce a SEP “gradual” event is described including the actual acceleration by compression and drift parallel to the motional electric field, ion injection at the shock, wave excitation by the SEPs, ion escape upstream of the shock, and the long-time decay of the event. The challenges of SEP acceleration to theory are presented including nonlinearity, the importance of temporal and spatial variations, and the transition upstream of the shock from scatter-dominated to nearly scatter-free particle transport. The importance of the excited waves is emphasized in yielding the observed “streaming limit” of SEPs, and in controlling ion fractionation, ion escape, and the spectral form of the high-energy cutoff. The interesting interplay between ion injection from both the solar wind and ambient energetic ions, injection energy thresholds dependent on magnetic field obliquity, and the resulting elemental and charge-state composition of the SEPs is addressed. Finally, an assessment of current models of SEP acceleration at coronal/interplanetary shocks is made and challenges outlined to achieving a predictive model for the particle radiation environment at Earth or Mars orbit.

Particle Acceleration by the Sun

R.P. Lin, Physics Dept & Space Sciences Laboratory, UC Berkeley

The Sun is a prolific and efficient particle accelerator. Large solar flares, the most powerful explosions in the solar system, accelerate ions up to tens of GeV and electrons up to hundreds of MeV, well into the energy range of galactic cosmic rays. Collisionless shock waves driven by fast coronal mass ejections accelerate particles to comparably high energies. In large and small flares, the accelerated particles often contain the bulk of the energy released, indicating the acceleration is intimately linked to the flare energy release process, most likely magnetic reconnection. Interestingly, the average rate of flare energy release, integrating down to micro/nano-flares, may be important for heating of the corona. High in the corona, frequent small impulsive accelerations produce 0.1-100 keV electrons that escape to the interplanetary medium. These events also accelerate ~ 10keV to MeV per nucleon ions that are enriched in heavy elements and enormously enriched in the isotope 3He. In addition, a non-thermal 1-100 keV electron population, the ``superhalo," is continuously present in the interplanetary medium, even at solar minimum, suggesting a steady-state coronal acceleration process. For these diverse phenomena, I will review the constraints provided by direct observations of the energetic particles from interplanetary spacecraft, and by remote-sensing observations of the X-ray/ gamma-ray and radio emissions produced by the particles; and discuss the implications for the particle acceleration and energy release processes.

End-to-end simulations of CMEs and SEPs

Tamas Gombosi and the CSEM Team
Center for Space Environment Modeling,The University of Michigan

Significant temporal variations of solar wind speed and magnetic field can be produced by CMEs. Indeed, the most severe storms in the space environment are driven by exceptionally fast CMEs. These very fast CMEs, which are ejected from the corona at speeds of more than 1000 km/s, also drive strong hydromagnetic shocks. These shocks are efficient producers of energetic particles, which have major impact on the space environment. A very important element of particle acceleration at CME-driven shocks and other transient shocks is that the shock evolves in time; the time variation in the location and strength of the shock, as well as the changes in the geometry and strength of the interplanetary magnetic field need to be incorporated into the model calculations. It is very important to model CMEs and SEPs in a coupled, self-consistent manner.

The Space Weather Modeling Framework (SWMF) aims at providing a flexible framework for physics based space weather simulations. The SWMF combines numerical models of the Solar Corona, which includes the Eruptive Event Generator, the Inner Heliosphere, Solar Energetic Particles, Global Magnetosphere, Inner Magnetosphere, Radiation Belt, Ionosphere Electrodynamics and Upper Atmosphere into a parallel, high performance model. All the components can be replaced with alternatives, and one can use only a subset of the components.

The components are coupled to the control module via standardized interfaces, and an efficient parallel coupling toolkit is used for the pairwise coupling of the components. The execution and parallel layout of the components is controlled by SWMF. Both sequential and concurrent execution models are supported. With concurrent execution the SWMF with all components coupled can run significantly faster than real time on massively parallel machines. The configuration, compilation and execution of the framework can be done with a user friendly Graphical User Interface. The SWMF enables us to do simulations that were not possible with the individual components. We highlight some numerical simulations obtained with the SWMF.

In this talk we briefly outline SWMF and its components and we will present coupled simulations of CMEs and SEPs.

SESSION INVITED TALKS
Monday

1. Sub-surface evolution of emerging magnetic fields

Yuhong Fan (HAO/NCAR)

The current prevailing picture is that magnetic active regions on the solar surface originate from strong, predominantly toroidal magnetic fields generated by the solar dynamo mechanism at the thin tachocline layer at the base of the solar convection zone. Understanding the process of magnetic flux emergence through the solar convection zone is therefore crucial for understanding the link between the observed magnetic activities at the surface and the dynamo-generated magnetic fields in the interior. In this talk I will give an overview of some recent results from MHD simulations of the formation and dynamic rise of buoyant Omega-shaped flux tubes in the solar convection zone. I will discuss how the Coriolis force, the flux tube twist, and convection affect the trajectory, cohesion, and structure of the emerging tubes. New results from a 3D spherical anelastic MHD model will be presented.

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2. The Source of Magnetic Shear that Drives CMEs

W. B. Manchester, Y. Fan

We present a two and three-dimensional numerical magnetohydrodynamic simulations of magnetic flux emergence in three geometries including horizontal layers, arcades and flux ropes. In all cases, the magnetic structures are initially embedded in gravitationally stratified plasma in non-force-free states in which plasma pressure confines the magnetic fields. As the magnetic fields buoyantly rise, they greatly expand in the reduced pressure of the upper atmosphere. In all cases, we find that the legs of ascending bipole loop structures move in opposite horizontal directions drawing the magnetic field parallel to the neutral line. The shearing motions naturally occur as the magnetic field expands in the stratified atmosphere which produces a gradient in the axial field. This gradient results in a horizontal Lorentz force that drives the legs of the bipole loop in opposite directions. The shearing motions transport axial flux and energy from the submerged portion of the field to the expanding portion, which may cause it to violently erupt. This shearing process is very robust and explains the highly sheared state of the magnetic field associated with prominences, flares and coronal mass ejections.

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3. Sub-surface Dynamics and Structures of AR8210 before the X1 Flare on May 2, 1998

Junwei Zhao & Alexander G. Kosovichev
Hansen Experimental Physics Laboratory
Stanford University, Stanford, CA94305-4085

Active region NOAA AR8210, which gave a few solar flares on May 1 and 2, 1998, has been widely studied recently to derive its photospheric flow fields. Efforts were also put on the connections between the flow fields and solar flares. Here, we present our analysis of this active region by use of time-distance helioseismology. Three dimensional subsurface flow fields, as well as sound speed variations, are derived. Subsurface kinetic helicity is computed from the inferred velocities. Preliminary analysis found that subsurface kinetic helicity increased fast before the occurrence of the X1 flare, which may imply that the subsurface sheared flows started to twist magnetic field and build up energies well before the occurrence of the flare.

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4. Local Helioseismic Inferences of Sub-surface Magnetism and Dynamics

D.C. Braun, NorthWest Research Associates

We review recent applications of Helioseismic Holography as examples of local helioseismic probes of the subsurface magnetism and dynamics of the solar convection zone. While perhaps best known for the routine imaging and forecasting of active region complexes on the farside of the Sun, helioseismic holography is now being applied in a systematic exploration of the dynamics of the solar convection zone and the shallow-subsurface acoustic properties of active regions. A significant challenge of current interest is the ability to detect subtle seismic (acoustic) signatures caused by submerged magnetic fields and their associated mass flows. For example, efforts to probe subsurface wave-speed variations and flows near and under solar active regions are complicated and potentially compromised by strong phase and amplitude perturbations introduced by magnetic fields in the photosphere. It is envisioned that a physical understanding of the perturbations caused by surface magnetic fields will be achieved through a combination of control observations designed to directly assess the surface effects with MHD modeling including simulations of the interaction of acoustic and magneto-acoustic-gravity waves with prescribed magnetic and sound-speed perturbations and flows (artificial data). It is likely that such an understanding, in combination of the development of appropriate tools for correcting the effects of the surface magnetism, will be vital for the detection and study of subsurface magnetic fields and dynamics. This work is supported by funding from NASA SR&T and Living With a Star programs and the NSF Stellar Astronomy and Astrophysics program.

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5. The role of sub-surface processes in the formation of coronal magnetic flux ropes

A. A. van Ballegooijen (SAO)

Large active regions emerge from a toroidal field believed to be located near the base of the convection zone. The emerging flux consists (at least initially) of Omega-shaped loops anchored in the toroidal field. I suggest that overshooting convection plays an important role in the formation of such Omega loops. The observed surface fields are likely to become disconnected from the toroidal field during the decay phase of an active region, leading to the "repair" of the underlying toroidal flux system; without such repair the loss of toroidal flux due to active regions would be too large for the dynamo to operate. Observations of magnetic helicity in active regions show that the emerging Omega loops are twisted, and that the helicity is predominantly negative (positive) in the Northern (Southern) hemisphere. During the decay of an active region, the helicity is further enhanced by reconnection associated with photospheric flux cancellation, which leads to the formation of coronal magnetic flux ropes (highly sheared or twisted fields overlying the polarity inversion line). I discuss the 3D structure of decaying active regions, including the effects of flux cancellation on the coronal and subsurface magnetic fields.

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6. Variation in average solar wind conditions during the solar cycle - Is there a role for ICMEs?

Ian Richardson, GSFC & Dept. of Astronomy, University of Maryland

The average properties of the solar wind clearly change during the solar cycle. For example, the magnetic field strength increases by a factor of ~2 from solar minimum to solar maximum; the cosmic ray intensity decreases, the geoeffectiveness varies and the He/proton ratio changes. The occurrence rates of CMEs and ICMEs also increase. Since ICMEs are often associated with stronger than average magnetic fields, produce short-term cosmic ray depressions and geomagnetic storms, and have unusual plasma compositions, it is natural to ask whether ICMEs contribute to the longer-term solar cycle variations in such parameters. We suggest that this may not be the case. For example, (a) Magnetic fields inside ICMEs typically have little influence on average magnetic field values on timescales of >~1 solar rotation. Such averages are dominated by background fields outside ICMEs. Similarly, average geomagnetic activity levels are determined predominantly by conditions in the background solar wind rather than by the storms associated with some ICMEs; (b) Variations in IMF and cosmic ray intensity do not simply follow the sunspot cycle, but show shorter term variations. Furthermore, the IMF tends to be weaker near the time of solar field reversal. These variations appear to reflect changes in the solar open flux, and are also closely related to mean photospheric flux ("sun as a star") values. This suggests that they are intimately associated with changes in magnetic fields at the Sun rather than by interplanetary conditions, such as the buildup of magnetic flux associated with the "legs" of CMEs that have moved out beyond 1 AU; (c) Decreases in the cosmic ray intensity can precede intervals of enhanced solar CME/ICME activity, and variations in the cosmic ray intensity may be modeled fairly successfully using only the mean IMF without any information on ICME/CME occurrence rates.

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7. Heliospheric flux and ICMEs

M.J. Owens and N.U. Crooker, Boston University

The properties of the solar wind change substantially over a solar cycle, with the average magnetic field magnitude doubling between solar minimum and maximum. It is unclear whether the observed increase can be explained by a build-up of closed magnetic flux in the heliosphere resulting from the enhanced rate of solar transients, or if it is indicative of a change in the solar magnetic field. In situ measurements of ICMEs can be used to estimate the heliospheric flux contribution from transient events, however it is possible that current methods are underestimating the ICME flux content. We make magnetic flux estimates with a new magnetic cloud model, and compare them to previous estimates and solar observations. Implications for the required rate of ICME opening with heliocentric distance are discussed.

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8. Solar Wind Sources - Where are we now?

J.G. Luhmann, SSL, University of California, Berkeley

A number of investigations in the last five years have focused on the details of the solar cycle and latitude-dependent sources of the solar wind. These revisits to the problem have been inspired by both the sophistication and maturity of in-situ data bases from WIND, ACE and Ulysses, in particular, and from the growing use of models to interpret their observations. In addition, the presence of SOHO, with its multispectral images of coronal holes and ability to infer heating mechanisms in the low corona, is critical for connecting the in-situ data to the Sun. Not to be overlooked are the additional implications of the LASCO observations showing transient features at the edges of coronal streamers, a sign of the existance of an expected transient component of the slow solar wind. And of course, one cannot minimize the essential contributions of solar magnetographs, both ground and space-based, which are used to suggest the presence of magnetic field-related acceleration processes, and on which all realistic models of coronal holes and solar wind depend. This presentation attempts to document "the facts" of where we are now in our understanding. The audience is invited to help fill in (or argue) the picture where the presenter fails to be complete, and to help produce a complete list of outstanding problems and needed observations and modeling to resolve outstanding issues.

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9. The nature and variability of the open magnetic flux in the heliosphere

Susan Lepri, University of Michigan

There has been considerable controversy in recent years over the slow evolution of the Sun's open field, which extends out to become the heliospheric magnetic field. In the standard solar model (e.g., Wang and Sheeley [1993]) the open flux can increase or decrease in response to the emergence or cancellation of magnetic flux at the photosphere. In the Fisk et al. [1999a, 1999b] model, on the other hand, the open flux is conserved and evolves primarily via interchange reconnection with closed field. This model predicts no long-term variations in the amount of heliospheric flux.

We compare and test these theories by measuring the behavior of the open magnetic flux in the global heliospheric magnetic field. Using multi-point measurements from the VHM instrument on the Ulysses spacecraft, we analyze in-situ radial magnetic field data and compared the behavior to that predicted by the SAIC MHD model which is a potential field model. During solar maximum, ICMEs significantly disturb the heliospheric magnetic field, making our comparisons difficult. We examine the radial component of the magnetic field in data from 1995 though 2002 in order to determine the variability of the open flux and hence the evolution of corona holes. We also consider the composition of the solar wind during solar maximum, as it gives us information regarding the solar sources of the highly variable magnetic field.

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10. Coronal Regulation of Solar Wind Helium over the Solar Cycle

J. Kasper (MIT)

Coronal helium does not directly experience the classical Parker acceleration mechanism. Instead, a combination of Coulomb drag and preferential wave absorption provide the force necessary to account for the helium observed in interplanetary space. The abundance of helium relative to hydrogen is a strong function of solar wind speed and phase of the solar cycle, with typical maximum values of 4.5% in steady solar wind and 15% within ejecta. I will present a study of the variation of the relative abundance of He/H as a function of solar wind speed and time. Our key finding is that during solar minimum He/H is separately a linear function of solar wind speed and heliographic latitude. The speed at which helium vanishes (the vanishing speed) is also the minimum observed solar wind speed at 1 AU. Theoretical explanations for the linear dependence, the vanishing speed, and the latitudinal gradient are presented.

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11. Suprathermal Ion Composition at Cassini from 1 to 9 AU

M.E. Hill [1], D.C. Hamilton [1], S.M. Krimigis [2], and D.G. Mitchell [2]; [1] University of Maryland, Department of Physics, College Park, Maryland; [2] Johns Hopkins University Applied Physics Laboratory, Laurel, Maryland

During the Cassini spacecraft's cruise to Saturn, the Charge Energy Mass Spectrometer (CHEMS) made measurements of ions having energies between 3 and 220 keV/e. Part of the Magnetospheric Imaging Instrument (MIMI) investigation, CHEMS combines an electrostatic deflection system with three time-of-flight telescopes, each terminating with a stopping solid-state detector. From CHEMS measurements we determine the elemental composition, energy, and charge state of incident ions, over an energy range well suited for study of pickup ions and other suprathermal particles. We report on the energy spectra of these particles, including protons, alpha particles, and singly charged He, during transient interplanetary shock events and longer-term averages of quiet times. We examine the radial dependence of the suprathermal ion composition during 1999 to 2004, as Cassini traveled from 1 to 9 AU.

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12. Transient Shocks and Associated Energetic Particle Events Observed by ACE during Solar Cycle 23

George C. Ho(1), David Lario(1), Robert B. Decker(1), Mihir I. Desai(2), Qiang Hu(3). (1)Johns Hopkins University Applied Physics Laboratory, Laurel, MD 20723 (2)Department of Physics, University of Maryland, College Park, MD 20742 (3)Institute of Geophysics and Planetary Physics, University of California, Riverside, CA 92521

From supernova remnant shocks to the solar wind termination shock, interplanetary (IP) shocks and planetary bow shocks, collisionless shocks are responsible for much of the energetic particle acceleration throughout the Universe. Particles can gain energy while interacting with shocks in many different ways. Each acceleration mechanism produces distinct features in energetic particle anisotropies, spectral indices, and time intensity profiles. Thus, a study of in-situ IP shocks and particle distributions in their vicinity provides the only meaningful way to test our theoretical understanding of shock acceleration. During the current solar cycle, Advanced Composition Explorer (ACE) detected 298 IP shocks during the period February 1998 to December 2003. More than half of these shocks produced signatures (so called ESP events) in the intensities of ions >47 keV. Of these ESP events, we compare the ion composition and energy spectra and investigate their relationship with the locally measured properties of the IP shocks. In general we find the measured particle spectral indices do not agree with steady-state diffusive shock-acceleration theory. Instead, ion spectra measured at the shock are often similar but softer than spectra of ambient ions measured well upstream of the shock. We will discuss the implication of such results in terms of seed particle population being accelerated by IP shocks when they reach 1 AU.

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13. Suprathermal Tails

Thomas H Zurbuchen, G. Gloeckler, L. A. Fisk, University of Michigan

Ion velocity distribution functions in the heliosphere are rarely Gaussian, but are found to have non-thermal tails. We discuss data from ACE and Ulysses of such tails, and their composition. We then address these data in the context of the composition of gradual SEP events.

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14. Pre-accelerated seed populations of energetic particles in the heliosphere

Nathan A. Schwadron, Southwest Research Institute

Suprathermal particles, which have higher mobility in the solar wind and thereby scatter more readily at shocks, are preferentially injected into diffusive shock acceleration. Pickup ions, which are singly charged and therefore distinguishable from solar wind ions, are a good example of a species preferentially injected at shocks. Pickup ions are introduced into the solar wind with higher energies than typical solar wind particles, and they are statistically accelerated by interacting with magnetohydrodynamic waves in the solar wind plasma. Since they are pre-accelerated, pickup ions form a natural seed population for higher energy particles accelerated at interplanetary shocks and anomalous cosmic rays accelerated at the termination shock. By analogy, we expect that interplanetary energetic particles accelerated by traveling interplanetary shocks also have a pre-accelerated seed population. Energetic particles accelerated at interplanetary shocks have enhanced He3 abundances, suggesting that the seed population originates from small flares that are extremely frequent near solar maximum. In this talk, we discuss recent observational and theoretical work that has used abundance and compositional signatures of energetic particles to reveal their true seed populations.

15. Statistical Acceleration in the Corona and Solar Wind

L. A. Fisk, University of Michigan

There are many contexts in the solar corona and the solar wind where it can be argued that the magnetic field diffuses. A simple description of the diffusion can be extended to describe the statistical acceleration of energetic particles. There are several interesting features of this type of statistical acceleration: it yields power-law spectra and may introduce dependencies on the mass per charge ratio of particles that are similar to those observed in impulsive solar flares. The basic acceleration mechanisms will be discussed and some possible applications to coronal loops, the overlying corona and the solar wind will be presented.

SESSION INVITED TALKS
Tuesday

16. Energy storage and release in the corona: The role of topology

Dana Longcope, MSU

According to a common view of solar activity, magnetic energy builds up in the corona as the field there adapts to slow changes in the photospheric field. This slow coronal evolution is occasionally interrupted by a rapid release of magnetic energy, such as occurs in a solar flare. The rapidity of this release and various associated effects, such as the production of non-thermal ions and electrons, has led to a wide-spread belief that magnetic reconnection plays an important role in it. This talk will discuss the requirements on a possible reconnection mechanism implied by the slow-storage/rapid-release scenario. It will present a quantitative model whereby the free energy storage may be estimated for any observed photospheric field evolution. The model also predicts how much of the energy stored throughout the corona might be releasable by a local reconnection process. The model is demonstrated on observed energy releases of various sizes.

17. A Unified Picture of Coronal Mass Ejections

D.S. Spicer, D. Dibeck, B.J. Thompson, and J.M. Davila LSSP, NASA/GSFC

A new coronal mass ejection (CME) picture is described that utilizes a number of attributes commonly found operating during magnetotail reconnection events. We first present key observational constraints any final model of CMEs must explain. We then describe how 3D reconnection occurs in the magnetotail and how magnetotail reconnection helps explain a variety of observed CME attributes. We then argue why reconnection, as usually described in the literature, cannot explain the particle acceleration process that occurs during the CME/flare process. Instead we argue that it the flow fields that are driven by the relaxation of the magnetic stresses by reconnection that are ultimately the cause of particle acceleration. In particular, the currents created by the flow fields which connect the corona to the chromosphere are in fact carried by high energy electrons. We compute the expected electron fluxes from these current systems and find they are of order those required. In addition, we discuss betatron acceleration during the dipolarization process that occurs when the flux rope/CME is ejection and how the hot particles generated during the dipolarization process can lead to traps in solar loops thereby helping to explain LDEs. Further, we examine whether particle acceleration by shocks can contribute to the mix. We also note that our new picture eliminates a number of paradoxes regarding the elimination of magnetic flux from the sun and how the Sturrock-Aly conjecture is not of consequence in our picture.

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18. The Breakout Model for CME Initiation

S. K. Antiochos, B. J. Lynch, and C. R. DeVore :(NRL and U Michigan)

The breakout model postulates that the initiation of a CME is due to reconnection between the magnetic field overlying a filament channel and neighboring flux systems. We discuss the physical requirements for such a process to occur and, in particular, the requirements for breakout in a fully 3D geometry. The latest simulations of breakout in both 2.5 and 3D topologies are presented. We also discuss the implications of our results for observations.

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19. The Role of Ideal-MHD Processes in CME Initiation

T.G. Forbes, University of New Hampshire

Energetic CMEs with speeds in excess of 1000 km/s often exhibit a maximum acceleration a few minutes after onset. The sudden forcing implied by the early peaking of the acceleration is suggestive of an ideal-MHD process, but a purely ideal process acting alone encounters difficulties in explaining pre-onset phenomena. Such phenomena include filament activation and the intensification of X-ray sigmoids prior to onset. Furthermore, many CMEs immediately exhibit reconnection features, such as flare ribbons, which are inherently non-ideal. Therefore, a hybrid combination of ideal and non-deal MHD processes is likely to be involved in the initiation of many CMEs.

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20. CME Initiation in a "Simple" Active Region

Jon Linker, Zoran Mikic, Viacheslav Titov, Roberto Lionello, and Pete Riley (SAIC)

The fastest coronal mass ejections (CMEs) typically originate from active regions on the Sun. From a theoretical standpoint, fast CMEs are the most difficult to understand and model, because they require that large amounts of magnetic energy be released rapidly. The May 12, 1997 CME event is an example of an eruption arising from a primarily bipolar active region. The active region is modeled as a localized bipole within a global dipolar configuration, which provides a good fit to the field produced when the actual flux distribution is used. We find that this so-called "simple" region has many interesting properties. We describe MHD computations of eruptive behavior arising from this region. We also discuss the role of the interaction of the local active region magnetic field with the global magnetic fields due to the surrounding magnetic flux, as well the implications of our work for the initiation of fast CMEs. *Work supported by NASA and the Center for Integrated Space Weather Modeling (an NSF Science and Technology Center).

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21. Using Energetic Particles to Understand the Interplanetary Characteristics of CMEs and Their Shocks

H. V. Cane NASA/GSFC

Energetic particles below about 10 MeV are commonly seen in association with CME-driven shocks in the inner heliosphere. These increases provide a tracer of the origin of the shock i.e. a specific solar event, and also provide information on characteristics of the shock and its causative CME. This talk will describe some of the results obtained from particle studies and in particular using the multi spacecraft combination of the two Helios spacecraft and IMP 8.

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22. Characterizing Interplanetary Shocks at 1 AU

J. Kasper (MIT)

Single spacecraft methods for identifying interplanetary shock properties are reviewed. The accuracy of the derived shock parameters can be quantified by comparing observed and predicted transit times for a shock passing multiple spacecraft. One hundred shocks seen by both Wind and ACE have been identified, and the derived shock parameters are compared as a function of spacecraft separation and analysis method. In general the shocks seen by the spacecraft have very similar orientations, mach numbers, and speeds. The variation of parameters as a function of spacecraft separation and shock strength is presented.

An online database of fast, slow, forward, and reverse interplanetary shocks observed by the Wind, IMP-8, ACE, and Voyager spacecraft is introduced (1). Individual web pages for each event provide derived shock parameters and plots of the selected data and steps in the analysis.

(1) http://space.mit.edu/home/jck/shockdb/shockdb.html

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23. Diffusion of Open Magnetic Flux and Its Consequences

L. A. Fisk and T. H. Zurbuchen, University of Michigan

It can be argued that the open magnetic flux of the Sun undergoes extensive diffusion by: random convective motions in the photosphere, by reconnection at the base of coronal loops and subsequent displacement, by reconnection in the canopy of loops on the quiet Sun, and by braiding and twisting of open field lines throughout the overlying corona resulting from diffusion at the base of the field lines. This approach has several possible implications: It permits a prediction of the distribution and behavior of open flux outside of concentrations of open flux such as coronal holes. It couples the behavior of the open flux to the acceleration of the solar wind, which may prove useful in the development of numerical models of the corona.

24. Constraints on Coronal Hole Topology

Spiro Antichos, Naval Research Laboratory

The Sun's magnetic field is the primary agent driving solar activity and, in open field regions, for coupling the Sun to the heliosphere. Although the details of this coupling depend on the quantitative properties of the field, many important aspects of the corona-solar wind connection can be understood by considering only the topology of the solar open field regions, (commonly referred to as ``coronal holes"). From straightforward assumptions, which are valid for the standard corona-solar wind theoretical models and are likely to hold in the Sun, as well, we derive three stringent constraints on the possible topology of coronal holes. These coronal hole constraints have important implications for the evolution of both the slowly-varying and transient corona/solar wind. Numerical simulations are presented that demonstrate the role of magnetic reconnection in establishing the coronal hole constraints.

25. Relating the Sub-Parker Spiral Structure of the Heliospheric Magnetic Field to Dynamic Sources of Solar Wind

Nathan A. Schwadron, Southwest Research Institute

Our view of the 3-D magnetic structure of the heliosphere is changing. The traditional Parker spiral is modified due to the motion of magnetic footpoints at the Sun. The strongest magnetic field distortions in the new configuration arise because footpoint motions on the Sun cause field lines to be connected between fast and slow wind streams. The field lines are subsequently distorted as fast wind pulls out the field faster than slow wind. This leads to a ``sub-Parker" spiral with field lines much less transverse than the Parker spiral. This sub-Parker spiral is readily observed because the field distortions are large and associated with rarefactions. One study discussed here shows the sub-Parker spiral in 17/18 co-rotating interaction regions crossed by Ulysses during its first polar orbit during solar minimum. The sub-Parker spiral is the rule, not the exception, for the structure of the heliospheric magnetic field. The effects of footpoint motions also fundamentally change our view of the sources of solar wind. Footpoint motions continually move magnetic field lines through coronal holes and across coronal hole boundaries. Beyond the coronal hole boundary motions of the footpoints of open field lines must be sustained to prevent flux pile-up and depletion on opposite sides of the Sun. It has been suggested that interchange reconnection between open field lines and closed loops may sustain footpoint motions beyond the coronal hole in the source regions of slow solar wind. There is increasing observational evidence from both remote and in situ observations that support this emerging view. We review recent work relating the sub-spiral structure of the heliospheric to the concept of dynamic sources of the solar wind.

26. Does the chromosphere have heliospheric impact?

McIntosh, S.W.; Jefferies, S.M.; Armstrong, J.D.; Leamon, R.J.

We discuss new results derived from timeseries observations of the solar chromosphere by the TRACE spacecraft and the MOTH experiment on the South Pole Solar Observatory. Inferred diagnostics of the chromospheric wave field near the "magnetic transition region" are indicating that changes in the chromospheric plasma reflect properties of eruptive processes readily observed in the EUV corona and properties of the nascent solar wind measured in situ. We discuss the implications of these efforts and look to near future capabilities.

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27. Post-Shock Compression and Forward-Reverse Shock Pair Resulting From CME Interaction With a Bimodal Solar Wind

W. B. Manchester, T. H. Zurbuchen, J. Kota, T. I. Gombosi, D. L. DeZeeuw, I. V. Sokolov, G. Toth

We have found that a magnetic flux rope ejected from the corona as a fast CME may interact with the bimodal solar wind to produce a variety of unexpected results. By means of a three-dimensional (3-D) numerical ideal magnetohydrodynamics (MHD) model we explore the propagation of a fast CME with a solar wind that possesses fast and slow speed solar wind at high and low latitude respectively. Within this model system, a CME erupts from the coronal streamer belt with an initial speed in excess of 1000 km/s which naturally drives a forward shock. We find that the ambient solar wind structure strongly affects the evolution of the CME-driven shock causing deviations of the of the fast-mode shocks from their expected global configuration. These deflections in front of the flux rope lead to substantial compressions of magnetic field along with strong velocity shear producing an environment very conducive to particle acceleration. We also find that when the CME is greater than 40 Rs from the Sun that a reverse shock forms poleward of the CME as a result of the interaction of the CME with the bimodal solar wind. In front of the CME, the slow wind is deflected to higher latitude while behind the CME, fast wind is deflected to low latitude. The deflected streams collide to form a reverse shock. The shock pair formed in this way naturally forms at high latitude in the fast wind stream. We will discuss these model results in the context of in situ solar wind data and make testable predictions based on this model.

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28. SEP Acceleration at CME-Driven Shocks: The Possible Role of Acceleration in the Sheath Between the Shock and the CME

J. Kota, University of Arizona; W.B. Manchester & T.I. Gombosi, University of Michigan

Large gradual solar energetic particle (SEP) events are believed to be accelerated by CME-driven shocks. The precise mechanism of acceleration is, however, not fully understood. We suggest that the region between the shock and the CME, which has a remarkable structure of its own, may play an important role: the compression of the magnetic field lines bending around the CME behind the shock will accelerate some particles and decelerate others. The net acceleration can be quite effective at low energies and this may play a part in the injection process, too. We shall discuss the implication of realistic CME simulations and present numerical results modeling SEP acceleration and transport. The numerical code assumes field-aligned transport and traces the field line as it is pushed by the evolving CME. Some implications of the model will be discussed.

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29. Determination of the Properties of Interplanetary Shocks

Adam Szabo, NASA GSFC 612.3, Greenbelt, MD 20771

There are a number of well established techniques to compute the shock normal directions and speeds of interplanetary shocks that depend on different sets of magnetofluid parameters and/or conservation equations. Unfortunately, most often the different techniques yield significantly different results that makes it difficult to establish the relationship between shock characteristics and particle acceleration efficiency and mechanisms. Multiple published studies have explored the advantages and limitations of most of the currently used shock fitting techniques. In this paper, recent experiences with shock fitting techniques applied to the latest and most complete data sets will be discussed. Specifically, versions of the Rankine-Hugonit, various coplanarity and multi-spacecraft timing methods will be compared. Moreover, it will be established that the reliability of the shock computations is strongly dependent on the strength and type of the interplanetary shock.

SESSION INVITED TALKS
Wednesday

30. Overview of the October-November 2003 Solar Eruptions

N. Gopalswamy

Fast coronal mass ejections (CMEs), X-class flares, solar energetic particle (SEP) events, and interplanetary shocks were abundantly observed during the episode of intense solar activity in late October and early November 2003. Most of the 80 CMEs originated from three active regions (NOAA ARs 484, 486, and 488). We compare the statistical properties of these CMEs with those of the general population of CMEs observed during cycle 23. We find that (i) the 2003 October-November CMEs were fast and wide on the average and hence were very energetic, (ii) nearly 20 percent of the ultra-fast CMEs (speed >/= 2000 km/s) of cycle 23 occurred during the October-November interval, including the fastest CME of the study period (~2700 km/s on 2003 November 4 at 19:54 UT), (iii) the rate of full-halo CMEs was nearly four times the average rate during cycle 23, (iv) at least sixteen shocks were observed near the Sun, while eight of them were intercepted by spacecraft along the Sun-Earth line, (v) the CMEs were highly geoeffective: the resulting geomagnetic storms were among the most intense of cycle 23, (vi) the CMEs were associated with very large SEP events, including the largest event of cycle 23. These extreme properties were commensurate with the size and energy of the associated active regions. This study suggests that the speed of CMEs may not be much higher than ~3000 km/s, consistent with the free energy available in active regions. An important practical implication of such a speed limit is that the Sun-Earth travel times of CME-driven shocks may not be less than ~0.5 day. Two of the shocks arrived at Earth in < 24 h, the first events in ~30 years and only the 14th and 15th documented cases of such events since 1859. Work supported by NASA/LWS and NSF/SHINE

31. The Extent, Mass, and Energy of the October-November CME Events in the Interplanetary Medium

B. V. Jackson, A. Buffington, P. P. Hick and Y. Yu

White-light Thomson scattering observations from the Solar Mass Ejection Imager (SMEI) have recorded the inner heliospheric response to several hundred CMEs including the October 28, 2003 halo CME. Here we show the extent of several well-observed CMEs during this latter time period in observations from SMEI and IPS, and show how we are able to track events from their first measurements in LASCO until they vanish beyond Earth in the SMEI 180° field of view. Several portions of large CMEs observed by the LASCO coronagraphs can be tracked into the interplanetary medium. We use a 3D reconstruction technique that obtains perspective views from outward-flowing solar wind as observed from Earth, iteratively fitting a kinematic solar wind density model using the SMEI white light observations and, when available, the Solar-Terrestrial Environment Laboratory (STELab), Japan interplanetary scintillation (IPS) velocity data. This 3D modeling technique separates the heliospheric response in SMEI from other sources of background noise, and provides the 3D structure of the CME and its mass and kinetic energy. For instance, the analysis shows and tracks outward the northward portion of the loop structure of the October 28 2003 halo CME observed in LASCO images that passes Earth on October 29. We determine an excess 3D mass for this structure of 6.7×10^{16} g and a total mass of 8.3×10^{16}g. The very fast structure compared in a 3D pixel-to-pixel comparison with the IPS velocity data gives a kinetic energy for the northward portion of this event of $\sim2.0\times10^{34}$erg as it passes Earth. The CME portions going both north and south for the event on October 29 may contain as much as 10^{35} ergs totaled over the entire earthward hemisphere.

32. Solar Energetic Particle Observations during the Large Solar Particle Events of October, November, 2003

R. A. Mewaldt, C. M. S. Cohen, A. W. Labrador, and R. A. Leske (Caltech, Pasadena, CA), G. M. Mason and M. I. Desai (University of Maryland, College Park, MD), M. D. Looper, J. E. Mazur, & R. S. Selesnick (The Aerospace Corporation, Los Angeles, CA), & D. K. Haggerty (APL/Johns Hopkins University, Laurel, MD)

The extraordinary period from late October through early November 2003 was marked by more than 40 coronal mass ejections (CME), eight X-class flares, and five large solar energetic particle (SEP) events. Using data from instruments on the ACE, SAMPEX and GOES-11 spacecraft, the fluences of nine elements with $1 \leq Z \leq 26$, have been measured in these five events over the energy interval from ~0.1 to > 100 MeV/nucleon for the ions. Electron fluences have been measure from ~0.04 to 8 MeV for electrons. The ion spectra are found to resemble double power-laws, with a break in the spectral index between ~3 and ~50 MeV/nucleon which depends on the charge-to-mass ratio of the species. Possible interpretations of the relative location of the spectral breaks are discussed. The proton and electron fluences in the 28 October 2003 SEP event are comparable to the largest observed during the previous solar maximum, and within a factor of 2 or 3 of the largest SEP events observed during the last 50 years. The two-week period covered by these observations accounted for ~20% of the high-energy solar-particle fluence over the years from 1997-2003. By integrating over the energy spectra, the total energy content of energetic particles in the interplanetary medium can be estimated. After correcting for the location of the events, it is found that the kinetic energy in energetic particles amounts to a significant fraction of the estimated CME kinetic energy, implying that shock acceleration must be relatively efficient in these events.

33. October November 2003 events: plasma and composition

T. H. Zurbuchen, J. Raines, S. Lepri et al.

We discuss results from the ACE and Ulysses plasma and composition experiments. We will focus on the origin of the CME associated plasma and the theoretical puzzles that remain to be addressed.

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34. Progress and Challenges Towards Data-Driven Numerical Models of Solar Eruptions

Ilia I. Roussev (Univ. of Michigan), Igor V. Sokolov, Yang Liu (Stanford Univ.), and Tamas I. Gombosi (Univ. of Mich.)

Improved understanding of solar eruptive phenomena requires developing more realistic coronal magnetic field models in which photospheric field measurements (e.g., high quality MDI and SOLIS data) are used as a boundary condition for the magnetic field at the Sun, and the field is reconstructed in the corona using one of the standard extrapolation techniques (e.g., potential field source surface model). Apart from that, the plasma properties at the photosphere and in the solar corona are also needed to drive the models. However, presently, this is far from being realistic. Future improved solar observations (e.g., those from STEREO, Solar B, SDO, and ATST) are expected to provide a more complete and realistic set of initial and boundary conditions to drive these computational models of solar eruptions, so that reliable tools for space weather predictions become available to the community.

The principal aim of our research is the development of data-driven numerical models of solar eruptions, which test the various CME-trigger mechanisms in the context of a particular event. The simulated CME properties, when tested against observations, will help us determine the viability of a particular CME initiation model. In this paper, we discuss the progress and challenges in modeling the Halloween solar event that took place on Oct 28, 2003.

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35. Driving models with 3D tomographic reconstructions from white-light, EUV and magnetogram data

Richard Frazin, Farzad Kamalabadi (Univ. of Illinois), Ward Manchester and Ilia Roussev (Univ. of Michigan)

Recently, significant progress has been made with model-independent, 3D tomographic determination of electron densities, EUV emissivities, temperature maps and filling factors. Preliminary work that incorporates this knowledge into numerical models of coronal structures and the solar wind is looks quite promising. This talk reviews the tomographic methods and discusses its impact on numerical models. Possible applications for ultra-high resolution potential and non-potential fields from magnetograms are discussed.

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36. Progress and challenges in modeling the May 12, 1997 CME

Zoran Mikic, SAIC

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37. Heliospheric Simulations of SHINE Events Using CME Cone Models

Dusan Odstrcil (CU/CIRES & NOAA/SEC)

Although empirical cone models offer no information about the important internal magnetic structure of a coronal mass ejection (CME), they do provide easy, observationally based heliospheric model input. Numerical 3-D MHD simulations are presented for selected SHINE events. Ambient solar wind is derived from SAIC and WSA coronal models utilizing photospheric magnetic field observations. Transient disturbances are derived from XPZ cone model based on geometrical and kinematic fitting of coronagraph observations of CMEs. Results show evolution of interplanetary shocks and connectivity of magnetic field lines. Application of the same approach to different events shows our current possibilities and limitations in predicting heliospheric space weather events.

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38. Modeling the 2003 October 28-30 CME/ICME Event: Can We Predict These things?

Jonathan Krall, NRL

A numerical model of an erupting solar flux rope is shown to reproduce quantitative near-sun dynamical properties of the 2003 October 28 coronal mass ejection (CME), the measured transit time between the eruption and the corresponding “interplanetary CME" (ICME) at 1 AU on October 29, and the strength and orientation of the observed ICME magnetic field. Based on near-sun and near-earth model-data comparisons, we find that the model flux rope is deflected by 7 degrees and that only one of the five orientation angles is affected as the flux rope transits from 0.1 to 1.0 AU. We also consider the development of an improved modeling capability, in which ICME properties at 1 AU are predicted, based on near-sun measurements. (Supported by ONR and NASA)

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39. Particle Acceleration and Atmospheric Response in Impulsive Solar Flares

James Miller, U. Alabama

We present results from a unified and self-consistent model of particle acceleration and atmospheric response in impulsive solar flares. In our model, electrons and ions are stochastically energized from thermal to relativistic energies on short timescale s by cascading MHD turbulence, which is assumed to have been excited initially in the coronal region of a flare loop during the primary energy release phase. The accelerated particles then propagate to the denser transition region and chromosphere, where they can deposit a large fraction of their energy and drive the formation of a hydrodynamic shock that propagates back into the corona. The density enhancements that accompany this shock in turn modify the particle acceleration processes in the corona by altering (in a spatially-dependent manner) the density and Alfv/'en speed, and hence the acceleration rates and threshold energies. The two main components of this simulation are the NRL Dynamic Solar Flux Tube Model code and a spatially-dependent quasilinear particle acceleration/wave evolution code. As such, it provides a comprehensive treatment of both macroscopic (chromospheric ev aporation) and microscopic (wave-particle interactions) processes. We demonstrate the coupling between acceleration and atmospheric response by presenting simulation results for realistic flare parameters, and show the importance of including the later process in particle acceleration studies. We also show that accelerat ion by cascading MHD turbulence is able to account for all the major features of flare energetic particles. This work was supported by NASA grant NAG5-12794.

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40. Particle Acceleration during Magnetic Reconnection in the Solar Corona

Yuri Litvinenko (UNH)

Electric fields at sites of magnetic reconnection can efficiently accelerate charged particles. This is a review of theoretical models for collisionless particle acceleration by the reconnection electric field during solar flares. Theoretical arguments and observational evidence for rapidly reconnecting current sheets in the solar corona are also discussed. Analytical results for particle orbits in a large-scale current sheet are reviewed. Estimates for the particle energy gains and acceleration times are presented. Numerical calculations of test particle orbits are described, stressing the use of exact MHD solutions for the magnetic fields and plasma flows in the sheet. The test-particle results guide the development of more realistic acceleration models. Recent studies relax the assumption of a single large-scale current sheet. MHD and full-particle codes are now used to follow the development of transient current sheets and particle energization in a complex magnetic field environment in the flaring solar corona. Yohkoh and RHESSI observations appear to be consistent with the viewpoint that electron acceleration in impulsive solar flares occurs in magnetic reconnection regions in the corona above the soft X-ray flare loops.

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41. The Mechanism of Acceleration of Energetic Charged Particles in Impulsive Flares

J. R. Jokipii, University of Arizona

The acceleration of energetic charged particles occurs in many places in astrophysics. A number of acceleration mechanisms have been proposed, ranging from the original Swan mechanism to ones which are modern and much more-sophisticated. It is clear that diffusive shock acceleration plays a role in many situations, such as, for example, at propagating interplanetary shocks. The recently proposed diffusive-compression acceleration also my play a significant role. Other popular mechanisms are the modern version of Fermi's second-order Fermi acceleration -- called statistical acceleration and parallel electric fields.

Of particular current interest is the mechanism for acceleration in impulsive flares. Here, much recent work has successfully applied statistical acceleration by turbulent electromagnetic fields, although this is not the only possibility. I will point out that shocks are also a good candidate in impulsive events, although they are not much discussed in this context. An important point in favor of diffusive shock acceleration is the frequently observed similar power-law spectral shape at low energies, which is a natural property of shock acceleration. The improvement in observations of solar flares apparent in recent years gives some hope that this very important issue can be resolved in the near future.

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42. Cascade and Damping of Turbulence in Solar Flares: Plasma Heating and Particle Acceleration

Vahe' Petrosian and Siming Liu (Stanford University)

There are several observations of solar flares which point out the importance of turbulence in heating of flare plasma and acceleration of energetic particles (SEPs) which produce most of the observed flare emission and are observed as Solar Energetic Particles. An accurate assessment of the above processes requires consideration of the generation, cascade via nonlinear processes, and damping of the turbulence by the background particles which results in the heating and acceleration. In this paper we will describe the cascade and damping of Alfvenic and fast mode turbulence and discuss some applications of the the results in describing recent observations by RHESSI of flare radiations and by ACE and WIND of SEPs, in particular relative enhancement of 3He and heavy ions.

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43. Particle Acceleration at CME-Driven Shocks

Chee K. Ng, Code 661, NASA Goddard Space Flight Center, and Department of Astronomy, University of Maryland, College Park

Observation of solar energetic particles (SEPs) indicates that GeV particles are accelerated ~ 15 minutes after CME launch. This short time scale demands very small particle mean free paths (< 10^-6 AU) in Fermi shock acceleration models, in apparent contradiction with the large mean free paths (> 0.3 AU) deduced from interplanetary transport of SEPs. Can wave amplification by SEPs reduce the mean free paths by many orders of magnitude in minutes? We will present our first attempt to address the above issue with a nonlinear model of SEP acceleration by a parallel shock, coupled to self-consistent Alfven wave amplification, and including wave transmission and reflection by shock. For typical plasma and shock parameters at a few solar radii, and starting with low wave intensities in the corona (mean free paths > 0.5 AU), our preliminary results show that 20 - 40 keV suprathermal protons, at ~ 1% of the ambient solar wind density, are accelerated to ~ 50 MeV in several minutes by a parallel shock, along with huge amplification of waves. Since quasi-perpendicular shocks are expected to be much more efficient in accelerating particles than parallel shock, our preliminary results are an encouraging first step toward fully explaining the observation.

SESSION INVITED TALKS
Thursday

44. CISM end-to-end Space Weather Modeling progress and plans

JG Luhmann (UC Berkeley) and the CISM Members

The CISM (Center for Integrated Space Weather Modeling) effort, led by Boston University, has after 3+ years of effort made some significant strides toward its goal of building a physics-based, coupled chain of space environment models from the photosphere to the Earth's middle atmosphere. This presentation provides an overview of the current state of that modeling effort, which includes solar and heliospheric elements of particular interest to SHINE. The work also allows some interesting insights into the key solar and heliospheric elements for producing space weather conditions of practical importance. For example, it allows the evaluation of various proposed CME initiation mechanisms for their likelihood of producing very fast CMEs, a more in-depth understanding of the CME ejecta "flux rope" picture, and exploration of the role of the ambient corona and solar wind in producing a geoeffective disturbance at L1. It also allows studies of the ways in which the geospace itself modifies the impact of a given interplanetary event. Overall, treatment of space weather from the holistic perspective seems to raise the question of whether it could ever be understood in terms of its isolated components. CISM is providing one tool for future practioners of the systems approach.

45. Present status and future challenges of modeling the Sun-Earth

R.S. Weigel and D.N. Baker, CU/LASP

Many space research groups are presently modeling key portions of the solar-terrestrial environment. Large-scale models of the solar corona, of the interplanetary medium, and of the coupled magnetosphere-ionosphere system are providing important insights into the dynamics and temporal evolution of these regions during normal, as well as disturbed, conditions. Some collaborative groups are now working on even more grand syntheses of models and are striving for a true end-to-end modeling capability. The challenges of such integrated modeling are immense: Vastly different spatial and temporal scales must be addressed and codes must be synchronized to a high degree. Since much of the underlying physics at micro- and meso-scales remains unknown (or only poorly known), many key interface regions must be treated using empirical or semi-empirical methods. Validating the results from such global-scale models is, in itself, a major undertaking. And last, but by no means least, the question of how available (sparse) data are assimilated into end-to-end models remains a major challenge to our community. This talk provides a broad overview of the present status and future challenges inherent in end-to-end modeling.

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46. Radio Emission from CMEs

Timothy Bastian, NRAO

Understanding radio emission from CMEs and their environment is in a fledgling state, yet radio emission holds the promise of bringing powerful new diagnostics to bear on the problem of CME initiation, acceleration, propagation, and associated particle acceleration. I will discuss previous observations of thermal and nonthermal radio emission from CMEs and what they tell us about these issues. I will outline how such observations could be more fully exploited, and conclude by briefly touching on next-generation ground- and space-based instrumentation that will, in fact, allow fuller exploitation of radio observations.

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47. Relationships between Solar Radio Emissions and Energetic Particle Events

H. V. Cane, NASA/GSFC

Although most radio bursts are caused by low energy (<100 keV) electrons, various correlations suggest that they provide information about ions at much higher energies as well. All particle events that increase rapidly at the time of the associated flare are associated with fast drift, type III radio bursts. If these type III bursts are short duration (last about 5 minutes at 50 MHz) and occur at the time of the onset of the flare then the particle events are also short duration and they are proton-poor. In the other 'prompt' events the particle increases are proton rich and last longer; the associated emissions last typically 20 minutes, occur near flare maximum and are called type III-l. Occasionally solar particle increases are not accompanied by type III bursts and in these cases the increases rise slowly and peak at the time of an associated interplanetary shock. The largest particle events are also associated with slow drift radio bursts seen at very low frequencies, so-called IP type II events. Thus radio bursts indicate that there are two basic acceleration sites relevant for solar particles. In addition to acceleration at CME-driven shocks there are stochastic processes in flare loops. In the largest events this latter process is likely to occur in larger loops after the impulsive phase of flares.

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48. Coronal radio bursts

S. M. White, T. S. Bastian and R. Bradley

Paper for the topic "Radio Observations of CMEs and Particle Acceleration": we will discuss the relationship between solar radio bursts, CMEs and particle acceleration using results from the Green Bank Solar Radio Burst Spectrometer where possible to illustrate the discussion.

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49. Radio Observations Related to CMEs and to Particle Acceleration

Mike Reiner

It has been known since the 1950's that coronal shocks and particle acceleration produce distinct radio signatures that can be remotely observed by ground-based and spaced-based radio observatories. The so-called type II radio bursts are generated by coronal shocks and can provide information on the origin and kinematics of these moving disturbances. On the other hand, the so-called type III radio bursts are associated with accelerated electrons. They therefore provide information on the origin and timing of particle acceleration sites in the corona, which can be directly compared to the in-situ particle observations. Although the details of the processes and conditions necessary for generating type II and type III emissions are not precisely known, they can nevertheless be used, particularly in conjunction with constraints provided by other complementary observations, to yield crucial information on solar energetic solar processes. For example, since major CME/flare events generally produce both type II and type III radio emissions, these observations can clarify the relationship between the CME and coronal particle acceleration.

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50. Finite time shock acceleration and fits to ESP ion spectra

David Ruffolo, Mahidol University

Chanruangrit Channok (1,2,3), David Ruffolo (2), Mihir Desai (4), and Glenn Mason (4) - (1) Department of Physics, Chulalongkorn University, Bangkok, Thailand (2) Department of Physics, Mahidol University, Bangkok, Thailand (3) Department of Physics, Ubonrajathanee University, Ubonrajathanee, Thailand (4) Department of Physics, University of Maryland, College Park, Maryland, USA

Energetic storm particles (ESP) of various ion species have been shown to comprise suprathermal seed ions accelerated by traveling interplanetary shocks. The observed spectral rollovers at ~0.1 to 10 MeV nucleon^{-1} can be attributed to the finite time available for shock acceleration. Using the locally measured shock strength parameters as inputs, the finite-time shock acceleration model can successfully fit the energy spectra of carbon, oxygen, and iron ions measured by ACE/ULEIS during 3 ESP events. The inferred scattering mean free path in the acceleration region ranges from typical interplanetary values for the weakest ESP events down to 4.0×10^{-3} AU for the strongest event. This is consistent with the idea that proton-amplified waves result from the very intense particle fluxes in major events.

Work in Thailand was supported by the Commission for Higher Education, the Rachadapisek Sompoj Fund of Chulalongkorn University, and the Thailand Research Fund. Work at the University of Maryland was supported by NASA contract NAS5-30927 and NASA grant PC 251428.

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51. How particles are accelerated to high energies in large SEP events - A secret recipe

Gang Li, IGPP, UCR

Gradual SEP events are believed to be CME-driven shock related. However, not every shock is capable of producing energetic particles. Many shocks can only accelerate particles to ~ MeV energies and some do not accelerate particles at all.

What makes the shocks behave so differently? What are so special of the shocks in large SEP events? What are the favorable conditions for diffusive shock acceleration to be effective? What can we learn from observations? I will discuss these questions in my talk, with a balance between theoretical work and observational evidence.

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52. Solar Energetic Particles: Acceleration and Transport in Realistic Magnetic Fields

Sokolov, I.V., I.I.Roussev, T.I.Gombosi, Center for Space Environment Modelling, University of Michigan

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53. Solar and Heliospheric Models at the CCMC

P.MacNeice(Drexel Univ.), C. N.Arge(AFRL),
D.Odstrcil(NOAA),M.Kuznetsova(NASA),L.Rastaetter(Catholic Univ), M.Hesse(NASA)

The Community Coordinated Modeling Center (CCMC) is a multi-agency effort to test research quality space weather research models and to assist in their transition to the Rapid Prototyping Centers where they are prepared for use in operational forecasting. The CCMC hosts a number of solar and heliospheric models. We have recently added the Wang-Sheeley-Arge and ENLIL models to this list. We report on these new additions which are running continuously in an automated realtime mode, and were being used to provide information on potential SEP activity to the DEEP IMPACT mission operators prior to their encounter with the comet TEMPEL 1. In addition these models are available for use by the community through our web accessed Run-On-Request facility. This provides researchers with access to these models so they can be used to establish relevant contexts for data analysis.

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54. The Solar Wind in the Outer Heliosphere

John Richardson: MIT

Voyagers 1 and 2 are now beyond 75 and 95 AU, respectively, and have been taking data since 1977. We describe plasma and magnetic field observations in the outer heliosphere and the evolution of the solar wind with distance. The interstellar medium has two major effects; it slows and heats the solar wind. We discuss the observed magnitudes of these effects and compare to theory. Significant structure remains in the solar wind and this structure evolves with distance; in recent data ICMEs drive the formation of large merged interaction regions which dominate the plasma structure at Voyager 2. Large events observed in the inner heliosphere can be traced to Voyager, such as the Halloween ICMEs. The magnetic field data are consistent with the Parker spiral predictions throughout the heliosphere. Although the Voyager 1 plasma instrument does not work, we can use Voyager 2 data to approximate solar wind conditions at Voyager 1. We show that the particle events associated with the termination shock are affected by the passage of the MIRs observed at Voyager 2.

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55. Mapping the Heliosphere: a New Look at Energetic Particle Increases at CIRs

Trevor Sanderson, ESA/ESTEC

We present a new look at energetic particle signatures of Co-Rotating Interaction Regions (CIR) out at 5 AU, based on a combination of particle and plasma observations from the Ulysses spacecraft, and ground-based observations from the Wilcox Solar Observatory and the Kitt Peak Solar Telescope. Using the ground based observations, we determine the position of the sources of the high speed streams and the position of the current sheet, and then map out the structure of the streams and sector boundaries to the position of the Ulysses spacecraft. We compare the local observations at Ulysses of the streams and sector structure with this structure. We examine the intensity profiles and flow directions of the energetic particles over a wide range of energies as measured by the Ulysses COSPIN instrument in the context of this structure. In between the forward and reverse shocks, close to the stream interface, and on field lines not connected to the shocks, we observe particles flowing outwards from the Sun. Upstream of the reverse shock, the particles are flowing towards Sun and towards the shock rather than away from the shock. This is a fast solar wind region, which maps out from the coronal holes. We conclude that this is further evidence for Fermi acceleration in this upstream region.

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56. Asymmetries in the Solar Wind from the Sun to the Outer Heliosphere

Devrie Intriligator, Carmel Research Center

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57. The Effect of Solar Photospheric Footpoint Motion on the Heliospheric Magnetic Field

Nathan Schwadron, Southwest Research Institute

The effects of footpoint motions in the photosphere lead to large observable distortions in the heliospheric magnetic field. The new field configuration of the heliosphere has broad implications for the propagation and acceleration of energetic particles, and the formation and evolution of solar wind. The strongest magnetic field distortions in the new configuration arise because footpoint motions on the Sun cause field lines to be connected between fast and slow wind streams. The field lines are subsequently distorted as fast wind pulls out the field faster than slow wind. In the inner heliosphere, this leads to a "sub-Parker" spiral with field lines much less transverse than the Parker spiral. During solar minimum conditions the low-mid latitude "interaction band" between fast wind at high latitudes and slow wind at low latitudes should significantly distort the heliospheric magnetic field, provided that there are latitudinal footpoint motions at the Sun. At the termination shock, these strong field distortions, termed "Favored Acceleration Locations at the Termination Shock" (FALTS), provide favored access for the injection of relatively low energy particles into diffusive shock acceleration. FALTS may be critical for the acceleration of Anomalous Cosmic Rays. Recent Voyager observations show that the Anomalous cosmic rays are generated at preferred locations on the termination. FALTS provide just such preferred acceleration regions. In this talk, we discuss implications of footpoint motions on the Sun for the global structure of the heliospheric magnetic field.

POSTER ABSTRACTS
Campaign Events

1. Investigation of the Stream Structure and Coronal Sources of the Solar Wind Using Improved, Mount Wilson Photospheric Field Synoptic Maps: The April 7th and May 12th, 1997 Halo CME Events

C. Nick Arge (AFRL/Space Vehicles Directorate), Giuliana de Toma (NCAR/HAO), & Dusan Odstrcil (University of Colorado/CIRES & NOAA/SEC)

We have developed a generalized code that can assemble synoptic maps of various types (e.g., standard Carrington, updated, as well as other specialized types) using virtually any type of solar disk data. With this code, we have constructed new, 0.5° resolution, Mount Wilson Solar Observatory (MWO) photospheric field synoptic maps for the two Carrington rotation (CR) time interval encompassing the April 7 and May 12, 1997 halo coronal mass ejections (i.e., CR1921-1922). The new maps are made from 0.5° resolution remapped MWO magnetograms that have been corrected for line saturation effects as well as having the line-of-sight field measurements converted to radial orientation. A set of 0.2° SOHO/EIT 28.4nm and 19.5nm EUV maps have also been constructed for these two rotations using our assembly routine and calibrated EIT disk data. We use these different synoptic maps in combination to better understand the coronal sources and stream structure around the times of the two CME events. In this initial study, we reduce the resolution of the new MWO maps to 2.5° and use them as input to the Wang-Sheeley-Arge (WSA) model, which is used to calculate the global coronal field configuration and the ambient solar wind speed and IMF polarity near Earth. The results generated by the WSA model are then compared with the WIND satellite observations near Earth as well as the EIT coronal synoptic maps. We plan to use the new MWO updated maps to drive the coupled WSA+ENLIL model (ENLIL is a 3D MHD solar wind code) during this same time interval in an effort to obtain a more accurate global prediction of the background solar wind structure, as it plays an important role in simulations of transient interplanetary disturbances.

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2. Heavy Ion Spectra and Composition of the Halloween 2003 SEP Events

Cohen, C. M. S[1]., Mason, G. M. [2], Stone, E. C.[1], Mewaldt, R. A.[1], Leske, R. A.[1], Desai, M. I. [2], Cummings, A.C.[1], von Rosenvinge, T. T.[3], Wiedenbeck, M. E.[4] ([1]California Institute of Technology, [2]University of Maryland, [3]NASA/Goddard Space Flight Center, [4]Jet Propulsion Laboratory)

We have combined data from the ULEIS and SIS instruments on ACE to obtain particle intensities over >3 decades in energy in the series of extremely large solar energetic particle (SEP) events of October and November 2003. We show how the event-integrated composition (carbon through iron) varies from event to event, and depends heavily on energy within an SEP event. We discuss these variations in terms of the energy spectra, in particular the observed element-dependent spectral breaks. We suggest possible interpretations of these breaks in terms of rigidity- and diffusion- related effects.

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3. Sub-surface evolution of AR 0486, AR 0069, and AR 9906

Komm, R., Howe, R., Hill, F. (NSO)

We study the subsurface evolution of the flows near active regions AR 0486, AR 0069, and AR 9906 during their disk passage. We use a local helioseismology technique, ring-diagram analysis, to determine the flows in the upper 16 Mm of the convection zone from high-resolution GONG data. The GONG network has been producing consecutive high-resolution images suitable for local helioseismology since July 2001. There are MDI Dynamics Program data available covering the disk passage of AR 0486 and AR 9906. In addition to the velocity components, we study the vorticity and kinetic helicity density of the flows near all three active regions. Since the current analysis is limited to regions within 60 degrees of heliographic latitude and central meridian distance, we cannot measure flows near the solar limb associated with the active regions that spawned the events on April 21 and August 24, 2002. But, we can study the flow history before the events. In a preliminary analysis of AR 0486, we find in the daily flow maps a systematic variation in the kinetic helicity density that might be a subsurface indicator of flare events. We will present the latest results.

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4. Flare and associated phenomena on May 12, 1997

Lokesh Bharti, Rajmal jain, Chandan joshi and S.N.A. Jaaffrey

The multispectral observations of NOAA active region No. 8038 during 10-13 May 1997 are presented. The observations of MDI/SOHO magnetograms show that in this active region continual but discrete growth and decay of magnetic field was taking place indicating either continuous evolution of magnetic flux or emergence of new flux region. The movie of these magnetograms reveal two important results that the major opposite polarities of pre-existing region were approaching towards each other, and a small north polarity flux i.e. moving magnetic feature (MMF) was ejecting out from major north polarity at a quasi-periodicity of about 10 hrs during 10-13 May 1997. It appears that as a result of flux cancellation by one such ejected north polarity flux with a newly emerged south polarity flux around 04:30 UT on 12 May 1997, a blast wave generated, seen by EIT/SOHO, producing CME and a moderate but long enduring 1B/C1.3 solar flare. The observations in H-alpha, soft X-ray, hard X-ray, ionospheric absorption, radio and interplanetary scintillations in association to this flare are presented in detail. The multiwavelength observations of the flare showed occurrence of at least two phases of energy release, first at 04:42 and second at 04:47 UT. We propose a qualitative model to interpret the observations, which, however, also explains the generation of CME and associated flare with two stages of energy release. The occurrence of type II radio burst at 04:54 UT was perhaps due to shock produced by the plasmoid erupted during second energy release at higher altitude in the corona. It appears that the plasmoid traversed through shock in the interplanetary medium so as to enhance the scintillation index on 14 May as inferred from IPS observations.

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5. The Magnetic Field Structure in the May 12, 1997 CME Event*

V. S. Titov, Z. Mikic, J. A. Linker, R. Lionello, and P. Riley, SAIC

A simple analytical model of the coronal magnetic field prior to the CME eruption on May 12, 1997 is developed in the current-free approximation. The magnetic field is constructed by superimposing a large-scale background field and a localized bipole field to model the active region. The background field is determined from the normal component of the observed photospheric magnetic field averaged over the longitude of the Sun. The influence of the solar wind is taken into account by imposing a source-surface boundary condition that makes the field radial at a specified radius. The field of the active region is modeled with the help of a subphotospheric dipole whose strength, location, and orientation are optimized to fit the magnetic field obtained from an MDI magnetogram. A corresponding force-free magnetic field is developed then by shearing and twisting the potential configuration. We demonstrate that the configuration contains the so-called hyperbolic flux tube which is a union of two intersecting quasi-separatrix layers. Its structure and evolution is analyzed and related to the characteristics of the observed eruption. *Research supported by NASA and the Center for Integrated Space Weather Modeling (an NSF Science and Technology Center).

Working Group 1
Solar

6. 3D MHD Simulations of Magnetic Flux Emergence in Active Regions

William Abbett, UC Berkeley

We report on the progress of 3D simulations of active region magnetic flux emergence (and decay) through the stratified, sub-photospheric layers of the turbulent upper convection zone into the solar atmosphere and low corona (the lower boundary of the computational domain extends to approximately 3.5 Mm below the visible surface). We use our recently-developed 3D semi-implicit MHD code (with a non-uniform, adaptive mesh) to address the inherent stiffness of the system of equations, and will compare our results with similar studies using second-order accurate, fully explicit numerical schemes.

7. CME-rich and CME-poor Active Regions

S. Akiyama (CUA), S. Yashiro(CUA), and N. Gopalswamy (NASA/GSFC)

We report the association of coronal mass ejections (CMEs) with strong X-ray flares (above M-level) occurring in flare-productive active regions (ARs). We defined flare-productive ARs as those, which produce at least three M-class flares during their disk passage as reported in the Solar Geophysical Data. There were 75 flare-productive ARs from 1996 through 2001, which produced a total of 521 strong X-ray flares. The CME associations rate (R) of these X-ray flares was examined using data from the Large Angle Spectrometric Coronagraph (LASCO) on board the Solar and Heliospheric Observatory (SOHO), and we used it as index of AR CME-productivity. We found that there are extremely CME-rich and CME-poor ARs. Out of the 75 ARs, 10 ARs were CME-rich ($R > 85\%$) and 8 ARs were CME-poor ($R < 15\%$). We discuss the characteristic difference between the two types of ARs.

8. Solar Polar Imager: Observing Solar Activity from a New Perspective

David Alexander, Paulett Liewer, Juan Ayon and the SPI Study Team

Our current understanding of the Sun and its atmosphere is severely limited by a lack of observations of the polar regions. The Solar Polar Imager mission uses solar sail propulsion to place a spacecraft in a 0.48 AU circular orbit around the Sun with an inclination of 75°. This first direct view of the polar regions of the Sun enables crucial observations not possible from the usual ecliptic viewpoint and will revolutionize our understanding of the internal structure and dynamics of the Sun. The rapid 4 month polar orbit and the combined in situ and remote sensing instrument suite allow unprecedented studies of the link between the Sun and the solar wind and solar energetic particles. Moreover, SPI can serve as a pathfinder for a permanent solar polar sentinel for space weather prediction in support of the Vision for Space Exploration. The Solar Polar Imager will provide the capability to - Monitor Earth-directed CMEs from high latitudes - Greatly improve models of the global heliosphere using better magnetogram coverage in longitude and latitude - Observe active regions for much longer than 13 days - Monitor ARs before they appear around the east limb - Provide better coverage of AR sources of CMEs and SEPs - Yield more complete information on subsurface flows and evolving ARs - Provide in-situ measurements of magnetic fields, solar wind and SEPs out of the ecliptic plane - Determine the latitudinal dependence of the total solar irradiance variability - Monitor Mars-directed CMEs from high latitude. In this paper we report on the results of a recent Vision Mission study refining the science objectives, instrument suite, orbit and trajectory analysis, solar sail characteristics and measurement strategy. The SPI provides an important step in improving our understanding of the physics governing solar variability on long and short time-scales and on local and global scales.

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9. Can Force-Free Extrapolations Reproduce the Coronal Magnetic Topology?

G. Barnes, K.D. Leka, M. Wheatland and Y. Fan

Several mechanisms have been proposed for producing solar energetic events, each of which tends to possess a distinctive topological feature. We consider two such features here: an X-type separator, as a likely site for reconnection, and the separatrix surface associated with a bald patch, as an important characteristic of flux tubes which may be susceptible to the kink instability. In order to distinguish the mechanism(s) which give rise to energetic events, it will be important to be able to reproduce the coronal topology from an observed boundary condition. We first outline a method for quantifying the performance of an extrapolation for a known solution, based on the notion of Quasi-Separatrix Layers. We then apply extrapolation techniques, one linear and one non-linear, to the two examples, and judge their performance. Both techniques have limitations, but in some instances we find that it is possible to reproduce the magnetic topology of the examples. This work was funded by the Air Force Office of Scientific Research under contract F49620-02-C-0191 and by the National Science Foundation under grant ATM-0454610.

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10. Coronal Magnetic Field Measurements Above a Large Sunspot at the West Solar Limb

J. W. Brosius (CUA) & S. M. White (UMD)

We obtained coordinated extreme-ultraviolet (EUV) and radio observations of NOAA Active Region 10652 at the west solar limb on 2004 July 29 and 30 as part of SOHO Joint Observing Program (JOP) 100. EUV spectra obtained with the Coronal Diagnostic Spectrometer (CDS) were coaligned with full-disk EUV images obtained with the Extreme-ultraviolet Imaging Telescope (EIT) and with full-disk photospheric longitudinal magnetograms obtained with the Michelson Doppler Imager (MDI). Radio observations at 15, 8.0, 4.5, and 1.4 GHz were obtained with the Very Large Array (VLA). The region contained a large sunspot with bright plume emission, spawned a GOES class C2.8 flare at 16:28 UT on July 29, and displayed a rising, expanding transequatorial loop. All of these features are clearly visible against the relatively dark background above the solar limb. This enables us to derive unambiguously the height dependence of the coronal magnetic field. In the sunspot this varies from 1000 Gauss at a height of 7500 km above the limb, to 170 Gauss at 30,000 km. (This work is supported by NASA grant NAG5-11757 to CUA.)

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11. Basic Properties of CMEs in the Low Corona

J. Burkepile, G. deToma, J. A. Darnell, A. Stanger, H. Gilbert, S. Gibson (NCAR /HAO)

It is widely believed that CMEs form low in the corona and interact with surrounding coronal and solar wind structures as they propagate outward, thus altering their basic properties. We examine the basic properties of CMEs, such as size, location, speed, acceleration, and start time, in the low corona (below 2.8 solar radii)as determined from MK3 and MK4 K-coronameter observations from the Mauna Loa Solar Observatory and compare these with the measured properties of the same CMEs as determined from the LASCO observations of the outer corona (2 to 32 solar radii). The average size and speed of the CMEs is significantly larger and the average acceleration is significantly smaller in the outer coronal observations by LASCO. The average start time as determined from low coronal observations is earlier then the start time determined from LASCO observations. These results are consistent with earlier results (e.g. St.Cyr et al. 1999) and suggest that CMEs attain a maximum acceleration low in the corona and undergo some angular expansion between the LASCO and MK3/4 field-of-views. Projection and instrumental effects will also be addressed.

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12. Reconstruction of coronal electron density using solar rotational tomography

Mark Butala, Univ. of Illinois at Urbana-Champaign

In solar rotational tomography (SRT), the three-dimensional (3D) coronal electron density (N_e) is reconstructed from a time series of white-light polarized brightness (pB) coronagraph images measured over a span of 14 days. In our previous work, the corona has been assumed to be static over the measurement period, resulting in significant artifacts in the N_e reconstructions. The dynamic nature of the corona can be accounted for by using Kalman filtering techniques, but such a methodology presents significant computational challenges. The purpose of this work is to summarize our current understanding in combating these challenges including the use of several different approximate Kalman filtering schemes.

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13. CME 'seismology'?

Chané, Poedts, Van der Holst (presented by Carla Jacobs)

The evolution of CMEs from the Sun up to 1 AU is simulated numerically in the framework of a 2.5D (axisymmetric) ideal MHD model. The CMEs are simulated by means of a very simple model, viz. a high density and high pressure magnetized plasma blob superposed on a background steady state solar wind model. The CMEs are launched at a certain velocity, in a given direction and are further characterized by a given flux rope density and magnetic field strength and polarity. We then try to reproduce the physical values (density, velocity and magnetic field) observed by the ACE satellite after the halo-CME event which occurred on April 4th, 2000. For this purpose, the background wind and the CME parameters (launching velocity, initial polarity, density, magnetic field strength, etc) are adjusted to yield the best possible fit of the ACE data. Hence, we actually use the information at 1 AU to derive the characteristics of the CME when it was still close to the Sun. This reverse-engineering technique could be called 'CME seismology', and could be extended to include information on the leading shock front and radio spectrogram data in the procedure to derive CME initiation parameters.

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14. UV and Hard X-ray evidence for 3-D reconnection in Large Flares

Aaron J. Coyner and David Alexander, Rice University

Coordinated observations of UV and hard X-ray emission in flares provide crucial diagnostic information regarding the relationship of active region topology to the flare-related energy release and potential CME initiation. We present analysis of the temporal relationship and spatial distribution of these disparate emissions for two X-class flares with high-cadence TRACE 1600=C5 observations and hard X-ray imaging from RHESSI. We verified the known temporal relationships from previous studies and compare the spatial distributions of the UV and hard X-ray emission to determine cases of spatial separation or extended development. The spatial distributions observed along with the temporal correlations require a complex 3-D topological picture involving the interaction of multiple flux systems fostering magnetic reconnection and thus flare energy release along a temporally evolving separator.

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15. Hard X-ray Substructure in the Halloween Flares of 2003

Antoun Daou and David Alexander, Rice University

We use the unprecedented spectral and spatial resolution of RHESSI to explore structure in the hard X-ray emission of large solar flares including the Halloween events of 2003. Spatially-independent substructures are identified within each event from the reconstructed RHESSI images in the 25-100keV range. We find that large flares are typically comprised of multiple isolated structures spanning a wide range of photon fluxes. This analysis improves our understanding of the distribution and strength of individual energy deposition locations in large flares from which we can hope to learn more about the sites of flare and CME triggering.

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16. Coronal Holes during Solar Cycle 23

G. de Toma, C.N. Arge, P. Riley

Historically, coronal holes have been observed as regions of reduced emission on the solar disk in X-Ray and EUV wavelengths or as relatively bright regions in the HeI 1083nm line. They are usually identified with the footpoints of magnetic field lines open into the heliosphere as derived from potential field or MHD model extrapolations. Because the appearance of coronal holes is different at different wavelengths, and there are not observational data to directly determine which regions on the Sun are magnetically open or closed, the identification of coronal holes has always been difficult. Here, we present a study of coronal holes during solar cycle 23, from solar minimum to its declining phase, that takes advantage of the SOHO observations and the most recent coronal models.

To identify coronal holes, we use the drawings made at NSO/Kitt Peak from K. Harvey and F. Recely as well as coronal holes maps generated by a computer code that we developed to automatically identify coronal holes. In our code we combine relative intensity images in EUV wavelengths from space, with ground based observations and magnetograms to find coronal hole regions. To model coronal holes we use the Wang-Sheeley-Arge (WSA) model and the SAIC coronal model. The WSA model uses a magnetostatic potential field source surface model coupled to a current sheet model. The SAIC model is a 3D magnetohydrodynamic model of the solar corona. Both models use the same solar synoptic maps to specify the photospheric magnetic field.

We use observations to study changes in area coverage and latitudinal distribution of coronal holes during the solar cycle and we make quantitative comparisons of observations with model computations. The solar maximum versus solar minimum phase is discussed, including the time of the polar reversal.

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17. Magnetic Free Energies of Breakout Coronal Mass Ejections II

C R DeVore & S K Antiochos (Naval Research Laboratory)

We have calculated the magnetic free energies available to power coronal mass ejections (CMEs) and their associated flares in spherically axisymmetric, multipolar breakout configurations. An earlier analysis was restricted to solitary eruptions of the central arcade starting from the potential state. Our expanded approach encompasses a model solar-wind initial state, solitary eruptions of either side arcade, and simultaneous or sequential eruptions of any two arcades. We report our initial results here. First, the pre-opening of the highest coronal field lines by the solar wind lowers all threshold free energies for CME onset, as anticipated. The available CME energies modestly increase for the central arcade and decrease for the side arcades, while the flare energies remain unchanged. Second, because the side arcades contain much more magnetic flux, their CME onset and flare energies are far higher than those for the central arcade. Their available CME energies also are greater, though not by as large a multiplier. Third, for the configurations we have analyzed thus far, the CME onset energy for simultaneously opening any two of the arcades exceeds the sum of the onset energies for the solitary eruptions. Consequently, simultaneous eruptions are not expected to occur. However, opening either side arcade in a CME dramatically lowers the eruption onset energy for the other side arcade, by reconfiguring its outermost flux through breakout reconnection. This result supports a scenario in which sequential eruptions occur in rapid succession in coronally connected but photospherically distant flux systems, i.e., the well-known phenomenon of 'sympathetic' CMEs. Our research was supported by NASA and ONR.

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18. Forecasting Coronal Mass Ejections from Line-of-Sight Magnetograms

D. A. Falconer (UAH/MSFC/NSSTC), R. L. Moore, G. A. Gary, (NASA/MSFC/NSSTC)

We report further results from our ongoing development and assessment of magnetogram-based measures of active-region nonpotentiality for forecasting of coronal mass ejections (CMEs). We present two generalized improved measures of active-region total nonpotentiality: WL_SS, the shear-weighted total length of all strong-field neutral lines in the active region, and WL_SG, the magnetic-gradient-weighted total length of all strong-field neutral lines in the active region. These new measures can be applied to active regions of any degree of magnetic complexity, thus removing our previous restriction to predominantly bipolar active regions. For predominantly bipolar active regions, we show that these new measures (1) predict the CME productivity as reliably as do our previous analogous un-weighted measures of only the main neutral line (L_SSM and L_SGM), and (2) can be measured with much less uncertainty for weakly nonpotential active regions. From a set of 48 vector magnetograms of arbitrary magnetic complexity (bipolar or multi-bipolar), we find that WL_SS and WL_SG each have a ~75% success rate for prediction of CME production within 2 days after the magnetogram. The measure WL_SG was obtained from only the line-of-sight component of our MSFC vector magnetograms. From a set of 25 of these active regions for which there were also SOHO/MDI line-of-sight magnetograms, we verify that for CME prediction, WL_SG measured from MDI magnetograms works practically as well as WL_SG measured from MSFC magnetograms. This opens the door to more extensive studies of active-region nonpotentiality and its evolution from analysis of MDI magnetograms. The continuity and cadence (96 min) of the MDI magnetograms allows measurement of the rate of change of active-region nonpotentiality and associated magnetic flows, and examination of their correlation with CME productivity. We present initial results on the evolution of active-region nonpotentiality and magnetic flows measured from MDI magnetograms. This work was funded by NASA through its LWS TR&T Program and its Solar and Heliospheric Physics SR&T Program, and by NSF through its Solar Terrestrial Research and SHINE Programs.

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19. Equilibrium and Evolution in a 3D Flux-Rope Model of CMEs

T.G. Forbes and P.A. Isenberg, University of New Hampshire

Based on earlier work by Titov & Démoulin (1999), ourselves, and others, we have developed a new analytical model which accounts for the onset and early evolution of CMEs. Unlike earlier models, the new model incorporates the full effect of the line-tying of the coronal magnetic field at the surface of the sun. This new feature allows us to determine the location and stability properties of the equilibria within the six-dimensional parameter space that prescribes the initial magnetic field configuration. We are also able to determine the initial evolution of the field in the case of unstable equilibria. The new model successfully explains several puzzling features of recent 3D numerical simulations by Roussev et al. (2003) and Török & Kliem (2003). These include (1) the failure of some erupting flux ropes to escape, (2) the strong out-of-plane twisting motions that are sometimes present, (3) the aneurism-like shape of most eruptions, and (4) the existence of collapsing flux ropes which fall downward. The model not only explains these features, but also allows us to predict them quantitatively as a function of the initial parameters.

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20. Real-Time Prediction of the Eruption Potential in Solar Active Regions: Magnetic Energy and Helicity Considerations

Manolis K. Georgoulis and Barry J. LaBonte, JHU/APL

We describe a technique to evaluate the energy/helicity formula in solar active regions by means of vector magnetic field observations taken on the boundary (photospheric or chromospheric) plane of these active regions. The potential, the non-potential, and the total magnetic energy, together with the magnetic helicity budgets in the active-region corona are readily calculated without using the - sometimes ambiguous - Virial theorem. Prior to the calculation, the 180-degree azimuthal ambiguity in the studied vector magnetograms is also readily resolved with the required computing time for this purpose ranging between a few seconds and a few minutes. Preliminary results indicate that with the total magnetic energy and the total magnetic flux between eruptive and non-eruptive active regions being comparable, there is a clear distinction in the total magnetic helicity and the relative non-potential magnetic energy between eruptive (flare-productive and CME-triggering) and non-eruptive active regions. This result, given the speed of the overall calculation, can be of interest to future space missions with vector magnetogram coverage of the solar disk, such as the Solar-B and the Solar Dynamics Observatory. The energy/helicity calculations are currently performed using the linear force-free approximation but an upgrade to a nonlinear force-free calculation of the above parameters is well underway.

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21. After the storm: end-states of erupting and partially-erupting coronal magnetic flux ropes

Sarah Gibson (NCAR/HAO), Yuhong Fan (NCAR/HAO), Tibor Toeroek (MSSL/UCL)

We will show how 3D numerical MHD simulations of erupting magnetic flux ropes capture observed properties of the coronal post-CME end state. In particular we will consider 1) the "standard" model of post-flare loops with a cusp current sheet formation below the erupting CME, 2) transient coronal holes/dimmings 3) the reappearance of X-ray sigmoids immediately after eruption, 4) partial- or non-eruptive filaments, and 5) magnetic cloud observations of possible entrained filament material. We will also discuss how the state of the coronal magnetic field prior to the CME, i.e. the presence or absence of a pre-existing coronal magnetic flux rope and the nature of connectivity of the flux rope to the photosphere, may affect the ultimate post-CME coronal end-state.

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22. Application of a new technique for deriving prominence mass from SOHO/EIT Fe XII (19.5 nm) absorption features

Holly Gilbert (HAO/NCAR)

It is presently unclear what role prominences play in the initiation and dynamics of coronal mass ejections (CMEs), although erupting prominences are strongly correlated with CMEs. The masses of prominences involved in CMEs are not generally measured, but the accurate determination of such masses may help in assessing the dynamical importance of prominences in CME events. We apply a new technique for deriving prominence mass to a sample of different types of prominences (eruptive, quiescent, and surges) in which we use observations of coronal radiation in the Fe XII (19.5 nm) spectral line, which is absorbed by prominence material. This new method allows us to consider the effects of both foreground and background radiation in our calculations.

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23. A New Technique for Mapping Open Magnetic Flux from the Solar Surface to the Heliosphere

J.A. Gilbert, T.H. Zurbuchen, L.A. Fisk

The solar wind carries magnetic flux into the heliosphere from the surface of the Sun. At the solar surface open magnetic flux is unevenly distributed, but at some distance in the outer corona it becomes radial and uniformly distributed. Potential-field models give non-uniform distributions of this open flux, due to the absence of magnetic pressure forces in the potential-field approximation. A new model for mapping open flux is presented, which gives a uniform distribution of magnetic flux in the outer corona. Using the location and shape of the current sheet in the outer corona as a boundary, and assuming a radial magnetic field, a relaxation technique is applied to the open flux to distribute it evenly across a surface of constant magnetic pressure. This results in a more realistic open-flux distribution, and a correct set of expansion factors which are often used to correlate with observed solar-wind flow speeds. We explain this new methodology and discuss its application under solar minimum and maximum conditions.

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24. Solar Supergranulation as Propagating Waves

Christina Green, HEPL, Stanford U.

It has been observed that the supergranulation pattern on the surface of the Sun appears to rotate faster than the photospheric plasma and magnetic features. It is postulated that this could be due to instabilities in the subsurface convective shear layer. This behaviour is modelled, starting with a linearized system of differential equations describing a convectively unstable region containing a horizontal shear flow. The system is solved numerically, using parameters drawn from the solar model and helioseismic inversions and assuming linear and non-linear shear flow profiles, for a range of wavenumbers. The phase speeds of the resulting wave solutions are found to be greater than the surface speed, possibly explaining the observed behaviour.

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25. Supergranulation Waves in the Sub-surface Shear Layer

Christina Green, HEPL, Stanford U.

Supergranulation plays an important role in the dynamics and evolution of the solar magnetic field. It has been observed that the supergranulation pattern on the surface of the Sun appears to rotate faster than the photospheric plasma and magnetic features. We suggest that this could be due to instabilities in the subsurface convective shear layer. This behaviour is modelled, starting with a linearized system of differential equations describing a convectively unstable region containing a horizontal shear flow. The system is solved numerically, using parameters drawn from the solar model and helioseismic inversions and assuming linear and non-linear shear flow profiles, for a range of wavenumbers. The phase speeds of the resulting wave solutions are found to be greater than the surface speed, possibly explaining the observed behaviour.

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26. Simulations Of Acoustic-Flow Interaction In Spherical Geometry: Steps Toward Validating Helioseismology

S.M. Hanasoge, T.L. Duvall Jr., M.L.DeRosa, N.E. Hulburt

We simulate acoustic wave interaction with flows in spherical geometry with the specific intent of using the results as artificial data for validation of helioseismology. The numerical procedure is pseudo-spectral; we employ a spherical harmonic representation of the spherical surface, compact finite differences in the radial direction and a fourth order Runge-Kutta time stepping scheme. We model the waves as linear perturbations to the background state. Towards validation, we apply techniques of helioseismology to the artificial data to determine the efficacy of the helioseismic inversion procedure.

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27. RHESSI and NoRH Observations of the 3 July 2002 Flare

K. Hori, Y. Katsukawa(NAOJ), M. Oka, Y. Sakamoto, K.(Univ. Tokyo), Watanabe(STE lab., Nagoya U.), H. Kurokawa(Kwasan Obs., Kyoto U.)

By combining spatially and temporally resolved X-ray and radio data sets from the Ramaty High Energy Solar Spectroscopic Imager (RHESSI) and the Nobeyama Radioheliograph (NoRH), we report the morphology and spectral evolution of a GOES X1.5 class flare of 3 July 2002. This event belongs to so-called "Hanaoka-Nishio type" flares (Aschwanden 2001); i) it was an impulsive flare that was accompanied by high-energy electrons (< 50 keV), ii) it involved in two non equal sized magnetic loops that share their one footprint in the same magnetic polarity (thus a three-legged structure), and iii) it was induced by an emergence of a magnetic flux (EMF), a twisted dipole in this event, through the photosphere. The EMF activity heavily distorted the shape of the magnetic neutral line, where the X1.5 flare occurred. In addition to a compact (< 20") hard X-ray source that is typically seen at footpoints of the interacting two loops, our event showed a brightening in the longer loop (40") in 20-50 keV. Prior to the appearance of the elongated HXR source, a 17 GHz radio source (Tb > 5 x 10^6 K) propagated from one footpoint (the flare kernel) to the other footpoint along the longer loop, with the propagation speed of about 1500 km/s. The flare did not show any eruptive features, such as Type II bursts and CMEs. We suppose that this evolution was observed because most of the released energy was confined in the flare region.

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28. Cassini Measurement of the Coronal Electron Density

E.A. Jensen (UCLA), L. Iess (Uni. Roma), S.W. Asmar (JPL), C.T. Russell (UCLA)

From June 9 to July 7, 2002, ranging data was collected in the X-band (8GHz) using Cassini. Ranging is a technique for measuring the columnar electron density of the solar corona along the line of sight using a "chirping" technique. Results of this experiment will be presented including testing of models from previous experiments. We find that the Tyler et al (1979) model gives the best fit to the background field.

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29. Modelling CME effects on Faraday Rotation

E.A. Jensen (UCLA), C.T. Russell (UCLA)

Transient Faraday rotation events have been measured in all previous solar conjunction Faraday rotation experiments. Faraday rotation is the observed rotation of the plane of polarization of an electromagnetic wave due to the product of the electron density and the parallel magnetic field. We compare these events to modeled CME transients in the Cassini Faraday rotation model with respect to expansion velocity, clock&cone angles, and maximum spiral pitch angle of the magnetic field.

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30. The Cassini Faraday Rotation Experiment

E.A. Jensen (UCLA), M.K. Bird (Uni. Bonn/Max Plank Inst.), L. Iess (Uni. Roma), S.W. Asmar (JPL), C.T. Russell (UCLA)

The Cassini Faraday rotation data will be presented including what it implies with respect to the 2002 coronal magnetic field. Faraday rotation is the observed rotation of the plane of polarization of an electromagnetic wave due to the product of the electron density and the parallel magnetic field. Faraday rotation was measured on Cassini's X-(8GHz) and Ka-bands(32GHz) around the June 21, 2002 and July 1, 2003 solar conjunctions.

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31. Quantification of CME triggering mechanisms

C.Jacobs, G.Dubey, S.Poedts, B.van der Holst Centre for Plasma-Astrophisics, 3001 Heverlee, Belgium

Coronal Mass Ejections (CMEs) play a crucial role in space weather and a carefull study of the origin, the structure and the propagation characteristics of these violent solar phenomena is essential for a deeper insight into space weather physics. Therefore, numerical simulations of some CME initiation models were performed by means of a finite volume, explicit solver to advance the equations of ideal MagnetoHydroDynamics (MHD). The studied CMEs are triggered with two different kinds of initiation models, namely foot point shearing and magnetic flux emergence. An important aspect of the study we performed is the fact that the simulations were done on top of three different models for the background solar wind. An extensive parameter study was carried out where we investigated on the one hand the effect of the used solar wind model on the CME initiation and evolution characteristics, and on the other hand the effect of the CME initial parameters, like for example the shear velocity, the extend of the shear region, and the emergence rate of the magnetic flux. This enables us to quantify the effects of both the CME parameters and the background solar wind on the CME evolution parameters such as the velocity, the amount of released energy, shock formation and topology, etc.

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32. Sub-surface evolution of flows near active regions

Komm, R., Howe, R., Hill, F. (NSO)

We study horizontal flows in the upper solar convection zone derived from GONG data using the standard dense-pack ring-diagram analysis. From the measured flow divergence, we can derive the vertical velocity component. We derive daily and synoptic maps of the velocity components. Active regions show convergent horizontal flows, which imply downflows, at depths less than about 10 Mm and divergent flows at greater depth implying upflows (in agreement with studies by other authors). We also calculate the vorticity and the kinetic helicity density of the flows. A preliminary analysis shows that the vorticity is enhanced near locations of active regions and that the kinetic helicity density associated with active regions correlates well with the X-ray flare intensity of active regions. These fluid dynamics descriptors are thus promising indicators for investigating the relation between active regions, their flare activity, and associated subsurface flows. We will present the latest results.

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33. The Global Magnetic Topology of the Solar Corona Preceding CME Eruptions

S. A. Ledvina(1), J. G. Luhmann(1), Y. Li(1), W. P. Abbett and N. Arge(2), 1. Space Sciences Lab, UC Berkeley, 2. Airforce Research Lab, VSBXS

Understanding coronal mass ejections (CMEs) is a key step to understanding and eventually predicting Space Weather. Three CME event periods have gained great interest lately due to the wide range of observations made before,during and after each event. These include the Halloween storms from October 2003, the eruption involving AR 8210 during CR 1935,and the May 12, 1997 halo CME. These events have been selected by several groups as an example of a real event that they will try to simulate. We present preliminary results of MHD simulations of the pre-eruption global coronal magnetic topology for each event,using a synoptic map-based ZEUS-3D MHD model of the solar corona. We compare and contrast the results to gain insight into the prevailing conditions, especially the open/closed field configurations surrounding the event sites.

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34. Chromospheric Magnetic Field Observations and Solar Energetic Events

K. D. Leka and T. R. Metcalf

Active regions, as the locations of complex and rapidly evolving magnetic fields, are the source of solar energetic events. Measurements of the chromospheric magnetic field should provide direct insights into the energy storage for solar energetic events since the chromospheric magnetic field is more likely to be force-free than the photosphere, allowing a direct measure of the magnetic free energy available for the events in question. Recent chromospheric vector field observations from the U. Hawai`i/Mees Solar Observatory Imaging Vector Magnetograph, obtained in the chromospheric Na-I line at 589.6nm, will be reviewed. The focus will be on measures of the magnetic energy from these chromospheric vector magnetic field measurements as they relate to the production of energetic events by the selected active regions. This work is supported by NASA contract NAG5-12466, AFOSR contract F49620-03-C-0019, and NSF/SHINE grant ATM-0454610.

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35. Coronal magnetic field topology above source regions of CMEs associated with quiescent filaments

Yan Li and Janet Luhmann, SSL/UCB

The magnetic field topology at the CME source regions is thought to be an important aspect for the CME initiations. In this work, we focus on CME productive quiescent filament regions. We use SOHO LASCO CME Catalog, coronagraph and EIT movies, and BBSO Halpha images and/or movies to select candidate events. We use MDI and/or GONG+ magnetogram data and MWO synoptic maps and PFSS model extrapolations to investigate the magnetic field configuration and field line topology around the filaments against current CME models, in particular, the Breakout model and flux cancellation model. We found that both multiflux topology required by the Breakout model and single arcade filed exist at CME source regions. We present these cases and our analyses of the magnetic field topology. With approximately 100 events through out the years 1996 to 2004, we investigate whether there is a solar cycle dependence as to the importance of the different field topology. We also study other characteristics of the events (e.g. CME speed) and seek contrasting behavior and properties of CMEs produced by different type of regions.

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36. Nature of the Reconnecting Current Sheet Developed by CME/Flare

Jun Lin (Harvard-Smithsonian Center for Astrophysics)

In the present work, we display our results of studying and analyzing the observational data from UVCS and other remote sensing instruments for three CME/flare events that obviously developed a long current sheet during the eruptions. These results include the thickness of the current sheets, magnetic diffusivities and electrical conductivities (resistivities) of the plasma inside the current sheets. This is the first time that the electrical conductivity (resistivity) within magnetic reconnection region during the real eruptive processes has been deduced since the theory of magnetic reconnection was applied to the solar eruptions about 6 decades ago. Our results indicate that values of magnetic diffusivity deduced for three different events are within the range of magnitude, and that they are all 10~12 and 6~8 orders of magnitude greater than those of the classical and the anomalous diffusivities, respectively.

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37. An MHD Model of Differential Rotation

R. Lionello, P. Riley, J. A. Linker, and Z. Mikic (SAIC)

Differential rotation is thought to cause large excursions of magnetic field lines in the upper corona and in the heliosphere. This is in contrast with the apparently rigid rotation of some coronal holes. The model of Fisk et al. (1999) consists of a dipole field with the magnetic axis distinct from the rotation axis. The field from the northern and southern polar holes superexpands into the solar wind. In order to reconcile the pattern of velocity in the upper corona with the photospheric differential flow, magnetic reconnection is invoked between open field lines and low-lying loops. This mechanism releases the plasma trapped in the closed field lines into the corona and originates the slow solar wind. We have used our MHD model in spherical coordinates to study this mechanism. We have imposed a magnetic flux distribution as in Fisk et al. (1999). After relaxing the system to steady state, we have applied differential rotation for the equivalent of 5 rotations. We will describe the changes in the coronal magnetic field in response to the photospheric flows.

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38. The Characteristics of Hard X-ray Production in Flares Driven by Filament Eruptions

Rui Liu & David Alexander

We investigate the temporal and spatial relationship between filament eruptions and the production of hard X-ray emission using spatially resolved high cadence data from TRACE and RHESSI. In particular, we focus on comparing the characteristics of the hard X-ray production in 'successful' and 'failed' filament eruption cases. Our preliminary findings indicate even failed eruption events can generate significant energy release and hard X-ray emission with the hard X-ray production apparently correlated to the rate of expansion of the filament. The spatial distribution of the hard X-ray emission, while depending upon the overall strength of the event, also depends on the evolutionary behavior of the filament as it erupts, e.g. loop-like versus "zipper"-like.

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39. Energy budget of halo CME-related active regions

Liu, Y., et al.

In this paper we have estimated magnetic energy in the halo CME-related active regions. We explore correlation between free energy in the active regions and energetic of the corresponding CMEs, and discuss our results here. SOHO is a project of international corporation between ESA and NASA.

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40. First Demonstration of 3D Breakout

B. J. Lynch (UM/NRL), S. K. Antiochos (NRL/UM), C. R. DeVore (NRL), T. H. Zurbuchen (UM)

We demonstrate the breakout model for CME initiation works in the most general, fully 3D magnetic topology. We present numerical MHD simulation results with the NRL 3D spherical ARMS code that (1) reproduce the 2.5D results, (2) produce an eruption in an elongated (90 deg) equatorially symmetric 3D geometry, and (3) produce an eruption in a more circular (60 deg) non-symmetric embedded bipolar configuration. Case (3) represents the most general 3D magnetic topology for breakout, with a single null point, spine, and separator fan surface. We show magnetic breakout produces a fast, super-alfvenic eruption (> 2000 km/s) and the classic flare reconnection beneath the expanding inner arcade region creates a twist flux-rope structure during the eruption. This work is supported by ONR and NASA. BJL is funded by NASA GSRP fellowship NGT5-50453.

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41. An MHD Simulation of Magnetic U-loops and Flux Cancellation on the Sun

T. Magara, S. K. Antiochos, C. R. DeVore, and M. G. Linton

In this poster we report our work on simulating flux cancellation through the emergence of U-shaped magnetic field lines (magnetic U-loops). Emergence of U-loops has been proposed as one of the ideas to explain flux cancellation at the solar surface and our MHD simulation reveals the evolution of the U-loops causing flux cancellation. We analyze plasma motions on selected field lines related to flux cancellation. We also infer a possible field-line configuration during flux cancellation.

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42. Effects of Photospheric Field Processing on Derived Coronal Magnetic Fields and HCS for the MAS and WSA Models.

Sarah McGregor, Jeffrey Hughes, C. Nick Arge, Jon Linker, Pete Riley

The coronal magnetic field is notoriously difficult to measure directly, so models are used to generate the coronal magnetic fields from photospheric measurements. Several different genres of models are used, examples of which are a three-dimensional resistive MHD model (SAIC's MAS model), and a coupled potential field source surface and Schatten Current Sheet model (Wang-Sheeley-Arge). Both models require the radial magnetic field (derived from synoptic maps of the observed line-of-sight photospheric magnetic field) as a boundary condition. However, processing of the synoptic maps prior to use is different for the MAS and WSA models. For MAS, a smoothing algorithm is applied to the synoptic maps to ensure that features are resolved over several grid points on the mesh, and values within ~20° of the poles (where the data is noisy) are replaced with a smooth fit derived from values in the interval 14~25. The WSA model applies no smoothing algorithm and simply regrids the synoptic map to a desired resolution. The WSA model replaces polar values with a temporal average based on the season (and therefore visibility) of a given pole. In order to assess the differences between these coronal field models, we must first ascertain what effects arise from different treatments of the boundary conditions. We therefore apply the processing used for MAS to NSO synoptic maps for several Carrington rotations during solar minimum and solar maximum, and then use these new maps to initiate both the MAS and WSA models. The WSA model is also run on the same NSO maps without this extra processing. We compare the shape, size, and location of the two regions of open flux as well as the shape and location of the heliospheric current sheet.

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43. Geoeffectiveness of halo CMEs

G. Michalek (CUA), N. Gopalswamy (NASA GSFC), A. Lara (Instituto de Geofisica, UNAM, Mexico), S. Yashiro (CUA)

Halo coronal mass ejections (HCMEs) originating from regions close to the center of the Sun are likely to be geoeffective. Assuming that the shape of HCMEs is a cone and they propagate with constant angular widths and velocities, at least in their early phase, we have developed a technique (Michalek et al. 2003) which allowed us to obtain the space speed, width and source location. We apply this technique to obtain the parameters of all full HCMEs observed by the Solar and Heliospheric Observatory (SOHO) mission's Large Angle and Spectrometric Coronagraph (LASCO) experiment until the end of 2002. Using this data we examine which parameters determine the geoeffectiveness of HCMEs. We show that major geomagnetic storms are caused by very fast halo CMEs propagating with the space velocities higher than $1100{km\over s}$ and originating from the western hemisphere close to the solar center. We illustrate how the HCME parameters can be used for space weather forecast. It is also demonstrated that the strength of a geomagnetic storm does not depend on the determined width of HCMEs. This means that HCMEs do not have to be very large to cause major geomagnetic storms.

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44. The Effect of Magnetogram Noise on Non-Linear Force Free Field Extrapolations

J. McTiernan SSL/UCB

In this work we discuss the effect of randomly generated noise on the extrapolation of the surface magnetic field into the corona. We use the optimization method of Wheatland, Roumelotis and Sturrock to create a non-linear force-free field extrapolation for a known field. We then do a Monte Carlo simulation in which we randomly vary the surface magnetic field by a small amount and do the field extrapolation. The results are compared with the "true" field, and we obtain a measure of the uncertainty in the extrapolated field.

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45. Comparison of the variation of solar indices and cosmic ray neutron monitor intensities

Milan Minarovjech and Vojtech Rusin, Astronomical Institute, Slovak Academy of Sciences,Slovakia

We compare the solar activity indices (coronal, chromospheric and photospheric) with the cosmic ray neutron monitor intesities. We investigate through out the years 1986 to 2005 if there is a cosmic ray variation dependence as to the solar indices variation. We survey the daily values of solar indices and cosmic ray intensities in an attempt to identify the possible solar sources of cosmic ray variation. This work is supported by APVT grant 51-012704 and VEGA grant 2/4011/24.

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46. TRACE Observations of X-flares and Rotating Sunspots

Richard W. Nightingale, Thomas R. Metcalf, Zoe A. Frank, and Charles A. Kang*
(Lockheed Martin Advanced Technology Center, Palo Alto, CA)
(*Henry M. Gunn High School, Palo Alto, CA)

The TRACE instrument in several wavelength channels has observed approximately 64 X-flares throughout its mission so far in solar cycle 23 from launch in April 1998 through January 2005. All of these X-flares can be associated with 23 solar active regions that contain 46 rotating sunspots, as observed by TRACE in white light and/or SOHO/MDI in magnetograms. These sunspots, rotating about the center of their umbras, appear to be manifestations of the twist and/or writhe, i.e., the helicity, as viewed at the photosphere and instilled in the rising active region omega loops as they travel through the convection region. About two-thirds of these flaring events appear to be associated with large Coronal Mass Ejections (CMEs) leaving the sun, of which 20 are associated with geo-effective solar particle events (SPEs), where energetic proton fluxes, observed by instruments on the GOES geosynchronous spacecraft, were observed to increase by several orders of magnitude shortly after the solar events occurred. It was shown at the SHINE meeting 2 years ago that the first 4 campaign active regions contained rotating sunspots and it will be demonstrated that the fifth campaign region in Oct.-Nov. 2003 does also. In addition the January 15-20, 2005 active region with its 5 X-flares, 3 rotating sunspots, and several overlapping geo-effective SPEs will be presented as a part of our on-going analysis of the connections of rotating sunspots, solar eruptions, and space weather forecasting. (This work was supported by NASA under the TRACE contract NAS5-38099)

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47. Revisiting the relation between CMEs and flare-associated ejections

Nariaki Nitta (LMSAL), Joan Burkepile (NCAR/HAO)

We revisit the relation between coronal mass ejections (CMEs) and X-ray plasma ejections typically seen during the impulsive phase of solar flares, using Yohkoh/SXT, HAO/MK4 coronameter and SOHO/LASCO data. This subject may have an impact on our understanding of how solar flares participate in CME initiation. Previous studies tend to imply that the CME onset precedes the associated flare by a range of times. Using MK4 data, we have a better view of how and when CMEs form, directly comparable to SXT high-cadence data. We show several such examples and discuss their implications.

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48. The Role of Magnetic Reconnection in Early-stage Mass Ejection

Jiong Qiu, BBSO/NJIT

Previous studies have shown a close temporal correlation and magnitude scaling relationship between magnetic reconnection rate and acceleration of flux ropes. In this study, we examine the reconnection-acceleration relationship in solar eruptive events of different magnetic configurations, e.g., bi-polar versus multipolar configurations, and cases with reconnection above or below the flux rope. We estimate important physical parameters of the evolving flux rope, including the total magnetic flux transported into the flux rope through reconnection and the expansion of the flux rope together with its rising motion. With multiple wavelength observations, we also explore the issue whether the flux rope is formed before or during eruption in the few events in our study.

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49. Light Curves for a Loss of Equilibrium Model of Solar Eruptions

Kathy Reeves, University of New Hampshire

We use a loss-of-equilibrium model for coronal mass ejections and eruptive solar flares to determine the thermal energy release in these events. A current sheet forms beneath the eruptive event and reconnection in this sheet releases magnetic energy, some of which is converted into thermal energy. The thermal energy release is calculated by assuming that all of the Poynting flux flowing into the reconnection region is eventually thermalized. The fraction of the released magnetic energy that is converted to thermal energy depends on the inflow Alfvén Mach number. We use this thermal energy to simulate flare light curves, and we examine the relationship between the thermal energy release rate and the derivative of the soft X-ray light curve and discuss the implications for the Neupert effect.

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50. Bursty Reconnection during Solar Eruptions: MHD Simulations and Comparison with Observations

Pete Riley, Roberto Lionello, Zoran Mikic, Jon Linker SAIC, San Diego, CA.
Jun Lin, Yuan-Kuen Ko,Harvard-Smithsonian Caner for Astrophysics, Cambirdge, MA.

Using global, resistive MHD simulations, we explore the eruption and evolution of coronal mass ejections (CMEs). In particular, we focus on the reconnection observed to occur underneath the erupting flux rope, which is both transient and episodic. We have previously investigated the generation of a post-eruption reconnection jet, which manifests itself as a velocity perturbation following the main ejecta. Here we focus on the formation and evolution of "blobs" within the reconnection site. We compare their properties with SOHO/LASCO observations of blobs flowing along current sheets associated with CMEs, and we relate their formation to theories of the tearing mode.

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51. Three-Dimensional Visualizations of the Solar Corona: Applications and Preliminary Results

A. Sandman^1, D. Alexander^1, C. J. Schrijver^2, M. J. Aschwanden^2, M. L. DeRosa^2 (1) Rice University, (2) LMSAL

We present an overview of a three-dimensional solar coronal simulation code, and discuss current and future applications of these simulations. The code builds on photospheric magnetic field models (Schrijver & DeRosa 2003) and analytical approximations of loop atmospheres (Schrijver & Aschwanden 2002), and renders images of the full solar corona; key attributes include including line-of-sight integration, instrument temperature response curves, and instrument point-spread-functions, allowing the final images to mimic space-based observations. These simulations were recently used to help place constraints on the coronal heating mechanism (Schrijver et al. 2004), and ongoing work includes progress toward high-definition image and parallel processing capabilities. Existing simulations are also being used to develop reconstruction tools in anticipation of stereoscopic imagery from STEREO. The simulations provide a tool for the investigation not only of the coronal heating mechanism, but the 3D morphology of solar active regions.

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52. The Accurate and Precise Estimation of Velocities and Associat ed Uncertainties in Magnetograms

Peter Schuck, NRL

The resolution of modern controversies in solar physics require a statistically robust technique for determining the ``optical flow'' perpendicular to the line of sight from a sequence of solar magnetograms. Local Correlation Tracking (LCT) is the de-facto standard for estimating optical flow in solar image sequences. However, this technique is inconsistent with the magnetic induction equation and mathematically inappropriate for tracking magnetic elements. I will present a new technique that incorporates the magnetic induction equation directly into the analysis. Work Supported by ONR.

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53. A celebration of 40 years of solar observations at Mauna Loa Solar Observatory (MLSO) 1965-200

G. Starr, H. R. Gilbert, G. de Toma, S. Gibson, J. T. Burkepile, T. E. Holzer, J. A. Darnell* and A. L. Stanger (High Altitude Observatory, National Center for Atmospheric Research)

In recognition of the 40th anniversary of the Mauna Loa Solar Observatory (MLSO 1965-2005), we summarize some of the recent scientific results obtained with the MLSO Advanced Coronal Observing System (ACOS). The ACOS was designed to study dynamic phenomena, such as coronal mass ejections (CMEs), prominence eruptions, flares and transient coronal holes with high time resolution, and to record the evolution of the corona and chromosphere over long time scales, such as the 11-year solar cycle. ACOS is comprised of three instruments: PICS, CHIP and Mk4, which together cover the solar chromosphere and low corona at a time resolution of 3 minutes and a time coverage of about 8 hours a day. PICS provides full disk and off-limb images of the sun in the Hydrogen-alpha (656.3 nm), CHIP gives Helium-I (1083.0 nm) full disk and off-limb images as well as velocity data, while the Mk4 coronagraph records the low corona in white light, from 1.12 to 2.8 solar radii from sun center. Highlights of recent work with MLSO observations includes: I) Study of chromospheric waves and transient coronal holes associated with CMEs and flares using MLSO Helium-I onbservations. The waves are visible in both the Helium-I line-center and velocity images and are cospatial with the corresponding coronal waves observed in extreme ultraviolet (EUV). The Helium-I observations indicate that multiple waves are present in most of the well-observed events suggesting that more than one driving mechanism may be involved. Transient coronal holes form at the same time as EUV intensity dimmings, which corresponds to the impulsive phase of the flare as observed in EUV, and the transient holes are cospatial with the EUV dimmings. The dimmings and transient coronal holes can be interpreted as different manifestations of decreased coronal density due to the occurrence of a CME. II) Determination of trajectories of erupting prominences and the basic properties of CMEs, in the early stages of their development, using MLSO H-alpha, Helium-I velocity and coronal white light images. Velocity images can be used to detect the early acceleration of Earth-directed CMEs. White light and H-alpha observational results indicate that CME acceleration is greatest in the low corona (below 3 solar radii) and that a correlation may exist between the acceleration of an erupting prominence and the speed of its overlying CME. III) Identification of quiescent cavities in the Mk4 white light observations. The dark cavity feature identified in many CMEs, is often observed in non-erupting helmet streamers in the low corona. In some cases, these streamer cavities can be tracked from limb-to-limb over several rotations and are seen to erupt as part of a CME. These cavities provide clues to the structure of the corona preceeding a CME and may play a key role in CME formation. Another advantage of ground-based observations is the potential for longevity and continuity of observations. The MLSO MK3 K-Coronameter recorded the intensity of the low corona from 1980 to 1999. The mass of the corona in an annulus between 1.2 and 2.2 solar radii has been determined from these 19 years of observations and the results show that the mass of the corona varies over the 11-year solar cycle from a low of 3 x 10^16 grams during the last two solar minimum to a peak of ~1.5x10^17 near the last two solar maximum.

54. Helicity injection associated with sigmoid eruptions and onset of very powerful coronal mass ejections

L. Tian^1, D. Alexander^1, B. Welsch^2 (1) Department of Physics and Astronomy, Rice University, Houston, TX 77005, USA (2) Space Sciences Laboratory, University of California, Berkeley, CA 94720-7450

Eruptions of soft X-ray sigmoids and the onset of fast coronal mass ejections (CMEs) are believed to be driven by the over-accumulation of coronal helicity. Thus, the helicity production and injection is an attractive issue recently. Both the emergence of twisted magnetic fields from below and the photospheric horizontal motions are the most likely means to produce and inject the helicity into the corona. We study the helicity injection for two strong solar events which occurring in NOAA 9684 and 9704 on Nov. 04 and 22 2001, which produced large flares (X1.0/3B and M9.9), associated with sigmoidal filament and soft X-ray eruptions, very fast CMEs (1840 and 1437 km/s) and very strong proton events (31700 and 18900 pfu). Since the two events occurred on the solar west disk (W18 and W34), we are able to study in detail the helicity production and injection before the events, using more reliable MDI 96 m line-of-sight magnetograms and a local correlation tracking (LCT) method. NOAA 9684 is found to have a rotating sunspot, while NOAA 9704 shows significant horizontal motions. Thus, our results provid clues to the roles plays by twist and writhe helicity in the filament and sigmoid eruptions, which are associated with onset of the powerful CMEs.

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55. Initial Magnetic Field Measurements from The Coronal Multi-Channel Polarimeter

Steven Tomczyk (HAO/NCAR)

We have constructed a filter-based polarimeter optimized for the measurement of magnetic fields in the solar corona. The instrument will observe the coronal emission lines of Fe XIII at 1074.7 and 1079.8 nm as well as the chromospheric He I emission line at 1083 nm. The instrument consists of a polarimeter allowing complete Stokes I,Q,U,V measurement followed by a Lyot birefringent filter with dual passbands of 0.14 nm width. Both the polarimeter and filter employ liquid crystals for rapid electro-optical tuning. This instrument was deployed to the 20-cm One Shot coronagraph at NSO's Sacramento Peak Observatory in January of 2004. Measurement of the longitudinal Zeeman effect provides information on the strength of the line-of-sight component of the magnetic field while the observation of resonance scattering will constrain the plane-of-sky field direction. Precise measurement of plasma velocity is also possible. Such measurements are critical for addressing many outstanding problems in coronal physics. The operation and performance of the instrument will be described. We will also describe the methodology for the coronal magnetic field measurement. Initial measurements taken with the instrument will be presented.

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56. Active Region Flows & Eruptive Events

B. Welsch and Y. Li, Space Sciences Lab, UC-Berkeley

We have undertaken a study of flows in several active regions, some which produced CMEs and some which did not. The flows, determined by local correlation tracking (LCT) and feature tracking (FT) applied to magnetogram time series, are to be analyzed to determine (among other things) baseline flow speeds and the relationships (if any) between shearing, convergence, flux cancellation, and CMEs. Here, we present preliminary results from a subset of our active region sample.

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57. Numerical MHD Simulation of Key Parameters for CME Initiation

S. T. Wu(1,2), A. H. Wang(1), D. A. Falconer(1,3,4) and C. D. Fry(5,1) (1) Center for Space Plasma & Aeronomic Research (2) Department of Mechanical and Aerospace Engineering (3) Department of Physics The University of Alabama in Huntsville Huntsville, AL 35899 USA (4) SD50, Marshall Space Flight Center, Huntsville Al 35812, USA (5) Exploration Physics International, Inc., Space Weather & Planetary Science, 6275 University Drive Suite 37-105, Huntsville, AL 35806-1776 USA

Recently, Falconer et al. (2002) have developed a set of physical parameters to correlate the coronal mass ejection productivity of solar active regions with measures of their non-potentiality from vector magnetograms. In this presentation, we will use a newly developed three-dimensional, time-dependent, magnetohydrodynamic model for Active Region (AR) evolution (Wu et al. 2005). This model is based on MHD theory with additional physics of the photosphere including differential rotation and meridional flow. Thus, the inertial centrifugal force and the coriolis force which are usually not taken into account in the MHD equations are included. In addition, the effect of diffusion due to random motion of the granules or super-granules and cyclonic turbulence are also included. This model is used to simulate those CME production parameters: (i) the magnetic flux content of the active region, (ii) the length of strong-shear, strong-field main neutral line, (iii) the net electric current and (iv) a flux-normalized measure of the field twist, suggested by Falconer et.al. (2002). An example is given by using SOHO/MDI magnetic field measurements of AR8100, recorded from October 31, =FF November 3, 1997. These simulated parameters show good agreement with the observations.

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58. Visibility of coronal mass ejections as a function of X-ray flare location and intensity

S. Yashiro (CUA), N. Gopalswamy (NASA/GSFC), S. Akiyama (CUA), G. Michalek (CUA), and R. A. Howard (NRL)

We report the visibility of coronal mass ejection (CME) of the Large Angle Spectrometric Coronagraph (LASCO) on board the Solar and Heliospheric Observatory (SOHO). We collected 1301 X-ray flare events (above C3 level) detected by the GOES satellite and their CME associations were examined using data form LASCO coronagraphs. The CME visibility was examined by the longitudinal variation of the CME association of X-ray flare. Our findings are: (1) the CME association rate clearly increased with X-ray flare size from 20% for C-class flares (between C3 and C9 levels) to 100% for huge flares (above X3 level), (2) all CMEs associated with X-class flares were detected by the LASCO coronagraphs while half (29-66%) of CMEs associated with C-class flares were invisible. We examined the statistical properties of the flare-associated CMEs and compared them by flare size and longitude. CMEs associated with X-class flares were significantly faster (median 1556 km/s) and wider (median 244 deg) than those of CMEs associated with C-class flares (432 km/s, 68 deg). We conclude that all fast and wide CMEs are detectable by LASCO, but slow and narrow CMEs may not be visible when the CMEs originate from the disk center.

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59. Observational Study on the Velocity and Acceleration of Coronal Mass Ejections

Jie Zhang, George Mason University

Investigating the kinetic behavior of CMEs, including the acceleration in the inner corona, may help understand the physics driving mechanisms of CMEs. It has been known that, CME velocity, measured in the outer corona where it does not show large acceleration/deceleration, varies significantly from event to event (from several tens km/s to several thousands km/s). We find that CME velocity in the outer corona is determined by two factors, one acceleration duration, and the other one acceleration magnitude. A fast CME can be resulted either from a strong/short acceleration or from a moderate/long acceleration. On the other hand, a slow CME is usually resulted from a persistent small acceleration, which is likely associated with solar wind dragging. The source region characteristics of different types of CME will be discussed.

60. The Ice Cream Cone Model for Halo CMEs

Xuepu Zhao, Stanford University

Many limb coronal mass ejections (CMEs) show a shape of an ice cream cone. We improve our cone model to determine the geometrical and kinematical properties of halo CMEs formed by Thompson scattering of an ice cream conical shell of dense CME electrons. It is found that for an ice cream cone with a half sphere sitting on top of a cone, the front half ellipse is greater than the rear half ellipse when the angle between the central axis of the ice cream cone and the line of sight is greater than 45 degrees; when the angle is less than 45 degrees, the elliptic halo is symmetric. In both cases, the geometrical and kinematical properties of the halo CMEs can be uniquely determined.

Working Group 2
Interplanetary

61. Identification of Solar Source Regions of 79 Major Geomagnetic Storms from 1996 to 2004

Watanachak Poomvises, Jie Zhang

From 1996 to 2004 there are about 79 major geomagnetic storms, defined by Dst index at peak time smaller than or equal -100 nT. Several major storms show complex Dst temporal profile; each of such storms exhibits multiple closely-related Dst peaks, which are likely caused by multiple ICMEs arriving continuously and possibly interacting with each other in the interplanetary space. We investigate and identify the solar sources of these major geomagnetic storms. We use an adaptive backward search window to find responsible halo CME if the storm is caused by an ICME. The solar wind speed of the ICME is used to calculate the search window, e.g., 69 hrs if the wind speed is 600 km/s and with a maximum of 120 hrs. Among the 71 events that have continuous SOHO observations, 58 (or 82%) events are caused by front-side halo CMEs observed by LASCO and EIT. About 11 (or 15%) major geomagnetic storms are mainly caused by CIR (Corotating Interaction Region) related to the presence of coronal hole on the solar disk. There are two events (or 3%) whose source regions remain to be identified, even though LASCO/EIT data are present. The surface source regions and associated surface phenomena (e.g., flares) of those geo-effective CMEs will be discussed.

62. A study of the Drift Rate of Type II Radio Bursts at Different Wavelengths

E. Aguilar-Rodriguez [CUA,NASA/GSFC,UNAM], N. Gopalswamy [NASA/GSFC], R. MacDowall[NASA/GSFC], S. Yashiro[CUA], and M. L. Kaiser[NASA/GSFC]

We present a study on the drift rate of type II solar radio bursts observed at different wavelengths. Radio observations were obtained from the (i) Radio and Plasma Wave (WAVES) experiment on board the Wind spacecraft, (ii) the ISEE-3 radio experiment, and (iii) the radio spectrograph of Potsdam. We obtained three sets of events, based on the frequency domain of occurrence: 125 events in the kilometric (km) domain (30 kHz to 1000 kHz, detected by WAVES/RAD1 and ISEE-3 receivers), 197 events in the decametric-hectometric (DH) domain (1 MHz to 14 MHz, observed by WAVES/RAD2), and a published list of 65 type II bursts in the metric domain. Statistical analysis shows that the magnitude of the drift rate in the DH-km domain increases with the starting frequency (fs) of type II bursts, which is in agreement with previous studies using type II bursts observed in the metric domain. By fitting the drift rate versus the starting frequency in a log-log plot for all the type II bursts, we found that the drift rate can be approximated by a power law, -df/dt = A fs^(1.77). Moreover, we considered a subset of 28 purely-km type II bursts (i.e., events without counterparts at higher frequencies) and found that they have a different power-law index. We discuss the implications of the frequency dependence of the drift rate in terms of the evolution of the associated coronal mass ejections.

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63. Mechanism for irreversible dissipation at collisionless shocks: Nonlinear ion acoustic instability

Li-Jen Chen(1), William S. Kurth(1), Donald A. Gurnett(1), Abigail M. Rymer. (2)(1) Department of Physics and Astronomy, University of Iowa, Iowa City, IA52242, USA (2) Mullard Space Science laboratory, University College London, London, UK

Comparison of electrostatic waves observed by Cassini at the bow shocks of Saturn and Earth revealed that the most dominant wave power above tens of Hz occurs in the same frequency range, and the waves have very similar waveforms at both planets. This comparison led us to identify this dominant wave component at both bow shocks to be nonlinear ion acoustic waves. To understand the role of the instability that generate the waves, we carried out particle simulations, and found that the nonlinear ion acoustic instability can increase the temperature of electrons, and produce flat-topped electron distributions which have been observed to be characteristic to the shock transition and downstream magnetosheath at Earth [Feldman et al., 1982]. The increase in the electron temperature is proportional to the relative drift between electrons and ions in our simulation, and hence is expected to increase with the cross-shock electrostatic potential, and consequently with the solar wind flow energy, a result that has been observationally established [Thomsen et al., 1987; Hull et al., 2000]. The nonlinear ion acoustic instability, therefore, appears to be the dominant mechanism for irreversible dissipation across collisionless bow shocks.

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64. Transport of the solar open flux with spatial diffusion - 2D simulation

Ofer Cohen, Lennard A. Fisk, Aaron J. Ridley, Ilia I. Roussev, and Tamas I. Gombosi

Diffusion processes of the open magnetic flux play an important role in the evolution of the large-scale solar magnetic field. Previous studies by Wang et al. (2000) showed that the total amount of open flux of the Sun remains virtually constant during the solar cycle. Under this assumption, Fisk et al. (2001, 2005) constructed, in a series of papers, a transport model for the open flux, including differential rotation, meridional flow and spatial diffusion. The latter depends on the local emergence rate of new coronal loops on the Sun. In a recent study, Fisk (2005) parameterized the diffusion coefficient in order to make it easier to apply the theory in numerical models. In this study we present a 2D numerical simulation of the Fisk diffusion model on the surface of the Sun. We discuss the results of the simulation, and we outline the direction of future work.

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65. New Model for protons particles interplanetary propagation

Ashraf Farahat, Ismael Sabah

We developed a new model to study the subatomic particles produced by the decay of solar flares neutrons. We simulate the scattering of the decayed protons back and forth along the spiral interplanetary magnetic field and the measured proton flux is calculated. This simulation provides a clear image for the protons interplanetary propagation. Using the new model we distinguish between the subatomic particles produced by direct decay of the neutron solar flares and those produced inside the corona. The electron spectrum is also investigated and new understanding of how energy is released from solar flares is introduced in this work.

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66. CME Kinetic Energy and the Wavelength Range of type II Radio Bursts

N. Gopalswamy, E. Aguilar-Rodriguez, S. Yashiro, S. Nunes, M. L. Kaiser & R. A. Howard

We report on a study of type II radio bursts from the Wind/WAVES experiment in conjunction with white-light coronal mass ejection (CME) data from the Solar and Heliospheric Observatory (SOHO). The type II bursts considered here have emission components in all the spectral domains: metric, decameter-hectometric (DH) and kilometric (km), so we refer to them as m-to-km type II bursts. CMEs associated with the m-to-km type II bursts were more energetic than those associated with bursts in any single wavelength regime. CMEs associated with type II bursts confined to the metric domain were more energetic (wider and faster) than the general population of CMEs but less energetic than CMEs associated with DH type II bursts. Thus, the CME kinetic energy seems to organize the life time of the type II bursts. Contrary to previous results, the starting frequency of metric type II bursts with interplanetary counterparts seems to be no different from that of type II bursts without interplanetary counterparts. We also verified this by showing that the average CME height at the onset time of the type II bursts is the same for the two metric populations. The majority (78%) of the m-to-km type were associated with solar energetic particle events. The solar sources of the small fraction of m-to-km type II bursts without SEP association were poorly connected to the observer near Earth. Finally, we found that the m-to-km type II bursts are associated with bigger flares compared to the m-limb type II bursts. Work supported by NASA/LWS and NSF/SHINE.

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67. Modeling the Solar-Terrestrial Environment as a Comprehensive System: Putting the Pieces Together

Charles Goodrich, Boston University

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68. Interactive Visualization of Solar Mass Ejection Imager (SMEI) and Interplanetary Scintillation (IPS) Volumetric Data

B.V. Jackson, Y. Yu, P.P. Hick, A. Buffington, (UCSD/CASS)

We present a volume rendering system developed for the real time visualization and manipulation of 3D heliospheric volumetric solar wind density and velocity data obtained from the Solar Mass Ejection Imager (SMEI) and interplanetary scintillation (IPS) velocities over the same time period. Our system exploits the capabilities of the VolumePro 1000 board from TeraRecon, Inc., a low-cost 64-bit PCI board capable of rendering up to a 512-cubed array of volume data in real time at up to 30 frames per second on a standard PC. Many volume-rendering operations have been implemented with this system such as stereo/perspective views, animations of time-sequences, and determination of CME volumes and masses. In these visualizations we highlight at least two time periods where halo CMEs were observed by SMEI to engulf Earth, on May 30, 2003 and on October 29, 2003. We demonstrate how this system is used to measure the distribution of structure and provide 3D mass for individual CME features, including the ejecta associated with the large prominence viewed moving to the south of Earth following the late October CME. If possible in the conference hall, we will also demonstrate how a simple high speed Internet connection can be used to remotely manipulate and share these volumes across the continent and the world to interactively view them.

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69. Identifying and Distinguishing ICMEs and Stream Interaction Regions (SIRs)

L. Jian, C. T. Russell, J. T. Gosling, and J. G. Luhmann

The two major and large-scale structures in the interplanetary space, Interplanetary Coronal Mass Ejections (ICMEs) and Stream Interaction Regions (SIRs), both greatly affect the direction and the dynamic pressure of the solar wind flow and greatly affect geomagnetic activity, but do so differently. Both for space weather predictions and to follow their evolving behavior over the solar cycle, we need a method to identify and distinguish them unambiguously. In our study, to be counted as an SIR, the total perpendicular pressure needs to exceed at least 50 pPa at its peak, and the difference in the velocities of the fast and slow streams needs to be at least 50 km/s. These properties should be accompanied by compression and deflection of plasma. While the identification requirements of an ICME are that the pressure should reach at least 40pPa, the change in the velocity should be at least 30 km/s, and there should be evident of magnetic structure. Finally, we show some interesting events: those classified as ICMEs by other research groups, which are considered in our study as parts of SIRs, and the hybrid events consisting of both SIRs and ICMEs.

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70. Solar Cycle Variation of the Properties of Stream Interaction Regions (SIRs)

L. Jian, C. T. Russell, J. T. Gosling, and J. G. Luhmann

A Stream Interaction Region (SIR) is formed when a fast solar stream overtakes a slow stream. The signatures of SIRs evolve as they move away from the Sun. If the velocity jump is sufficiently large relative to the compressional wave speed, one or more shocks may arise. Based on the study of the WIND (1995-2003) data, we find that the occurrence rate of shocks at SIRs is about 30% on average, which is unexpected high at 1 AU. This rate declines during the rising phase of the solar cycle, while the number of SIR events varies little over the solar cycle. In order to address the effect of SIRs on geomagnetic activity, we also determine the solar cycle variation of the change in velocity from slow stream to fast stream, and the solar cycle variation of the maximum magnetic field and the peak total perpendicular pressure. Finally, we find that rotations of magnetic fields often occur at the sector boundary ahead of the SIR, that the north-south (Bz) component of the magnetic field is typically highly fluctuating within the SIRs, and that the thickness of the interaction region varies.

71. Downstream structures of interplanetary fast shocks associated with coronal mass ejections

R. Kataoka, S. Watari, N. Shimada, H. Shimazu, and K. Marubashi, National Institute of Information and Communications Technology

We investigate 17 coronal mass ejection (CME) events identified by the ACE spacecraft during solar cycle 23, focusing upon the fine structures of the sheath region between the CME and its associated shock to find their dependences on the shock parameters. We observe the planar magnetic structure (PMS) downstream of a quasi-perpendicular shock when the Alfvén Mach number >2.0. Here, the PMS is characterized by the magnetic fields changing directions abruptly and intermittently within a plane parallel to the shock plane. The downstream PMS does not form when a magnetic cloud exists just upstream of a shock with a small Alfvén Mach number <2.0 and a low ¦Â value <0.05. The magnetic fields become more turbulent in the downstream, when the upstream is dominated by Alfvén fluctuations with a shock angle <60¡ã and/or a high ¦Â value >0.5.

72. Heating of Heavy Ions by coronal Mass Ejection Driven Collisionless Shocks

K.E. Korreck, T.H. Zurbuchen, S.T. Lepri

Coronal Mass Ejections (CMEs) propagating through interplanetary space form collisionless shocks ahead of their ejecta. CME shocks interact with the solar wind heating and accelerating all solar wind ions. These shocks have been studied both theoretically (Zhao et al. 1991) and through analysis of data from plasma instruments aboard spacecraft in the solar wind (Ogilvie et al. 1980; Zertsalov et al. 1976; Berdichevsky et al. 1997). The heating mechanisms and their dependencies on mass and charge are not well understood. This study focuses on thermal velocities from the ACE satellite for 19 shocks which are well characterized and for which good data for heavy ions exist. In addition to the proton thermal data, helium, He2+, oxygen (O6+, O7+), carbon (C5+, C6+), and iron, Fe10+ thermal data were available. The heating was found to be dependant on plasma and shock magnetic angle. A mechanism for heating as described in Fuselier and Schmidt (1997) is examined to explain the trends in the heavy ion heating data.

73. Flux-Rope CME Geometry and its Relation to Observed CME Morphology

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Observed flux-rope CME morphology depends on the underlying flux-rope geometry and its observed projection onto the two-dimensional plane of the sky. We use a simple parameterization of a three-dimensional flux rope to determine a "typical flux-rope geometry" that corresponds to the "average observed flux-rope coronal mass ejection (CME) morphology" as observed at a leading-edge (LE) height of about 5.5 solar radii (e.g., LASCO/C2). Our parameterized flux rope, the curved axis of which is assumed to trace out an ellipse, can be described in terms of eccentricity of the ellipse, the width (minor diameter) of the flux rope at the apex, and the height of the apex above the solar surface (at an LE height of 5.5 solar radii, the resulting morphology is only a weak function of the foot point separation). Assuming that flux-rope expansion is self-similar, we have only two geometrical parameters: the eccentricity and the axial aspect ratio, which we define to be the apex height over the apex width. For each pair of geometrical parameters, we consider an ensemble of possible orientations (latitude, longitude, and rotation about the vertical direction) each with a corresponding synthetic coronagraph image. These images are used to produce statistical measures of the morphology for comparison to statistical measures of observed flux-rope CME morphology. The geometrical parameters that best fit the observations constitute a quantitative geometrical description of a typical flux-rope CME. Supported by ONR and NASA

74. Geometry of the interplanetary CME & shock deduced from the network observation of the cosmic ray anisotropy

Takao Kuwabara 1, Kazuoki Munakata 2, 1. Bartol Research Institute, University of Delaware, 2. Physics Department, Shinshu University

A coronal mass ejection (CME) associated with an X17 solar flare reached Earth on October 29, 2003, and produced a strong enhancement of the "B x Gradient" anisotropy of high-energy galactic cosmic rays recorded by the ground-based muon detector network. Based upon a simple inclined cylinder model, we use the anisotropy data to derive the three-dimensional geometry of the cosmic ray depleted region formed behind the shock. We find the geometry derived from cosmic rays for this particular event being in a fairy good agreement with that derived from the Magnetic Flux Rope model using situ measurements of the interplanetary magnetic field (IMF) and solar wind velocity. An interplanetary shock reached Earth earlier on October 28, 2003, in association with a "loss-cone" precursory anisotropy observed during ~7 hours prior to the shock arrival. This anisotropy was clearly observed by a muon hodoscope in operation at Mt. Norikura in Japan. The observed directional intensities are well reproduced with a "loss-cone" anisotropy in space, in which the intensity is depressed in the sunward IMF direction. By best fitting a model anisotropy to the observed directional intensities, we suggest that the "loss-cone" anisotropy in this event has a rather broad pitch-angle distribution about the IMF. According to numerical simulations of high-energy particle transport across the shock, this implies that the shock is a "quasi-parallel" shock.

75. GEOMAGNETIC STORM INDUCED GRAVITY WAVES

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The magnetosphere is the source of generation of geomagnetic storm on the earth's atmosphere. The influence of geomagnetic storm on the earth's atmosphere has been studied by several workers at mid and high latitude, but the study at low latitude is meager. We have made an attempt to study the influence of geomagnetic storm at low latitude northern hemisphere. The array of microbarograph has been used to measure the pressure variation at Tirunelveli (8.7oN, 77.8oE), India. The spectral plot obtained for the pressure variation shows the presence of acoustic gravity waves between 10 and 200 minutes. The amplitude and phase variation has been studied for 2003 and 2004. There is enhancement in the amplitude of the acoustic gravity waves obtained immediately after the severe geomagnetic storm. Some of the recent storm studies in the present work are Oct-Nov 2003, July 2004, and Nov 2004. It has been observed that more than one consecutive storm causes changes in the shape of the AGW days-amplitude-period contour graph, i.e., distortion in the actual shape of the of the contour has been observed during Oct-Nov 2003, which was the period of severe geomagnetic storm. On the other hand, the spectral plot obtained during July and Nov' 2004 shows the consistent increase in the amplitude and phase of acoustic gravity waves, immediately after the geomagnetic storm. The most likely pathway through which geomagnetic activity influences climate and weather phenomena is the disturbances propagating from upper atmosphere to the lower atmosphere and affects the tropospheric circulation. The detailed results will be presented during the symposium.

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76. Interplanetary Magnetic Clouds and their Geoeffectiviness

Cythia Lopez-Portela

In this work we study the geoeffectiviness of Magnetic Clouds (MCs) over the years 1996 to 2002 observed by Wind at 1 AU. Magnetic Clouds are perturbations in the interplanetary medium often observed in situ by different spacecraft. These perturbations satisfy the next three characteristics: (1) the magnetic field is higher than the ambient solar wind field, (2) the magnetic field rotates smoothly on a plane, and (3) the temperature is lower than in the solar wind. Such perturbations are a subset of interplanetary coronal mass ejections (ICMEs) characterized by enhanced and well ordered rotating magnetic fields. Because of this they are good candidates to study their geoeffectiviness. In this study we investigate their geoeffectiviness using the Dst index, which represents geomagnetic perturbations at medium latitudes. As some MCs travel faster than the ambient solar wind, a shock is formed ahead of them and subsequently a sheath region appears. The main objective in this work is to study if MCs with a sheath region can be more geoeffective than the ones where no sheath exists. And what is the contribution of the sheath-cloud region in causing two step storms.

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77. 3-D Simulation of the interaction of two CMEs from Sun to Earth

N. Lugaz, W. Manchester

We present a three-dimensional (3-D) compressible magneto-hydrodynamics (MHD) model of the interaction of two coronal mass ejections (CMEs). Two identical CMEs are launched in the exact same direction into a pre-existing solar wind, the second one 10 hours after the first one. Our global steady-state coronal model possesses high-latitude coronal holes and a helmet streamer structure with a current sheet near the equator, reminiscent of near solar minimum conditions. Within this model system, we drive the CMEs to erupt by the introduction of two 3-D magnetic flux ropes embedded in the helmet streamer. After an initial phase, when the trailing shock and the second CME propagate into the disturbed solar wind medium, they reach the edge of the first magnetic cloud, leading to complex magnetic interactions and a steep acceleration of the shock. Later, the trailing shock reaches the dense sheath of plasma associated with the leading shock, where it decelerates to a speed about 100 km/s larger than the speed of the leading shock. Eventually, the two shocks merge and a stronger, faster shock forms in association with a contact discontinuity between the "old" and "new" downstream regions. We find that the trailing shock always remains a fast-mode shock. A reverse shock is driven after the collision of the two magnetic clouds due to the difference in speed within the reconnection region. At Earth, the two magnetic clouds can still be distinguished, with a compressed and heated first cloud and a second over-expanded cloud. The transit time of this complex ejecta is reduced by about 7 hours compared to the case of the first CME without interaction.

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78. Can We Detect Coronal Mass Ejections in Lyman-alpha?

M. Leila Mays (University of Texas at Austin), O. C. St. Cyr (NASA-GSFC, CUA), Seiji Yashiro (CUA), Eric Quémerais (Service d'Aéronomie), Stephan Ferrón (Service d'Aéronomie), Jean-Loup Bertaux (Service d'Aéronomie), and Russell Howard (NRL).

We have investigated the possibility that coronal mass ejections (CMEs) may be observed in neutral Lyman-alpha emission. An observing campaign was initiated for SWAN, a Lyman-alpha scanning photometer on board the Solar and Heliospheric Observatory (SOHO) dedicated to monitoring the latitude distribution of the solar wind from its imprints on the interplanetary sky background. This is a new investigation as it is not known how CMEs will interact with the solar wind and interplanetary neutral hydrogen at this distance (~60 Rs), and there are few methods of tracking CMEs beyond 30 Rs. Using LASCO, white-light coronagraphs on SOHO, and EIT, an extreme ultraviolet imaging telescope also on SOHO, CMEs candidates were identified which, subject to certain criteria, should have been observable in SWAN. The criteria included SWAN observation time and location, and CME position angle and extrapolated speed. Data analysis of the SWAN data included pixel-by-pixel analysis and time-sequence movie analysis. From our analysis, we report a negative detection of the 4 best candidate LASCO/EIT CMEs in SWAN data. However, SWAN data for all of the l84 observing runs was also analyzed. The Lyman-alpha emission from all of the observing runs could be categorized as due only to celestial motion, constant, an overall increase, an overall decrease, or due to a possible CME. Only two of the observing runs had a Lyman-alpha emission pattern possibly produced by a CME and can be traced back to a LASCO/EIT CME.

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79. Correlation between the Magnetic Fields Measured by ACE and WIND

Q. Y. Luo, J. Giacalone AND J. R. Jokipii, LPL/UA

The fluctuating interplanetary magnetic field and solar wind are investigated through the correlation analysis. We concentrate on the transverse correlation scale evaluation with data measured by ACE and WIND. Due to the appropriate separation between the two spacecrafts, the measured magnetic fields exhibit high degree of coherence. We find the expected decaying correlation with increasing spatial lag and the transverse correlation scale is ~1.76 10^6 km near 1 AU. And the correlation contour in real spatial distribution shows different configuration from the Maltese Cross.

80. How significant is electron impact ionization in producing He+ PUI at and within 1 AU?

E. Moise (Univ. of Arizona), J. Steinfadt (Univ. of Arizona), R.Cook (Univ. of Arizona), K.C. Hsieh (Univ. of Arizona), T.H. Zurbuchen (Univ. of Michigan), J.T. Gosling (LANL), and G. Gloeckler (Univ. of Michigan)

The penetration of local interstellar gas into the heliosphere is well established by observations in EUV resonant scattering and by detections of "pickup ions" (PUI). Among the production mechanisms of PUI is electron-impact ionization. We explore the relative importance of electron-impact ionization of interstellar He in the region ? 1 AU by examining cross-correlation between the electron flux in the energy range 27 to 516 eV, as measured by the Solar Wind Electron Proton Alpha Monitor (SWEPAM), and He+ PUI between 1.6 and 1.9 the solar-wind speed, as detected by the Solar Wind Composition Spectrometer (SWICS). Both instruments are on the Advanced Composition Explorer (ACE) and the data cover a period of 5 years. We shall discuss the preliminary result of this study.

81. An improved flux-rope model of magnetic clouds

M.J. Owens, V. Merkin, P. Riley, G. Siscoe and N.U. Crooker

Force-free magnetic flux-rope models have proven to be an extremely valuable tool for understanding the global context of in-situ observations of magnetic clouds. However, it is apparent from both observations and modelling that magnetic clouds have highly non-circular cross-sections, as is assumed when fitting a force-free model to spacecraft data. A number of approaches have been adopted to relax the circular cross-section approximation. Frequently the cross-sectional shape is allowed to take an arbitrary shape, increasing the number of free parameters that are fit between data and model. Whilst a better "fit" to the observed time-series may be achieved, it is not always clear that this translates to a more accurate reconstruction of the global structure of the magnetic cloud. We attempt to make non-circular cross-section fits, but to constrain the additional fit parameters by observations of CMEs/ICMEs and knowledge of the physical processes acting on the magnetic cloud: The magnetic cloud is assumed to take the form of a force-free flux-rope in the low corona, but to be deformed by a combination of axis-centred self-expansion and heliocentric radial expansion. The resulting analytical solution is fit to artificial time series produced by numerical MHD simulations of magnetic clouds, and shown to accurately reproduce the global structure.

82. Solar and Heliospheric Applications of Low Frequency Radio Arrays

D. Oberoi, J. Salah, C. Lonsdale (MIT Haystack Observatory), J. Kasper (MIT Center for Space Research)

Key measurements needed to improve our understanding of the evolution and dynamics of the solar wind and interplanetary CMEs include the density, velocity and most importantly, magnetic fields from near the solar surface to 1 AU. Although such challenging observations are difficult to make, remote sensing techniques using widefield radio arrays operating at low frequencies offer great promise, and augment other systems that have been previously used. The measurement approaches rely on probing the magnetoionic medium of the heliosphere with unprecedented precision using radio propagation effects such as interplanetary scintillations and Faraday rotation during both quiescent solar wind conditions and CME transient events. Though these techniques have been known and used previously, their application using the next generation radio arrays will vastly increase their effectiveness and science returns. In addition, the imaging of solar bursts, particularly type II, can provide information about the location and morphology of the bursts and help clarify their relationship to CMEs. We have been investigating the suitability of a novel radio array to provide the needed measurements. The Mileura Widefield Array, Low Frequency Demonstrator (MWA-LFD) has been designed to operate in the 80 to 300 MHz frequency range, with a 32 MHz bandwidth, and will consist of 8000 dual polarization dipoles, arranged in 500 stations that are distributed over a radius of about 1.5 km. The MWA-LFD has been proposed for installation in an exquisitely radio-quiet environment at Mileura, Western Australia. Early deployment tests have been conducted to confirm the suitability of the site and the design of the basic components. This paper will describe the design and status of the MWA-LFD instrument and its ability to provide measurements that would contribute to the overall study of the sun, heliosphere and interplanetary transients.

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83. Scattering of suprathermal electrons in the solar wind

C. Pagel, BU, P Gary, LANL, N. Crooker , R Skoug LANL, C de Konig, LANL

Suprathermal electrons at 1AU (typically E>80 eV) can be thought of as two seperate populations - a focused magnetic-field aligned beam termed the strahl, and a background population over all pitch angles called the halo. The width of the strahl is variable and at least at times it is clear that the strahl electrons are being scattered. However, a definite scattering mechanism has proved elusive. By focusing on a subset of strahl broadening events, during times when d|B|/|B| is high in the solar wind, we find a characteristic energy dependence of strahl scattering which we believe can be explained by resonance with whistler waves.

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84. CME Characteristics of Decametric-Hectometric Type IV Radio Bursts Observed by Wind/WAVES

S. Petty (CUA), N. Gopalswamy (NASA/GSFC), and M. L. Kaiser (NASA/GSFC)

We analyzed Wind/WAVES decameter-hectometric (DH) type IV radio bursts and the CME characteristics related to these events. It appears that type IV radio bursts in this frequency range are associated with faster CMEs than the metric type IV bursts. The average CME speeds are approximately 840 km/s and 1540 km/s for the metric and DH type IVs, respectively. This indicates possible enhanced magnetic field reconnection, creating type IV activity, which arrives into the DH wavelengths. Most of the DH type IVs have an associated metric event occuring within approximately 1 hour prior to the DH event. This suggests that the DH type IVs are continuations of the metric events, indicating that broader frequency type IV bursts are created by faster CMEs. Studying these DH type IV bursts may be helpful in identifying CMEs that produce considerable space weather effects.

85. Comparison between coronal dimming regions and coronal mass ejections

Alysha Reinard, U of Colorado/NOAA

Coronal dimmings are a phenomenon frequently associated with CMEs. Dimmings can vary in size, shape and intensity, with observations suggesting a relationship between the mass loss from the dimming region and the mass contained within the CME. We will report preliminary results of a statistical analysis of CME associated dimming regions observed with SOHO/EIT, determining their relative dimming compared to a pre-event image and then comparing each with the CME mass as determined by SOHO/LASCO observations. The results are expected to provide insight into CME origins and may help improve predictions of CME-related parameters.

86. Survey of Interplanetary Coronal Mass Ejections in the Near-Earth Solar Wind During 1996 - 2005

Ian Richardson and Hilary Cane, Goddard Space Flight Center

We extend and update our comprehensive survey of ICMEs in the near-Earth solar wind (Cane and Richardson, JGR, 2003) to include the declining phase of solar cycle 23, and take into account compositional signatures of ICMEs which help to refine the event identifications. We discuss the variation in properties such as occurrence rate (including evidence for a ~150 day periodicity), speed, magnetic field intensity, fraction of ICMEs that are magnetic clouds, the relationship between geomagnetic storms and ICME properties, and association between LASCO halo CMEs and near-Earth ICMEs. An updated list of ICMEs will also be presented.

87. Turbulence, dropouts, and suppression of the field line random walk

David Ruffolo (1), Piyanate Chuychai (1,2,3), William H. Matthaeus (3), and George Rowlands (4) - (1) Department of Physics, Mahidol University, Bangkok, Thailand (2) Department of Physics, Chulalongkorn University, Bangkok, Thailand (3) Bartol Research Institute, University of Delaware, Newark, DE, USA (4) Department of Physics, University of Warwick, Coventry, UK

We employ the well-tested two-component model of solar wind turbulence to explain dropouts in impulsive SEP events over distances ~1 AU from the Sun, while at longer distances, much faster diffusive transport is found. Magnetic field lines are temporarily trapped in filaments defined by the small-scale topology of the 2D component of turbulence (fluctuations with perpendicular wave vectors). Within such islands, the 2D component does not contribute to the random walk, which therefore takes place at the much slower rate for the slab component (fluctuations with parallel wave vectors). A further consideration is that both observed and simulated dropouts occur very sharply. We provide computational evidence and a theoretical explanation that strong 2D turbulence can inhibit diffusion due to the slab component. Therefore, while the dropout filaments are basically defined by the small-scale topology of 2D turbulence, there can be sharp trapping boundaries where the 2D field is strongest. Partially supported by the Thailand Research Fund and the NASA Sun-Earth Connections Theory Program (grant NAG 5-8134).

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88. Solar Cycle Variation of the Properties of Interplanetary Coronal Mass Ejections (ICMEs)

C. T. Russell, L. Jian, J. T. Gosling, and J. G. Luhmann

In the poster "A New Parameter for Characterizing ICMEs" for 2004 SHINE meeting, we advocated the use of the total perpendicular pressure for ICME studies. We classified Interplanetary Coronal Mass Ejections (ICMEs) into three groups depending on the behavior of the perpendicular pressure, which itself may be controlled by the impact parameter of the spacecraft passing through the ICME relative to the center of the flux rope. Though there are indeed some weak and spent ICMEs at 1 AU that may not have pressure signatures, we have used these signatures in the pressure to identify ICMEs and characterize them. We give the occurrence rate, peak pressure and the maximum magnetic field of the three groups of ICMEs based on the study of 9 years WIND data, to determine if concept of an impact parameter dependent signature can explain the conventional wisdom that only about one-third of ICMEs are found to contain a magnetic cloud. In addition, we give the solar cycle variation (1995-2003) of the number of identified ICME events, the percentage of events with shocks, the distribution of the change in the velocity of events, and the distribution of the peaks of the magnetic field and total perpendicular pressure. Basically, the peak pressure grows over the rising phase of the solar cycle and becomes greatest at solar maximum, producing the strongest interaction with the Earth's magnetosphere at solar maximum.

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89. Streamer Puffs from Homologous Compact Ejective Flares

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We discuss SOHO EIT, MDI, UVCS and LASCO observations of recurrent (3--4 per day) ejections that occurred over November 26--29, 2002, many of which resulted in narrow CMEs. In EIT He II 304 images, which detects plasma at temperatures typical of the chromosphere, show the ejections to be compact and homologous. The ejected plasma expands at higher levels and is sampled by the UVCS slit at 0.7 solar radii over the solar limb. Some of these ejections continue out into the interplanetary medium, appearing as the narrow CMEs in LASCO C2 and C3 data, while several of the other He II ejections produce only weak narrow-CME-like disturbances in the LASCO images. EIT, MDI and LASCO data show the source of the ejections to be compact flares associated with an included polarity in an active region located in the outskirts of the base of a coronal streamer. While the streamer is perturbed by each eruption, its general structure persists throughout the entire series of events; this is a basic difference from "standard" streamer-associated CMEs, which generally disrupt the coronal structure within which the ejection occurs. We therefore take our eruptions to be a new variety of narrow CME, which we call ``streamer puffs." We give results from detailed analysis of EIT, UVCS, and LASCO data, and present a possible scenario to explain how the magnetic pattern at the base of the streamer can give rise to recursive magnetoplasma ejections, some of which escape as narrow CMEs and others of which are confined within the enveloping streamer field.

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90. Origin of Heliospheric Magnetic Field Polarity Inversion at High Latitudes

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High latitude observations of the magnetic field by the Ulysses spacecraft have shown a significance number of cases where the radial magnetic field polarity is reversed with respect to the dominant polarity of the coronal hole from which the wind emanates. Such reversals have the nature of folded back magnetic field lines. It has been suggested that such reversals are due to reconnection of closed and open field lines in the lower corona which would launch a large amplitude Alfvén wave into the solar wind. We suggested an alternative mechanism for the generation of the polarity reversal, namely, the coupling of standard large amplitude Alfvénic turbulence in the low frequency regime propagating away from the sun with the microstream shears observed in the high speed solar wind. Here we show that pressure and density signals are similiar to those observed in the data, and discuss the correlation of the reversals with the high latitude microstream structure.

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91. The International Heliophysical Year – An international program of scientific research

David Webb[1], Joseph Davila[2], Nancy Crooker[3], Nat Gopalswamy[2] & Barbara Thompson[2]
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On October 4, 1957 the launch of Sputnik marked the beginning of the space age. Discovery of the radiation belts, the solar wind, and the structure of Earth's magnetosphere prepared the way for human exploration to follow. Today a similar story is unfolding, as the spacecraft Voyager is leaving the heliosphere, and for the first time, man will begin to explore the local interstellar medium. It is inevitable that, during the next 50 years, exploration of Mars and the Outer Planets will be the focus of the space program, and a better understanding of the global heliophysical processes will be required.

Like the IGY before it, The International Heliophysical Year (IHY) will focus on the cross-disciplinary physics governing all of heliophysics through the study of Universal Processes in the solar system. Basic science themes are (1) Evolution and Generation of Magnetic Structures and Transients, (2) Energy Transfer and Coupling Processes, (3) Flows and Circulations, (4) Boundaries and Interfaces: Sheaths, Shocks, and Layered Interfaces, and (5) Synoptic Studies of the 3D Heliosphere.

The IHY will consist of research campaigns defined by the participants to study universal processes in the solar system. In conjunction with the United Nations Basic Space Science Program, small instrument arrays such as magnetometers, radio antennas, GPS receivers, all-sky cameras, etc, will be deployed around the world. In some cases these will be new arrays, and other cases extensions of existing facilities. A series of cross-cutting, CDAW-like workshops will be organized to develop scientific interpretations, and the workshop results will be published.

The IHY includes a strong outreach, education, and history component. An IGY history preservation effort has been initiated in conjunction with the AGU History Committee, and the IGY Gold Program has already begun to honor participants in the IGY. In addition, plans are underway to develop new educational outreach materials, and a planetarium show illustrating the role of universal processes within the Sun-heliosphere-planetary system is being developed.

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92. Exploring the Occurrence Rate of Solar Wind Periodic Number Density Structures

Nicholeen Viall, Larry Kepko, Harlan Spence, Astronomy Dept., Boston University

The solar wind is generally thought to be a fully turbulent plasma, with a featureless power-law spectrum that does not contain power at discrete frequencies. However, recent observations have shown the existence of highly periodic number density variations in the solar wind that occur at discrete frequencies in the mHz range in the Earth's reference frame. These observations are inconsistent with the fully turbulent plasma picture for describing the solar wind. It was also shown that these number density oscillations were highly geoeffective and drove global magnetospheric oscillations at the same discrete frequencies. The previous studies examined only a few events, and did not determine the occurrence rate of these structures. In this paper we present the results of a statistical examination of the periodic number density structures in the solar wind in order to establish the occurrence frequency of significant spectral peaks. In addition we attempt to reconcile the turbulent picture of the solar wind with the new observations.

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93. Fe Charge states in and outside Magnetic Clouds

H. Xie, N. Gopalswamy, and S. Lepri

In this paper, we present a study of the Fe charge state , solar wind plasma density, flow speed, and temperature in magnetic clouds (MC) and compare them with those in the sheath (SH) region. The list of MC events used is from R. Lepping http://lepmfi.gsfc.nasa.gov/mfi/mag_cloud_S1) for the period 1998 to 2002. The Fe charge states were obtained from ACE. The solar wind plasma density N, temperature T, and flow speed V were obtained from Wind. It is found that the SH and MC present different characteristics in and various solar wind parameters . The results show that the enhancement is only present in the MC but not in the SH region. The mean value of in the SH and MC are 11.3 and 15.1, respectively. The result implies that the SH corresponds to the compression region in front of CMEs, while the MC is the interplanetary counterpart of CME emanating from the Sun. It is also found that the mean is well correlated with the mean value of the flow speed in the MC with a correlation coefficient (CC) = 0.78. However, there is a relatively poor correlation of with in the SH with CC = 0.36. An interesting finding is that the average density is negatively correlated with with CC = -0.50. The relationship of the density in the MC as well as with the brightness of CMEs in coronagraph images will be discussed.

Working Group 3
Energetic Particles

94. Elemental abundance variations of solar energetic particles at low energies as measured by WIND/STEP over the last solar cycle

M. Al-Dayeh, J. R. Dwyer, H. K. Rassoul, G. M. Mason, M. I. Desai, and J. E. Mazur

Solar energetic particles (SEPs) can be used to probe the composition of the solar corona independent of spectroscopic measurements. However, SEP elemental abundances in large gradual events can vary considerably from event to event; this must be taken into account when using SEP measurements to deduce the coronal composition. These variations may be produced either by acceleration/transport effects or variations in the source abundances, the latter of which might be expected to show up as a solar cycle dependence in abundance ratios. Using the Supra-Thermal-through-Energetic-Particle (STEP) instruments onboard the WIND spacecraft, we have measured the ratios of He/O, C/O, NeS/O, and Fe/O at low energies between 0.02 and 0.6 MeV/nucleon for a survey of gradual SEP events between 1995 and 2004. Solar Cycle variations of these ratios were also measured. In this study, we will report and discuss the results.

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95. A statistical study 0f high energetic (~90 MeV) proton events observed with SOHO/ERNE during solar cycle 23

Amjad Al-Sawad, Jarmo Torsti, Leon Kocharov, and Kalle Huttunen-Heikinmaa

During the period of SOHO observation for the solar cycle 23 we selected 51 energetic proton events with energies of (79.2-114), (80,2-101) and (86.7-101) MeV and intensities of > [10^-3/(cm^2.sr.s.MeV/n)] detected by Energetic and Relativistic Nuclei and Electrons (ERNE) on-board SOHO. We exam the first injection time of those events through two methods, first by estimating the flight time of non-scattered protons of those nominal energies along the Archimedean field line of nominal length 1.2 AU. Secondly by considering more possible wide range of proton energies for the same events and assume a simultaneous release and that the path length does not depend on the energies. Those events were associated with CMEs observed simultaneously with Large Angle and Spectrometric Coronagraph (LASCO) and solar flare observed with soft X-ray telescope onboard GOES. We find that most of those events are due to CMEs and 84% of those CMEs (43/51) were associated with solar flares. The solar flares were 49% of class X, 47% of Class M, and 4% of class C. The mean value of speed and angular width of those CMEs associated with X-class flare are higher than those which associated with the M-class. 79% 0f those CMEs located at heliocentric location between (1-5) solar radii at the time of first proton injection of >90 MeV energy, and 84% located at over 10 solar radii at the time of maximum intensity, and those maximum intensities were achieved much earlier than the possible IP sock passage in mean time difference between onset and maximum of 4 hours. 3 events were excluded for suspicion of the source of the first injected protons. From the whole CMEs about 82\% (42/51) were located on the west side of the sun. 94\% were associated with metric radio emission of type II or/and IV and/or DH type. Average speed and angular width decreases as the CMEs associated with metric/DH type II and IV, only metric type II and IV, No association of any metric or DH radio emission. About 61% of those CMEs were halo. The highest intensity were achieved with halo CMEs acceded 1000 km/s and with those events associated with X class flare. The proton production of energetic protons of nominal >90 MeV seems to start with flare and CME-liftoff processes in low corona and continues during CME propagation farther from the Sun

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96. Record-Setting Ground Level Enhancement: January 20, 2005

John W Bieber, Bartol Research Institute, University of Delaware
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Within a 6-minute span on January 20, 2005, the count rate registered by a neutron monitor at the sea level station of McMurdo, Antarctica increased by a factor of 30, while the rate at the high-altitude (2820 m) site of South Pole increased by a factor of 56. The size of the increase at McMurdo qualifies it as the largest observed at sea level since the famous 1956 event, while the increase at South Pole may have been the largest (in percentage terms) ever registered by a neutron monitor. This paper uses data from the "Spaceship Earth" network of neutron monitors to characterize and model the time evolution of cosmic ray density and anisotropy during the event of January 20, 2005. Supported by NSF grant ATM-0000315, the Thailand Research Fund, and the Rachadapisek Sompoj Fund of Chulalongkorn University.

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97. Energy Dependent Broadening of Low-Energy Solar Electron Bursts

Curt A. de Koning, S. Peter Gary, J. T. Gosling, Ruth M. Skoug, John T. Steinberg, LANL

Solar active processes frequently produce electron bursts which, at 1 AU, extend to energies less than 1.4 keV. The characteristics of these solar electron bursts vary considerably from event to event due to the physical processes involved in their acceleration and propagation to Earth. Previous observations have shown that some bursts have a broader field-aligned pitch-angle distribution than the preceding strahl, suggesting that propagation effects are important for understanding 1 AU observations. We present a study of suprathermal electron pitch-angle distributions observed in 2002 by ACE/SWEPAM before, during, and after solar bursts. We find that 41 of 72 bursts observed at energies less than or equal to 713 eV broaden. Prior to the burst onset, 60 of the bursts had a half width half maximum (HWHM) less than 40 degrees. Fourteen of the broadened bursts had a HWHM which exceeded 60 degrees. These width characteristics stand in marked contrast to previously published results for solar burst electrons in the 2-15 keV range which consistently found that the electrons were highly beamed along the magnetic field direction with HWHM less than 15 degrees. Typically, we observe that the width of the burst suprathermal electron distribution increases with increasing energy up to 1.4 keV. The observed energy dependence and the beamed distributions above 2 keV suggest that the scattering rate for electrons as a function of energy has a maximum between 1 and 2 keV. Computer simulations based on bi-Maxwellian core and halo distributions suggest that electron-driven instabilities cannot explain the observed beam broadening. We discuss the role of pitch-angle scattering by ambient whistler turbulence in the dissipation range as a mechanism for the energy dependence of the beam broadening.

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98. Observation of Neutron and Gamma Ray Emission from the October 28, 2003 Solar Flare

Paul Evenson, University of Delaware

John Bieber, John Clem, Paul Evenson and Roger Pyle, all at Bartol Research Institute, University of Delaware, Newark, Delaware J. Bernard Blake and Tamitha Mulligan, both at Space Sciences Department, The Aerospace Corporation, Los Angeles, California David Ruffolo, Department of Physics, Faculty of Science, Mahidol University, Bangkok, Thailand Alejandro Saiz, Department of Physics, Faculty of Science, Mahidol University, Bangkok, Thailand and Department of Physics, Faculty of Science, Chulalongkorn University, Bangkok, Thailand

Recently we published an analysis of the response of the Tsumeb neutron monitor to the large solar flare of October 28, 2003. (GRL doi:10.1029/2004GL021492, 2005) We concluded that the flare produced neutrons over an extended interval of approximately seven minutes. Gamma-rays observed from the SAMPEX spacecraft now confirm the extremely long duration of energetic emission from this event. Both POLAR and SAMPEX have detected protons that may have resulted from the decay of neutrons emitted by this flare. We use these data to determine the energy spectrum of neutrons emitted by the flare, and to further refine our calculation of the time structure of the emission. We compare the emission time structure of the neutrons and gamma-rays with available optical data, and with the injection profile of the GeV interplanetary protons in an attempt to identify the source region of this energetic radiation. Supported in part by NSF grant ATM 0000315, the Thailand Research Fund, and the Ratchadapisek Sompoj Fund of Chulalongkorn University.

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99. Solar Proton and Near-relativistic Electron Events -- What is the relationship?

Dennis Haggerty and Edmond Roelof JHUAPL

We investigate the relationships between the time histories of energetic protons and near-relativistic electrons observed in Solar Energetic Particle (SEP) events through the course of the ACE mission (from Aug 25, 1997). NOAA has cataloged a list of 85 Solar Proton Events (SPE) Affecting the Earth Environment, while the ACE/EPAM instrument has observed 624 near-relativistic electron events with widely varying intensity, fluence, and onset characteristics. We examine the onsets, peak intensity, rise to maximum or "rise-time", and spectra of the 85 SPE events (E > 10 MeV) observed by GOES and the 624 near-relativistic electron events observed by EPAM (40 < E < 300 keV). This study intends to answer some very specific questions regarding near-relativistic electrons and energetic protons: Is there always an electron event for each identified SPE event? What is the difference between the arrival time of the energetic protons and the electrons? Is there a minimum intensity/energy/spectral-slope for the electron events where over such threshold there is always an SPE event?

100. Particle-in-cell modeling of electron acceleration in fast shocks

Michael Hesse, Lyndsay Fletcher, and Thomas Neukirch

The existence of fast shocks, at the interface between reconnection outflow jets and underlying magnetic loops, has been suggested by a number of researchers. Should they exist, fast shocks would provide an effective mechanism to convert a large fraction of the combined kinetic energy in the reconnection outflow into thermal energy of the shocked plasma. Since this process affects directly a large number of particles, it may provide a solution to the problem of explaining the number of electrons that are apparently involved in the generation of the high-energy X-ray signatures observed by RHESSI. In order to investigate this possibility further, we present the results of fully-electromagnetic, relativistic, particle-in-cell simulations of fast shock structure and evolution. In particular, we discuss the effect on downstream nonthermal electrons of parameters such as Mach number, plasma beta, and the angle between shock normal and the upstream magnetic field. We will compare our results to earlier kinetic studies of fast shocks, and provide an evaluation of the shock mechanism as a means to explain nonthermal, relativistic electron distributions such as expected in conjunction with RHESSI X-ray events.

101. ESP Events: Comparison between ACE Observations and Simulations

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Past attempts to order characteristics of energetic ion particle fluxes at interplanetary shocks with shock strength or shock normal angle have not led to very convincing answers. Also from the theoretical side, ion acceleration at weak and/or oblique shocks remains little understood. Possible reasons for this difficulty may lie in the level of upstream seed particles, or in the way energetic particles can mirror back from upstream or downstream perturbations or in global field topologies. We are revisiting this problem by comparing ACE energetic particle data for selected events with large-scale hybrid simulations (kinetic ions, fluid electrons). In this work, we concentrate on relatively mild Mach numbers (2 to 5) and study the energy range up to and around 1 MeV. Several cases of almost identical Mach number and shock normal angle allow us to quantify the spread in the observations, and make it possible to address the question of seed particles and other effects that may have an impact on ion acceleration. Thus, our work can help constrain models of the parameter dependence of shock source characteristics of SEPs (solar energetic particles).

102. Extending Measurements of Ultra-Heavy Elements in Solar Energetic Particle Events to Higher Energies

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Measurements from Wind/LEMT and ACE/ULEIS at energies below several MeV/nucleon have shown that the abundances of elements heavier than Ni (Z=28) can be enhanced by factors of ~100 to 10,000 in impulsive solar energetic particle (SEP) events. The Solar Isotope Spectrometer (SIS) on ACE measures the composition of energetic nuclei for elements up to ~Zr (Z=40) at energies from ~10 to more than 100 MeV/nucleon. At these energies, even large gradual events are often very iron rich and may appear similar in composition to impulsive events, perhaps due to admixtures of flare seed material. Since the launch of ACE in August 1997, SIS has detected ~1000 Zn (Z=30) nuclei along with measurable abundances of well-resolved heavier species such as Ge (Z=32) and Se (Z=34). We report the average SEP composition for elements from Z=30 to 40 and examine the distribution of these nuclei in time to see whether they arrived preferentially during gradual SEP events or impulsive events. We test whether all gradual events are basically similar in their ultra-heavy composition or whether the iron-rich gradual events show noticeably larger ultra-heavy enhancements as expected if these events contain flare seed material, and we test whether the large excesses of ultra-heavy elements in impulsive events extend up to the higher energies measured by SIS. This work was supported by NASA at Caltech (under grant NAG5-6912), JPL, and GSFC.

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103. Macroscopic source and transport aspects of SEP event time profiles

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SEP event time histories are often attributed to the spatial and/or temporal behavior of the diffusion coefficient along their paths. However, the time profiles for gradual events are in fact a complex convolution of the temporal spatial and history of the shock source, the particular sample of shock-connected field lines encountered by the observer during the event, and any scattering effects during their transport. The first two of these represent macroscopic aspects that underlie the well known organization of SEP event profiles by the related solar event longitude with respect to the observer. Lario and coworkers and Kallenrode and coworkers integrated these macroscopic aspects into semi-empirical models of SEP events developed several years ago. Now more realistic Global models of interplanetary shocks moving through the heliosphere provide a unique opportunity to investigate the interplay of macroscopic and diffusive aspects. One such model has been under development by the CISM (Center for Integrated Space Weather Modeling) group. In this study we investigate the transport of ions in the >10 MeV energy range in the magnetic fields produced by CISM heliospheric MHD simulations, assuming the moving interplanetary shock is a time and space-dependent source. We also introduce a variable amount of Monte-Carlo style pitch angle scattering to add a diffusive aspect to the ion transport. The combination of shock source characteristics, observer field line sampling, and assumptions about scattering importance all influence the ion events at a given location. Such numerical "experiments" help to sort out the complicated origins of SEP event profiles and illustrate the importance of knowing the big picture.

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104. Neutral-atom physics in the heliosphere

Pran Mukherjee

Neutral-atom physics in the heliosphere is still a relatively unexplored topic since we lack adequate in-situ data with which to form theories. In particular, the formation of pick-up ions in near-solar regions depends on significant neutral populations that we so far have not detected except through optical means. Unfortunately, current neutral detectors are generally large and heavy. Microelectromechanical systems (MEMS) technologies allow for the creation of detectors of similar or greater sensitivity for far smaller mass, volume, and energy costs, ideal for spacecraft with tightly constrained design budgets. We present here a neutral-atom instrument design for Solar Probe that uses MEMS devices massing only a few grams.

105. GCR short-period variations and magnetic field modeling: Implications for the local and non-local geometry of Interplanetary Coronal Mass Ejections (ICMEs)

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Short-period variations in the integral GCR fluence measurements (> 100 MeV) seen by Polar have been found in neutron monitor data. The Polar instrument, designed to measure radiation-belt electrons, makes clean measurements of the integral GCR fluence when Polar is outside the radiation belts. The GCR measurements show variability on a variety of time-scales including 0.1 mHz - 1 mHz. This short-term variability might indicate a change in magnetic scattering power, the passage of a shock discontinuity, a large-scale magnetic rope or tangential discontinuity in the solar wind. We examine these variations from the Polar spacecraft along with IMF and plasma data from ACE. Using a non-force-free magnetic flux rope model along with particle data allows investigation of the geometry of Interplanetary Coronal Mass Ejections (ICMEs), associated with these GCR variations. Often spacecraft entry into and exit from ICMEs are accompanied by abrupt changes in GCR decrease and recovery rates. These changes are usually attributed to ICME effects superposed upon shock decreases. However, observations indicate different decrease and recovery rates for magnetic cloud topologies than for non-cloud ICME drivers. Modeling of observations reveal these differences are due to non-local, three-dimensional characteristics of ICME shock, sheath, and envelope regions.

106. The effects of adiabatic cooling on the rigidity dependent SEP mean free path

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Solar energetic particles (SEP) experience the effect of adiabatic cooling because of the differential solar wind convection. We find that the adiabatic energy loss contributes significantly to the interplanetary transport of SEP events, and the mean free path obtained by fitting SEP transport equation with energy loss is different from that without energy loss. In this paper, we will discuss the influence of the adiabatic cooling effect on the rigidity dependence of mean free path in large gradual SEP events.

107. Relativistic Solar Protons on 1989 October 22: Injection along Both Legs of a Loop

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Worldwide neutron monitor observations of relativistic solar protons on 1989 October 22 have proven puzzling, with an initial spike at some stations followed by a hump with bidirectional flows and a very slow decay. We analyze data from polar monitors, which measure the directional distribution of solar energetic particles (mainly protons) at rigidities of ~1-3 GV. The inferred density and anisotropy are simultaneously fit by simulating the particle transport for various magnetic field configurations and determining the best-fit injection function near the Sun. The data are not well fit for an Archimedean spiral field, a magnetic bottleneck beyond Earth, or particle injection along one leg of a closed magnetic loop. A model with simultaneous injection along both legs of a closed loop provides the best explanation. Refined fits indicate a very low spectral index of turbulence, q<1, and hence an unusually low correlation length of magnetic fluctuations in the loop, a parallel scattering mean free path of 1.2 to 2 AU, a loop length of 4.7+/-0.3 AU, and escape from the loop on a time scale of 3 hours.
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108. Comparison of Solar Energetic Particle Events and Impulsive Nitrate Increases in Arctic Ice Cores

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Previous studies suggest that historic, large solar proton events have been identified in high time-resolution (decimal year) nitrate records in arctic ice cores. It has been proposed that spikes in ice core nitrate concentration are produced by the precipitation of an elevated, impulse of middle atmospheric nitrates. Consequently, ice core nitrates have the potential to track the processes which create atmospheric nitrates, including those known to be associated with major, impulsive solar proton events (i.e., those with significant fluxes > 30 MeV). In an attempt to explore and to validate these previous results we have examined shallow (~30 meter depth) ice cores obtained in June 2004 from Summit, Greenland. Thirty meter depth cores at Summit span the time period from ~1930 to present. We report on high-resolution nitrate analysis of these ice cores using a continuous flow analysis system designed, built, and in operation at Boston University. We examine the correlation between impulsive nitrate spikes in the ice strata and solar proton events over the past ~75 years. For this comparison, we appeal to ground-level-enhancement cosmic ray observations in the era before in situ spacecraft observations of solar protons were available. We report on the amplitude and timing of measured ice core nitrate increases in relation to the onset and characteristics of known (or inferred) SEP events. A time delay between nitrate spikes and SEP onset has previously been observed to be a few weeks, which is much faster than current atmospheric downward transport theory allows. Independent assessment of these previously-determined time delays will also be presented.

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109. A Model for SEP Spectral and Compositional Variability at High Energies

Allan J. Tylka (NRL) & Martin A. Lee (University of New Hampshire)

Shocks driven by fast coronal mass ejections (CMEs) are widely believed to be the ultimate accelerators in large, so-called "gradual" solar energetic particle (SEP) events. At high energies, above a few tens of MeV per nucleon, these events are highly variable in their spectral shapes and elemental composition, especially Fe/O. (The SHINE campaign events of 2002 April 21 and 2002 August 24 are particularly good examples of this variability.) Tylka et al. [ApJ 625, 474-495, (2005)] suggested that that this variability can be understood as a natural consequence of evolution in the shock normal angle $\theta_{\mathbf{Bn}}$ as the shock moves outward from the Sun, coupled with a compound seed population, typically comprising suprathermals from both flares and from the corona/solar-wind. We present results from a simple analytic model embodying these ideas. We show that these calculations semi-quantitatively reproduces many key features of the observed SEP variability, including both new observations (such as correlations between spectral steepening and high-energy Fe/O, spectral morphologies, and energy dependence in Fe/O, <QFe>, 3He/4He) and long-standing puzzles (such as the origin of the Q/M-dependent fractionation discovered by Brenneman and Stone [1985]). These calculations are too simple to be the final word. However, their success suggests that it will be important that these factors to be taken into account in the more sophisticated CME/SEP modeling efforts currently under way.

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110. A study of the solar injection for eleven impulsive electron/3He-rich SEP events

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We examine the solar injection of electrons and ions in impulsive electron/3He-rich solar energetic particle (SEP) events. The WIND 3-D Plasma and Energetic Particle experiment (3DP) provides electron observations with the energy range of <~1 keV - 400 keV, and the ACE Ultra-Low Energy Isotopic Spectrometer (ULEIS) provides high sensitivity ion measurements with the energy range of ~0.02 - 10 MeV/nucleon. We select eleven electron/3He-rich SEP events from August 1998 to January 2003 with a clear velocity dispersion, the 3He/4He ratio > 0.1, and good count statistics. The electron path length is estimated from the linear fit to in situ electron peak times at energies above 25 keV and the ion path length from in situ ion onsets. We find that these path lengths are comparable to each other and the predicted Parker spiral length, implying nearly scatter-free propagation. Thus, we are able to obtain the electron injection profile versus energy from the in situ observations for all the selected events, and the ion injection profile for one event with good enough ion statistics. We estimate the onsets and peaks of the ion injection from in situ observations for the other events. We find a systematic delay of the solar injection of 3He-rich ions relative to associated impulsive electrons. The majority of the events have no H_alpha and GOES SXR flares, but all have a type III burst and one has a coronal type II burst. Nine of the ten events with the SOHO/LASCO coronagraph coverage have a fast (> 570 km/s) west-limb CME that begins close to the start time of electron injection, and reaches a median height of ~ 5 Rs at the start time of ion injection. Eight of the nine CMEs are narrow (a average width of 30 degrees and a maximum of 62 degrees).

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