

Welcome to the SHINE 2004 Workshop!

Dear SHINER,

Welcome to the 2004 SHINE workshop at Big Sky Montana. We have 146 participants, roughly same as last year's in Maui. Last year we introduced the abstract book. This year we have improved it by including abstracts for all the invited talks (plenary and working group sessions). We hope that these abstracts will be useful in tracking down interesting topics and authors. There are 61 invited talks in various sessions. The working group leaders and the steering committee must be congratulated for this achievement. There are 91 poster abstracts. They are numbered in such a way to group related papers. Thanks to Joan Burkepile, David Webb and Nick Arge for ordering the posters.

It is encouraging to see that the number of students has grown to 25. This is a good sign. The Student day program has also improved. It includes review talks on each working group topic to serve as tutorials to the students. Student presentations are also included. Thanks to Ben Lynch for putting this together with the help of the steering committee members. NSF/SHINE grant was able to support the travel of seventeen students (all who asked for support); the travels of 8 other researchers were also partly supported.

I take this opportunity to thank the team, which put the logistics of the workshop together: Umarani Adivikolanu, Alejandro Lara, Ernesto Aguilar-Rodriguez, Ana Rosas, Seiji Yashiro, and Hong Xie (from the Catholic University) and Carol Tedore (secretary, Planetary magnetospheres Branch, Goddard Space Flight Center).

Nat Gopalswamy
SHINE Workshop Coordinator
2004 June 26

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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.

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 (2004) Steering Committee:

Jon Linker (SAIC), Chair	linkerj@saic.com
David Alexander	dalex@rice.edu
Joan Burkepile (HAO)	iguana@hao.ucar.edu
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SHINE 2004 Workshop Program

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

Sunday, June 27

SHINE student day – Students and Invited Speakers only

9:00 Breakfast
Welcome/Opening Remarks J. Linker
SHINE Logistics N. Gopalswamy
9:30 Working Group 1 Review Talk T. Forbes
10:30 Working Group 2 Review Talk T. Holzer
11:30 Coffee Break
11:45 Working Group 3 Review Talk A. Tylka
12:45 Group Lunch
1:45 Student talks - Maher Al-Dayeh
Elizabeth Jensen
Kathy Reeves
Rhona Maclean
3:00 Coffee break
3:15 Student talks - Loraine Lundquist
Angela Des Jardins
Linghua Wang
4:00 Coronagraph Instrumentation/Data talk - Chris St. Cyr
4:30 Group activity or free time
6:30 Group dinner
9:30 Informal social time with established scientists

Monday, June 28

7:00 Breakfast
8:30 Opening remarks J. Linker and N. Gopalswamy
8:45 SHINE and NSF P. Bellaire
9:00 SHINE and NASA's Living with a Star
C. St. Cyr
9:15 SHINE and AFOSR Dave Webb (for David Byers)
9:30 Description of working group (WG) sessions
WG 1: Solar T. Metcalf and Simon Plunkett
WG 2: Interplanetary N. Arge and C. Smith
10:10 Coffee break

10:40 WG 3: Energetic Particles

Mihir Desai and Joe Giacalone

11:00 Invited paper: Aad van Ballegooijen. Topic: Low Coronal Signatures of CMEs

11:45 Lunch break

1:15 Invited paper: Thomas Holzer, The Slow Solar Wind

2:00 Plenary session: Overview of the SHINE Campaign events,

3:15 Coffee break, Plenary continues

5:30 Welcome reception and Posters

Tuesday, June 29

7:00 Breakfast

8:30 SHINE Campaign Events: Splinter Sessions (Session Leaders)

1) Energetics of the Corona (Tom Metcalf, David Alexander)

2) Modeling Campaign Event CMES: Case Studies (Nick Arge, Simon Plunkett)

3) *In situ* observations and flux rope fitting for campaign events (Dave Webb, Chuck Smith)

4) Comparison of SEP Theory with Observations (Mihir Desai, Joe Giacalone)

10:00 Coffee break, Splinter sessions continue

11:45 Lunch break

1:15 Invited paper: Glenn Mason Topic: Impulsive SEP events

2:00 Working Group Sessions

WG1: Understanding the Corona from Vector Field Measurements (Tom Metcalf, Jim Klimchuk)

WG1, WG2: Origin and Evolution of the Slow Solar Wind (Nick Arge, Simon Plunkett)

WG3 (WG1*): CMEs and SEPS - Impulsive SEP events (Mihir Desai, Joe Giacalone)

3:15 Break, WG sessions continue

5:15 Poster session with refreshments

7:00 Adjourn

Wednesday, June 30

7:00 Breakfast

8:30 Working Group Sessions

WG1, WG2: Origin and Evolution of the Slow Solar Wind (Nick Arge, Simon Plunkett)

- WG2 (WG1*) CME models: What do they predict for interplanetary observations (Chuck Smith, Thomas Zurbuchen)
- WG3 (WG1*, WG2*) SEP electrons (Mihir Desai, Joe Giacalone)
- 10:00 Coffee break, WG sessions continue
- 12:00 Lunch, free afternoon
- 6:00 Steering Committee, Working Group Leaders, Agency Representatives Dinner

Thursday, July 1

- 7:00 Breakfast
- 8:30 Working Group Sessions
 - WGI: Low coronal signatures of CMEs (Simon Plunkett, Tom Metcalf)
 - WG2 (WG1*): Connecting *In Situ* Observations of CMEs to their solar source (Chuck Smith, Nick Arge)
 - WG3 (WG1*, WG2*) Extreme SEP events (Mihir Desai, Joe Giacalone)
- 10:15 Coffee break, WG sessions continue
- 12:00 Lunch break
- 1:30 Working Group Sessions
 - WGI: Low coronal signatures of CMEs (Simon Plunkett, Tom Metcalf)
 - WG2: Flux Rope Fitting (Chuck Smith, Nick Arge)
 - WG3: Solar variability of SEPs (Mihir Desai, Joe Giacalone)
- 3:15 Break, WG sessions continue
- 3:30 Steering Committee Meeting
- 5:00 Poster session with refreshments
- 7:00 Banquet

Friday, July 2

- 7:00 Breakfast
- 8:30 Reports from liaisons and related meetings
- 9:00 WG summary reports, challenges, and discussion
- 10:45 Discussion of plans for next year N. Gopalswamy
- 11:00 Adjourn

SHINE 2004

Session Invited Speakers

Monday afternoon :
Plenary Campaign Events

Tuesday morning: Splinter Sessions for Campaigns

Energetics of the Corona (Presiding: Tom Metcalf, David Alexander)

David Alexander – Energetics of the Corona

Tom Metcalf – The Magnetic Free Energy in AR0486

Jim McTiernan – The Magnetic Structure of AR0486 on 2003 Oct 29

Angelous Vourlidas – CME Energetics of the SHINE Campaign Events

Modeling Campaign Event CMES: Case Studies (Presiding: Nick Arge, Simon Plunkett)

Illia Roussev – A Numerical Model of CME Initiation and Shock Development for the 1998 May 2 Event: Implications for the Acceleration of GeV Protons.

Dusan Odstroil – Heliospheric simulations of selected SHINE events

Zoran Mikic - Progress and challenges in modeling the May 12, 1997 CME

In situ observations and flux rope fitting for campaign events (Dave Webb, Chuck Smith) Flux rope fits for 1997 and 1998 events:

Ben Lynch - 3D Breakout

Qiang Hu - Non-Axisymmetric and Multi-tube Magnetic Flux Ropes in the Solar Wind

Alysha Reinard - Combining remote and in situ observations of CME ejecta

Chuck Goodrich - Geospace effects of the impact of flux ropes.

Tamitha Mulligan- ICME Models

Comparison of SEP Theory with Observations (Mihir Desai, Joe Giacalone)

Allan Tylka, Martin A. Lee - Shock Geometry, Seed Populations, and the Origin of Variable Elemental Composition at High Energies in Large Gradual Solar Particle Events

Mihir Desai - Spectral Properties of Heavy Ions Associated With the Passage of interplanetary Shocks Near 1 AU

Jozsef Kota - Modeling SEP acceleration at CME driven shocks: toward a realistic CME

Gang Li – Particle Acceleration and transport at CME- driven shocks: A Case Study

Joe Giacalone - Acceleration by Shocks: The Injection Problem, Shock-Normal Angle, and Time Dependence

Tuesday afternoon: Working Group Sessions

WG1: Understanding the Corona from Vector Field Measurements (Tom Metcalf, Jim Klimchuk)

K.D. Leka - Photospheric and Chromospheric Vector Field Observations:
Striking Similarities and Intriguing Differences

Bill Abbett – A Data-driven MHD Model of AR-8210

Steve Tomczyk – Initial Measurements from the Coronal Multi-Channel
Polarimeter

Haosheng Lin – Infrared Zeeman Coronal Magnetic Field Measurements

WG1, WG2: Origin and Evolution of the Slow Solar Wind (Nick Arge, Simon Plunkett)

Marcia Neugebauer - The Low-Speed Solar Wind

John Raymond - Abundances, temperatures, and outflow speeds in coronal
streamers

Uri Feldman - What have we learned from solar observations about the
source of the slow speed solar wind

WG3 (WG1*): CMEs and SEPS - Impulsive SEP events (Mihir Desai, Joe Giacalone)

Glenn Mason - Abundances of Heavy and Ultra-Heavy Ions in 3He-rich Solar
Flares

Don Reames - Heavy-element abundances in solar energetic particle events

Sam Krucker - Interacting Coronal Mass Ejections and the Release of Solar
Energetic Particles

Vahe Petrosian - Enhancement of 3He Abundance in Solar Energetic Particle
Spectra by Stochastic Acceleration

Randy Jokipii- Diffusive Compression Acceleration: Spectra and Composition

Jim Miller - Stochastic Acceleration via Novel Wave-Particle Interactions

Wednesday morning: Working Group Sessions

WG1, WG2: Origin and Evolution of the Slow Solar Wind (Nick Arge, Simon Plunkett)

Leon Ofman -The origin of the slow solar wind

Russell Dahlburg - Formation and acceleration of the slow solar wind

Joseph Hollweg - The Fast Solar Wind Then and Now

WG2 (WG1*) CME models: What do they predict for interplanetary observations (Chuck
Smith, Thomas Zurbuchen)

Spiro Antiochos - Predictions of the Breakout Model for Interplanetary
Observations

Jonathan Krall - Magnetic Flux Ropes from the Sun to 1 AU

Pete Riley - A Generalized Flux Rope Fitting Technique Incorporating
kinematic distortion effects

Illia Roussev (for Chip Manchester): Signatures of CME propagation near 1AU

WG3 (WG1*, WG2*) SEP electrons (Mihir Desai, Joe Giacalone)

Dennis Haggerty – Drift velocity and initiation times of interplanetary type- III
radio bursts

Mike Reiner - Solar Origin of the Radio Characteristics of a Complex Type III Burst Observed on April 11, 2001

Jack Gosling - Correlated Dispersionless Modulations in Suprathermal Electron and Impulsive Energetic Ion Events in the Solar Wind

Paul Evenson - Spaceship Earth Observations of the 24 August 2002 Event

Nariaki Nitta - Identification of Solar Sources for Energetic Electron Events

Wednesday afternoon: Free

Thursday morning: Working Group Sessions

WG1: Low coronal signatures of CMEs (Simon Plunkett, Tom Metcalf)

Jie Zhang - Properties of CME Acceleration in the Low Corona

Hugh Hudson - CME/flare energetics and RHESSI observations

WG2 (WG1*): Connecting *In Situ* Observations of CMEs to their solar source (Chuck Smith, Nick Arge)

Nancy Crooker - Filament Evolution in CMEs and Implications for ICMEs

Dick Canfield - The AR-ICME Topology Connection

Thomas Zurbuchen - Compositional Signatures of ICMEs

WG3 (WG1*, WG2*) Extreme SEP events (Mihir Desai, Joe Giacalone)

Nat Gopalswamy - Solar Origins of the Extreme Events

Christina Cohen - An Overview of SEPs During the October-November 2003 Storms

Joe Mazur - New Radiation Belts and Other Effects of Cycle 23 SEP Events

Dave Webb - Observations and Historical Context of the late October 2003 Geoeffective Halo CMEs

Frank Toffoletto - Extreme events impact on geospace from a modeler's perspective

Thursday afternoon: Working Group Sessions

WG1: Low coronal signatures of CMEs (Simon Plunkett, Tom Metcalf)

Alphonse Sterling - CME Eruption Onset Observations from EIT and SXT

Terry Forbes - Dimmings and Related X-ray Structures Following CME Onset

WG2: Flux Rope Fitting (Chuck Smith, Nick Arge)

Qiang Hu - Non-Axisymmetric and Multi-tube Magnetic Flux Ropes in the Solar Wind

Charlie Farrugia - Evolutionary Signatures in Complex Ejecta and Their Driven Shocks

Pete Riley - Fitting Flux Ropes to a Global MHD Solution: A Comparison of Techniques

WG3: Solar variability of SEPs (Mihir Desai, Joe Giacalone)

Gerard Bond - Sun-Climate Connections on Decadal to Millennial Timescales

Ken McCracken - Cosmic ray modulation and SEP Events, 850-1950AD

Leif Svalgaard - Determination of Interplanetary Magnetic Field Strength, Solar Wind Speed, and EUV Irradiance, 1500-2000

Vladimir Florinski - Solar system environment effects on cosmic-ray propagation in the heliosphere: Consequences for cosmogenic isotope production.

Plenary Talks

Observational Signatures of CMEs in the Low Corona

A. A. van Ballegoijen

The EUV and X-ray signatures of CMEs (sigmoids, flare loops, high-temperature emissions, shocks, dimming regions) are discussed. Some of the key questions are: What is the pre-event magnetic structure? What triggers the onset of a CME? What is the role of magnetic reconnection during onset and early rise? The observations are interpreted in terms of CME models in which a magnetic flux rope is destabilized by reconnection occurring above or below the flux rope (break-out vs. tether-cutting). The conversion of magnetic free energy into other forms of energy (thermal, kinetic, gravitational, energetic particles) is discussed.

The Slow Solar Wind

T. Holzer

This talk will begin with a description of the basic physical processes important in the acceleration of the solar wind, focusing on the particular ingredients required to drive a slow solar wind. The principal observational constraints on slow solar wind models will then be outlined. Next, some of the slow solar wind models that have been proposed will be reviewed. Finally, a brief discussion will be presented of the opportunity for physical insight offered by the surprising predictive success of the WSA scheme.

Solar Energetic Particles: recent Observational Progress for shock-related and Impulsive Events

Glenn M. Mason¹, J. E. Mazur², M. I. Desai³, and J. D. Dwyer⁴

¹ Department of Physics and I.P.S.T., Univ. of Maryland, ² The Aerospace Corp., Los Angeles, ³ Department of Physics, Univ. of Maryland, ⁴ Department of Physics & Space Science, Florida Institute of Technology, Melbourne

Particle acceleration in large solar energetic particle events is generally associated with shocks driven by coronal mass ejections. Although such shock acceleration of particles has long been the subject of theoretical investigation, nevertheless key energetic particle properties such as intensity and spectral index are only roughly correlated with predictions of the theories. Recent measurements have shown that trace elements in the thermal plasma (e.g. singly ionized He, and ³He) often show dramatic enhancements in the energetic particle population. Although the observational picture is far from complete, it appears that the injection threshold in these events is ~1.5-2 times the solar wind speed. In this range, multiple particle sources are present, including solar wind suprathermals, pick up ions, and remnant material from prior shocks and impulsive events. Thus, the enhancements are not due to properties of the shock acceleration, but rather are primarily due to the properties of the seed population. This points to new

opportunities for theoretical and experimental investigations to quantitatively model shock accelerated particle populations using realistic seed populations. In contrast to shock-associated events, particles accelerated in impulsive events appear to be energized by a distinct mechanism operating close to the Sun. Impulsive events are rich in electrons, ^3He , and, sometimes, ultra-heavy elements (up to $M \sim 200$). Recent observations on their composition, spectra, and possible source locations may make it possible to identify the sources of these events and further constrain the acceleration processes operating in them.

SESSION INVITED TALKS

Tuesday

1. Energetics of the Corona

David Alexander, Rice University

Associated with many CME eruptions is a reconfiguration and energization of the low corona. In particular, solar flares are often the most energetic signatures of a CME in the low corona. We will discuss the energetic signatures of the low corona in the aftermath of a CME, emphasizing the high energy particle and photon emissions accompanying these events and their apparent association with topological structures in the magnetic field.

2. The Magnetic Free Energy in AR0486

Tom Metcalf

During October/November 2003, the dramatic active region 0486 traversed the solar disk and produced many large solar flares. During this time, we obtained chromospheric vector magnetic field data for AR0486 using the Imaging Vector Magnetograph (IVM) at Mees Solar Observatory, Haleakala, Hawaii. We will describe these vector field data and will use them to compute the magnetic free energy, and its time variation, for AR0486. This large, complex active region contained an unusually large amount of free magnetic energy, not surprising considering the level of activity it produced.

3. The Magnetic Structures of ARO486 on 2003 Oct 29

Jim McTiernan

The optimization method of Non-linear Force Free Fields (NLFFF) is described. Examples of NLFFF extrapolations from vector magnetograms will be used to show how the results can be used to interpret the different source patterns and motions seen in RHESSI and TRACE images of flares. Also the usefulness of field extrapolations for calculations of the magnetic free energy will be discussed.

4. CME Energetics of the SHINE Campaign Events

Angelous Vourlidas

I will discuss the energetics associated with the CME events during the active period of October-November 2003. I will also describe the methods used to obtain information on the energy content of CME in general.

5. A Numerical Model of CME Initiation and Shock Development

Illia Roussev

A Numerical Model of CME Initiation and Shock Development for the 1998 May 2 Event: Implications for the Acceleration of GeV Protons.

6. Heliospheric simulations of selected SHINE events

Dusan Odstrcil

Heliospheric simulations of selected SHINE events 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 geometrical and kinematic fitting of coronagraph observations of CMEs. Results show evolution of interplanetary shocks and connectivity of magnetic field lines. Attention is given to May 12-15, 1997 interplanetary event and to effects of evolving ambient solar wind.

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

Zoran Mikic

TBA

8. 3D Breakout

Ben Lynch, Univ. of Michigan / Naval Research Lab

We present preliminary results of the breakout model for solar coronal mass ejections in 3D. The multi-polar flux system now has finite azimuthal extent. We plan on demonstrating a fully 3D breakout eruption. Observational implications are discussed.

9. Non-Axisymmetric and Multi-tube Magnetic Flux Ropes in the Solar Wind

Qiang Hu, Charles Smith, Norman Ness, and Ruth Skoug

We will present a review of the Grad-Shafranov (GS) reconstruction technique and its applications to the interplanetary magnetic flux ropes at 1 AU. These structures were identified from magnetic field measurements by primarily looking for signatures of smooth rotation of magnetic field direction. Magnetic clouds constitute a subset of them, and they generally belong to ICMEs. The GS reconstruction technique is capable of generating a 2 1/2 D cross section of a cylindrical flux rope objectively and self-consistently from in-situ spacecraft data. Results from Wind and a survey of ACE data in the years 1998-2002 will be reported. They show the pronounced non-axisymmetry of single cylindrical flux ropes. Some exhibit more complexity with multiple single flux ropes embedded within one boundary. This analysis will aid in the interpretation of data, numerical modeling, the propagation and interaction of CMEs, and their solar sources.

10. Combining remote and in situ observations of CME ejecta

Alysha Reinard, NRL/Artep

We describe a study of the compositional properties of heliospheric CME ejecta within the context of solar CME observations. In this study, we first examine CME-ICME pairs to determine if a given CME is associated with a flare or a prominence event. For each of these pairs the charge state ratios are averaged over the event and compared. We find that events originating near the central meridian are more likely to contain significantly higher charge state ratios. In those events that are associated with prominences we find that both oxygen and iron charge states increase with X-ray flare magnitude.

11. Geospace effects of the impact of flux ropes.

Charles Goodrich

TBA

12. ICME Models

Tamitha Mulligan

Interplanetary Coronal Mass Ejection (ICME) models have remained virtually unchanged for over a decade. They do not sufficiently address expansion and evolution or explore the possibility of non-symmetric flux rope geometries. We develop a new model consistent with both in situ observations of ICMEs and solar models of CMEs. Using this model we invert multi-spacecraft observations of ICMEs and more clearly reveal their three-dimensional structure and evolution in the solar wind. We determine that existing models incorrectly describe how ICMEs are topologically connected to the Sun. Fitting flux ropes to ICME observations reveals that the leading field directions of the ropes correspond to the global polar field direction of the Sun while the axial field lies in the plane of the heliospheric current sheet. This result allows us to predict the long-term variations in the magnetic field signature of ICMEs and is consistent with observations of CMEs originating in the coronal streamer belt.

13. Shock Geometry, Seed Populations, and the Origin of Variable Elemental Composition at High Energies in Large Gradual Solar Particle Events

A.J. Tylka, Martin A. Lee, E.O. Hulburt Center for Space Research Space Science Center and Institute for the Study of Earth, Oceans, and Space, University of New Hampshire

Minor ions are powerful probes of the acceleration and transport processes involved in large, gradual solar energetic particle (SEP) events. As highlighted in the SHINE campaign events of 2002 April 21 and 2002 August 24, the Fe/O ratio in these events sometimes exhibits very dramatic energy-dependent behavior. This energy dependence reflects, of course, differences in the energy spectra of these two species. It has recently been proposed that this behavior arises from the interplay of two factors – shock geometry and a compound seed population, typically comprising both solar-wind and flare suprathermals. We will briefly review the observational results that motivate this

hypothesis. We will also report on recent heuristic modeling efforts that capture the essential features of the hypothesis. The results of these simplified calculations suggest that the hypothesis might indeed account for the observed spectral and compositional variability, including a harder power-law spectrum for Fe than for O and the resulting increase in Fe/O with energy that is seen in some events.

14. Spectral Properties of Heavy Ions Associated With the Passage of Interplanetary Shocks Near 1 AU

Mihir Desai, University of Maryland

We have surveyed the energy spectra of ~ 0.1 -100 MeV/n. C, O, and Fe nuclei associated with the passage of 72 interplanetary (IP) shocks observed on board the ACE spacecraft during the period 1997 October – 2002 October. Our main results are: (1) The spectral fit parameters are independent of the local shock properties. (2) About $\sim 7\%$ of the events exhibit increasing Fe/O ratios with energy; the remaining events have Fe/O ratios that either remain constant or decrease with energy. (3) The Fe/O ratio in the shock associated particles is typically $\sim 30\%$ lower than in the ambient population. (4) The fractionation pattern of the elemental abundances, the O spectra, and the energy-dependence of Fe/O at the IP shocks are remarkably similar to those of the ambient interplanetary suprathermal ion population. Our results are inconsistent with acceleration models where the IP shocks inject stable mono-energetic seed populations of thermal or suprathermal solar wind ions. Instead, we suggest that the IP shocks studied here re-accelerate energetic particle seed spectra composed of ions from impulsive and gradual SEP events by a systematic rigidity-dependent mechanism in which higher rigidity ions are accelerated less efficiently than lower rigidity ions.

15. Modeling SEP acceleration at CME driven shocks: toward a realistic CME

J. Kota, W.B. Manchester, J.R. Jokipii, D.L. De Zeeuw, T.I. Gombosi

We report on an effort to model the acceleration and transport of solar energetic particles (SEPs) in the complex scenario of a simulated coronal mass ejection (CME). The present work combines the Arizona SEP code with the CME simulations developed in Michigan. The solar wind and magnetic field data of the Michigan CME-simulation are used as input to the SEP code developed in Arizona. We discuss the structure of the CME-driven shock and its implications on SEP acceleration. We find that acceleration is most effective at the region of perpendicular compression where the magnetic field is bent around the expanding flux rope. Our SEP code solves the Fokker-Planck equation including convection, focusing, adiabatic cooling and acceleration, and pitch angle scattering of charged energetic particles moving along magnetic field lines. The Fokker-Planck equation is first cast in a form that is suitable for incorporating time-dependent magnetic fields. We present simulation results and discuss their physical implications.

16. PARTICLE ACCELERATION AND TRANSPORT AT CME-DRIVEN SHOCKS: A CASE STUDY

Gang Li, IGPP, Univ. of California at Riverside

Gradual solar energetic particle (SEP) events, where particles are often accelerated to 10's of MeV energies, are associated with CME-driven shocks. As a CME-driven shock propagates, expands and weakens, particles are accelerated diffusively at the shock. A small number of these particles travel far enough upstream of the shock and escape into the interplanetary medium. These escaping energized particles then propagate along the interplanetary magnetic field (IMF), experiencing only weak scattering from fluctuations in the IMF. The detection of these energetic particles prior to the shock arrival often serves as a precursor for subsequent geomagnetic storms. Although the underlying acceleration mechanism, diffusive shock acceleration, is reasonably well understood theoretically, a comprehensive model that tracks particle acceleration and transport is necessary to interpret observations made by spacecraft such as ACE and WIND. In this paper, we discuss our dynamical model of particle acceleration and transport at a propagating CME-driven shock. The expanding shock is followed numerically using a shell model. The particle spectrum at the shock is decided by explicitly calculating the wave intensity due to streaming protons. The transport of the escaped particles is followed using a Monte-Carlo technique, which yields the predictions of the temporal intensity profile, particle spectra, etc. at 1 AU. We have applied this model to the April 21, 2002 event and find promising agreement between our model simulation and observations. We believe this approach may provide an important step towards understanding the influence of large SEP events in interplanetary and geospace environments.

17. Acceleration by Shocks: The Injection Problem, Shock-Normal Angle, and Time Dependence

Joe Giacalone, University of Arizona

We discuss the physics of particle acceleration by interplanetary shocks from near the Sun to the point of observation at 1 AU. We show that, quite generally, quasi-perpendicular shocks can accelerate low-energy particles as efficiently as quasi-parallel shocks, under certain parameter regimes. One particular example is that in which total power in random magnetic field fluctuations is comparable to the total power in the mean field; and, furthermore, the spectrum of fluctuations is dominated at spatial scales that are much larger than the particle gyroradii. This is the case of the interplanetary magnetic field at 1 AU and there is reason to believe that this is also true nearer the Sun. Recent numerical simulations of particle acceleration by shocks of arbitrary obliquity are presented which demonstrate this. Moreover, quasi-perpendicular shocks accelerate particles much more rapidly than quasi-parallel shocks. This is also important to what is observed at 1 AU and will be discussed in this talk.

18. Chromospheric vs. Photospheric Vector Fields: Striking Similarities and Intriguing Differences

K. D. Leka, CoRA Div., NWRA

Observations of the solar magnetic field have been well developed for the photosphere, where the radiative transfer and observational constraints lead to fairly well-understood diagnostics. However, the reliance upon photospheric field observations for understanding the higher layers of the solar atmosphere, i.e. as the boundary condition for magnetic-field extrapolations and MHD simulations, is compromised by a variety of physical truths: the most significant of these is probably that the solar photosphere is forced, i.e. there are significant non-zero Lorentz forces in the photosphere. The non-force-free nature of the photosphere leads to a contradiction when photospheric magnetic field measurements are used as the boundary condition for force-free extrapolations. One solution to this dilemma may be the use of chromospheric vector field observations so that a force-free extrapolation is derived from a force-free boundary state. In this talk I present very recent results of the differences between photospheric and chromospheric vector magnetic field data obtained with the Imaging Vector Magnetograph at U. Hawai'i Mees Observatory. Specifically, I will address general similarities and differences in the vector field observed at the two atmospheric heights and the differences arising from using the two data sets for magnetic field extrapolations. There will also be a short discussion on the uses of chromospheric data for such disparate subjects as magnetic free energy calculations and azimuthal-ambiguity resolution. With chromospheric vector field data now obtained routinely, the full impact of the diagnostics available must be explored to help improve our understanding of the solar chromosphere and corona.

19. A Data-driven MHD Model of AR-8210

Bill Abbett

Eruptive phenomena in the solar atmosphere are thought to be caused by reconnection processes in complex magnetic structures. Therefore, the complexity of the magnetic field should be closely related to the eruption activity. We use a statistical approach to determine the measure of complexity of the line-of-sight magnetic field in active regions of different level of flare activity. We then compare the time variations of our statistical parameters with timing and parameters of flares and associated CMEs. We will show that the measure of complexity correlates with the speed of the CME and the X-ray class of the flare.

20. Initial Measurements from the Coronal Multi- Channel Polarimeter

Steve Tomczyk

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 FeXIII at 1074.7 and 1079.8 nm as well as the chromospheric HeI 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.

21. Infrared Zeeman Coronal Magnetic Field Measurements

Haosheng Lin

A critical problem for understanding the solar corona has been to measure its magnetic field that we believe determines its structure and dynamics from the upper chromosphere out into the heliospheric environment. The direct measurement of this field has been a longstanding problem. Only recently have Zeeman splitting observations of infrared coronal emission lines (Lin et al. 2000) been used to deduce the coronal magnetic flux density. We have extended this technique and report here our first results from a novel coronal magnetometer that uses an off-axis reflecting coronagraph (SOLARC) and optical fiber-bundle imaging spectropolarimeter (OFIS). Our results reveal the line-of-sight magnetic flux density with a sensitivity of a few gauss with 20 arcsec spatial resolution and approximately 60min temporal resolution. These full Stokes spectropolarimetric data of the forbidden FeXIII emission line at 1075nm imply a line-of-sight coronal magnetic field above an active region with a flux density of 9G. Although these first results from SOLARC/OFIS have relatively coarse resolution, they have potential for solving our coronal "dark energy" problem with infrared magnetometry.

22. The Low-Speed Solar Wind

Marcia Neugebauer

The compositional and dynamic properties of the slow solar wind are distinctly different from those of the fast or the transient winds. This paper reviews those differences and their implications for the solar sources of the wind, the acceleration mechanisms, and interplanetary dynamics.

23. Abundances, temperatures, and outflow speeds in coronal streamers

John Raymond

TBA

24. What have we learned from solar observations about the source of the slow speed solar wind

Uri Feldman

TBA

25. Abundances of Heavy and Ultra-Heavy Ions in 3He-rich Solar Flares

Glenn M. Mason¹, J. E. Mazur², J. D. Dwyer³, J. R. Jokipii⁴, R. E. Gold⁵, and S. M. Krimigis⁵, Department of Physics and I.P.S.T., Univ. of Maryland, The Aerospace Corp., Los Angeles, Department of Physics & Space Science, Florida Institute of Technology, Melbourne, Department of Lunar & Planetary Science, Univ. of Arizona
Johns Hopkins Univ/Applied Physics Lab, Laurel, Maryland

We have surveyed 3He-rich solar energetic particle (SEP) events over the period September 1997 to April 2003 in order to characterize abundances of heavy ions near 400 keV/nuc. The first part of the study focused on 20 distinct SEP events that showed the previously observed pattern where relative to O, heavy ions through Fe are enriched with the enrichment increasing with mass. We find that these enrichments are well correlated such that 3He-rich SEP events with high Fe/C also show larger enrichments in other heavy ions. Ultra-Heavy (UH, taken as 78-220 amu) ions are routinely seen in these events with abundance enhancements correlating with Fe/C but with even larger flare-to-flare variations. In one event with unusually little interplanetary scattering, we were able to estimate the time of heavy and UH ion injections at the Sun and they were found to be simultaneous. The second part of the study summed up many impulsive event time periods in order to construct a mass histogram of UH nuclei; this histogram showed broad mass peaks similar to those in compilations of solar system abundances. In this summed period, relative to O, the average enhancement of heavy nuclei increases with mass with values of ~ 7 for Fe, ~ 40 for mass 78-100 amu, ~ 120 for mass 125-150 amu, and ~ 215 for 180-220 amu. The maximum UH enhancements seen in the most enriched events are at least a factor of 5 larger. The enhancements are approximately proportional to the particle mass-to-charge ratio raised to a power, as seen previously in large shock-associated solar energetic particle events.

26. Heavy-element abundances in solar energetic particle events

D.V Reames, NASA/GSFC

We survey the relative abundances of elements with $1 \leq Z \leq 82$ in solar energetic particle (SEP) events observed at 2-10 MeV amu⁻¹ during nearly 9 years aboard the Wind spacecraft, with special emphasis on enhanced abundances of elements with $Z \geq 34$. Abundances of Fe/O again show a bimodal distribution with distinct contributions from impulsive and gradual SEP events as seen in earlier solar cycles (Reames 1988). Periods with greatly enhanced abundances of $(50 \leq Z \leq 56)/O$, like those with enhanced ${}^3\text{He}/{}^4\text{He}$, fall prominently in the Fe-rich population of the impulsive SEP events. In a sample of the 39 largest impulsive events, 25 have measurable enhancements in $(50 \leq Z \leq 56)/O$ and $(76 \leq Z \leq 82)/O$, relative to coronal values, ranging from ~ 100 to 10,000. By contrast, in a sample of 45 large gradual events the corresponding enhancements vary from ~ 0.2 to 20. However, the magnitude of the heavy-element enhancements in impulsive events is less striking than their strong correlation with the Fe spectral index and flare size, with the largest enhancements occurring in flares with the steepest Fe spectra, the smallest Fe

fluence, and the lowest X-ray intensity. Thus it seems that small events with low energy input can produce only steep spectra of the dominant species but accelerate rare heavy elements with great efficiency, probably by selective absorption of resonant waves in the flare plasma. With increased energy input, enhancements diminish, as heavy ions are depleted, and spectra of the dominant species harden.

27. Interacting Coronal Mass Ejections and the Release of Solar Energetic Particles

Sām Krucker, Space Science Lab, UC Berkeley

Gopalswamy et al. (2001) reported that interacting Coronal Mass Ejections (CME) are producing radio signatures in interplanetary space. Furthermore, they also reported that Solar Energetic Particles (SEP) events are very often associated with interacting CMEs. How are SEP events associated with interacting CMEs? Are SEPs produced by the interaction of the CMEs, or are the SEPs accelerated independently of the interaction? This poster investigates these questions by analyzing the timing of WIND/3DP electron (1keV-1MeV) and proton (<6MeV) observations and compare it with the timing of the CME and the associated radio emissions as observed by SoHO/LASCO and WIND/WAVES.

28. Enhancement of ^3He Abundance in Solar Energetic Particle Spectra by Stochastic Acceleration

Vahe Petrosian, Stanford University, Varian Physics Bldg.

Stochastic acceleration by plasma turbulence or waves has proven very successful in describing many radiative signatures of accelerated electrons and protons. Abundance ratios of many ions in the observed spectra of solar energetic particle (SEP) events also point to a stochastic mechanism for acceleration of these particles as well. Some detail analyses have shown quantitative agreement of such models with the observed spectra of some SEP ions, except for some heavy ions and for ^3He , which shows a varied and sometimes dramatic enhancement compared to photospheric values. We have shown that under certain conditions stochastic acceleration model can explain these large overabundances seen in some SEPs and the relative spectra of ^3He and ^4He . The details of this model will be presented and its merits and shortcomings will be discussed.

29. Diffusive Compression Acceleration: Spectra and Composition

Randy Jokipii

The mechanism of the acceleration of particles by compressions instead of shocks has proven useful in understanding otherwise puzzling observations of energetic particles in association with CIR's near the Earth. The mechanism may occur elsewhere where shocks are not present and may help explain other observations as well. I will discuss the physical foundations of the mechanism, show how it may explain observations. In

particular, the effects of the mechanism on the spectrum and composition of accelerated particles will be examined and compared with observations.

30. Stochastic Acceleration via Novel Wave-Particle Interactions

Jim Miller

Normal stochastic acceleration occurs when primary resonances corresponding to a specific harmonic number ℓ but different waves overlap. Such overlap leads to global stochasticity, and particles may reach high energies in short time intervals. The maximum energy in this case depends on the maximum or minimum wave frequency (depending on the specifics of the waves) present in the spectrum. This version of stochastic acceleration has been shown to be quite successful in impulsive solar flares, where it can account not only for energetic ion and electron fluxes but for ion abundance enhancements and spectra as well. We now consider two different versions of stochastic acceleration, which still rely on the same basic wave-particle resonance as before: (1) Arnold diffusion, which is a general property of multiple-wave systems, does not require resonance overlap, takes place in a direction (in phase space) normal to that of resonance-overlap acceleration, and enables the particles to reach much higher energies; and (2) resonance overlap of multiple- ℓ resonances in the same wave, which actually leads to unlimited energy gain. We will discuss the implications of these mechanisms for flare particles.

Session Invited Talks

Wednesday

31. The origin of the slow solar wind

L. Ofman (CUA/NASA GSFC)

The slow solar wind has been associated with equatorial solar regions for some time, and it is dramatically different from the fast wind, as evident by Ulysses and ACE observations. The difference manifests itself not only in the average flow speed, but also, in the density, temperature, variability, and composition of the solar wind plasma. These differences lead to the assumption that the acceleration and heating mechanisms of the slow wind are fundamentally different from the ones that produce the fast wind. However, the exact mechanism of the slow solar wind acceleration and heating, the origin of the variability, and the compositional variation are still being debated. The combination of new observations and numerical modeling begin to address some of the questions. I will discuss how recent in-situ observations by Ulysses, ACE, white light and EUV observations by the LASCO and UVCS instruments on SOHO advanced our understanding of the slow solar wind. I will briefly review the current state of numerical MHD modeling of the slow wind, and the possible mechanisms that may produce it. I

will present the results of recent multi-fluid model of the slow solar wind in coronal streamers that addresses some aspect of its variability, and composition.

32. Formation and acceleration of the slow solar wind

Russell B. Dahlburg, Code 6440

I will describe progress on our model for the formation and acceleration of the slow solar wind. The model is based on the dynamical behavior of a plane fluid wake flowing in a current sheet. The results are applied to the study of the formation and acceleration of plasma 'blobs' observed by the LASCO instrument onboard the SOHO spacecraft. The results of the computations are in good agreement with LASCO observations.

33. The Fast Solar Wind Then and Now

Joe Hollweg, UNH

Before the discovery of the fast solar wind in the mid - 1970s, it was known that even the average solar wind could not be well explained by models in which electron heat conduction was the energy source and the electron pressure gradient was the principal accelerating force. The Alfvén waves discovered around 1970 were thought for a while to provide the sought - after additional energy and momentum, but their wave pressure ultimately failed to explain the rapid acceleration of the fast wind close to the Sun. By the late 1970s, various in situ data were suggesting that protons and heavy ions were being heated and accelerated by the ion - cyclotron resonance far from the Sun. This notion was soon applied to the acceleration region in coronal holes close to the Sun. The models which resulted suggested that the fast wind could be driven mainly by the proton pressure gradient (which is mainly the mirror force if the anisotropy is large), and that the high temperatures and flow speeds of heavy ions could originate within a few solar radii of the coronal base; these models also emphasized the importance of treating the extended coronal heating and solar wind acceleration on an equal footing. By the mid 1990s, SOHO, especially the UVCS (Ultraviolet Coronagraph Spectrometer), provided remarkable data which have given great impetus to studies of the ion cyclotron resonance as the principal mechanism for heating the plasma in coronal holes, and ultimately driving the fast wind. We will discuss the basic ideas behind current research, emphasizing the particle kinetics. We will discuss remaining problems such as the source of the ion - cyclotron resonant waves (direct launching, turbulence, microinstabilities), the roles of inward - propagating waves and instabilities, the importance of oblique propagation, and the electron heating. Some alternatives will also be mentioned.

34. Predictions of the Breakout Model for Interplanetary Observations

Spiro K. Antiochos, NRL

In the breakout model, magnetic reconnection external to the sheared/twisted field of a filament channel is responsible for initiating a coronal mass ejection. Therefore, the field in the corona must be multipolar, and in principle, reconnection below the filament

channel is not required for eruption. We will discuss the implications of these features of the model for plasma and magnetic observations at 1AU. In theory, an ICME produced via the breakout scenario need not be a flux rope, but in fact, all our simulations, to date, have produced a clearly-defined magnetic flux rope by 30 solar radii. We discuss possible mechanisms for producing non-flux rope ICMEs.

35 . Magnetic Flux Ropes from the Sun to 1 AU

Jonathan Krall

Any model that is intended to describe coronal mass ejection (CME) and magnetic cloud phenomena in the heliosphere must conform to available observational constraints from sun and to 1 AU. Recent theory data comparisons near the sun (Chen et al., 1997, 2000; Krall et al., 2001; Chen and Krall, 2003) and in the heliosphere (Krall et al., 2000) have shown that the flux rope model of Chen (1996) provides a physics-based characterization of flux-rope CMEs and subsequent magnetic clouds over this range. This talk will address latest code developments, specific model "deliverables" and how these can be quantitatively compared to observations, and the implications of our results for upcoming missions, such as STEREO.

36. A Generalized Flux Rope Fitting Technique Incorporating kinematic distortion effects

Pete Riley, SAIC

Flux rope fitting techniques are an invaluable tool for inferring information about the properties of a sub-class of interplanetary CMEs, known as magnetic clouds. In this poster we discuss the basic features and limitations of several of these methods. Guided by global MHD simulations as well as simple kinematic arguments, we propose a generalization to these techniques that incorporates the basic distortion of the ejecta. Specifically, we include the effects of: (1) spherical expansion; and (2) uniform expansion due to pressure gradients between the ejecta and the ambient solar wind. Using both real and simulated in situ observations of magnetic clouds, we assess to what extent this new method provides a more accurate determination of the flux rope parameters, including: orientation, impact parameter, width (both radial and transverse), and sign of helicity.

37. Signatures of CME propagation near 1 AU

Iliia Roussev, CSEM, University of Michigan

We present a three-dimensional (3D) numerical ideal magnetohydrodynamics (MHD) model describing the time-dependent propagation of a CME from the solar corona to 1 AU from which predict features that should be observed near Earth. We begin by developing a global steady-state model of the corona that possesses high-latitude coronal holes and a helmet streamer structure with a current sheet at the equator. The Archimedian spiral topology of the interplanetary magnetic field is reproduced along with fast and slow speed solar wind. Within this model system, we drive a CME to erupt

by the introduction of a Gibson-Low magnetic flux rope that is embedded in the helmet streamer in an initial state of force imbalance. Physics based AMR allows us to capture the structure of the CME focused on a particular Sun-Earth line with high spatial resolution given to the bow shock ahead of the flux rope as well as to the current sheet behind. We will discuss many features that our model predicts at 1 AU such as the spatial extent and Mach number of the shock, shock accelerated SEPs, and also the magnetic and density structure of the magnetic cloud and surrounding solar wind.

38. EFFECTIVE DRIFT VELOCITY AND INITIATION TIMES OF INTERPLANETARY TYPE-III RADIO BURSTS

Dennis Haggerty, JHUAPL

We derive an “effective drift velocity” (EDV) from dynamic WIND/WAVES spectrograms of interplanetary type-III fast-drift radio bursts associated with 171 near-relativistic electron events observed at 1 AU during the past 6 year (1997-2003). The EDV should be regarded as a phenomenological parameter that characterizes the burst drift rate. A frequency-time contour at a constant observed intensity is a sample of emission from an irregular volume within which the extended exciter region encounters plasma frequency corresponding to the observing frequency. Therefore the contour of the spectrogram that defines the “leading edge” of the emission is produced by the earliest exciter electrons to reach regions with that particular plasma frequency in sufficient numbers to produce type-III emission measurable at the WIND spacecraft. The “leading edge” is established by a best fit of multiple time-frequency points obtained from different frequency cuts. The onset point for each given frequency is determined when the intensity curve rises above background. The same analysis technique also yields an estimate of the time at which the interplanetary type-III radio burst was initiated in the low corona. In this sense, the EDV and initiation times derived from the “leading edge” of the type-III bursts is a useful phenomenological parameter for the characterization of burst propagation. It is certainly a more robust a parameter than the ill-defined “transit time”, when a contour of the emission pattern reaches the local plasma frequency. We examine the EDVs and initiation times with respect to the delayed injection of near-relativistic electrons, measured at ACE, to determine whether the EDVs are correlated with the observed delays.

39. Solar Origin of the Radio Characteristics of a Complex Type III Burst Observed on April 11, 2001

M. J. Reiner, K.-L. Klein, M. Karlicky, A. Klassen, M. L. Kaiser, J.-L. Bougeret Catholic U and GSFC

We report here on the solar origin of the unusual radiation characteristics observed for a complex decametric type III solar radio burst that was associated with a major solar flare and CME on April 11, 2001. The associated decimeter (Ondrejov) and meter (Potsdam) wavelength spectral radio emissions indicate that there were two different populations of electrons accelerated during this solar eruptive event. The Nancay radioheliograph images and additional evidence of plasmoid propagation suggest that the secondary electron acceleration event resulted from coronal reconfigurations probably due to the

erupting CME. These observations provide new insights into the origin of the unusual characteristics of complex type III-like radio emissions that are typically observed at decameter wavelengths during major solar eruptive events.

40. Correlated Dispersionless Modulations in Suprathermal Electron and Impulsive Energetic Ion Events in the Solar Wind

Jack Gosling, Los Alamos National Laboratory

Large dispersionless modulations in particle intensity observed in impulsive solar energetic ion events have been interpreted in terms of spatially limited source regions and magnetic field line foot point motions during the 2-4 days it takes solar wind plasma and the embedded heliospheric magnetic field to travel from the Sun to 1 AU. Similar dispersionless modulations in particle intensity are observed within some low-energy (less than 1.4 keV) solar electron bursts at 1 AU. The latter commonly occur in direct association with discontinuous changes in the intensity of the solar wind electron strahl and can also largely be explained in terms of spatially limited burst source regions and magnetic field line foot point motions in the solar atmosphere. Concentrating on impulsive ion modulation events previously reported, we show that there is a close connection between dispersionless modulations in energetic ions and dispersionless modulations in low-energy solar electron bursts and in the electron strahl. This demonstrates that dispersionless modulations in both particle species have a common cause and generally occur on the same field lines. However, we find that a subset of the more dramatic ion modulations reported, which have corresponding dramatic changes in suprathermal electrons, appear to be more closely related to structural boundaries in the solar wind flow than to field line foot point motions.

41. Spaceship Earth Observations of the 24 August 2002 Event

Paul Evenson

The 24 August 2002 SHINE campaign event was observed as a small (five percent or less) ground level enhancement by several of the Spaceship Earth neutron monitor stations. This event was much smaller than any other analyzed to date, so our typical approach is hampered by statistical errors. Nevertheless, since this is a SHINE campaign event, we present our best estimates as to particle acceleration timing and other propagation parameters. John Bieber and others will be co-authors.

42. Identification of Solar Sources for Energetic Electron Events

Nariaki Nitta , Lockheed Martin Solar and Astrophysics Laboratory

Impulsive SEP events (also known as 3He-rich flares) are known to be associated with 2-100 keV impulsive electron events and kilometric type III bursts. Impulsive solar flares at well-connected longitudes are often said to be responsible for these SEP events. In reality, however, identification of the solar source is not easy because the X-ray brightening seen around the time of the type III burst is often very small, as we give some examples. In this talk, we will show Yohkoh and TRACE observations of the solar

sources tentatively identified for a few electron events observed by Wind/3DP, and discuss how simple magnetic field extrapolation may help us understand the origin of impulsive electron or ion events.

Session Invited Talks

Thursday

43. Properties of CME Acceleration in the Low Corona

Jie Zhang

CMEs are well known to propagate at a more or less constant speed in the upper corona, or the field of view of most space-based white-light coronagraphs. However, for the purpose of understanding CME origin, the key issue is to observe CME initiation/acceleration in the low corona. In this presentation, we review the progress made on this issue in the past several years, in particular, the observations provided by LASCO/C1 (1.1 to 3.0 R_{sun}). We show complete kinematic evolution of CMEs, which demonstrates different phases that may correspond to different dynamic processes in the corona. The CME acceleration duration, magnitude and height range will be discussed. A statistics on CME acceleration will be presented. We will also discuss the possible relationship between CMEs and flares.

44. CME/flare energetics and RHESSI observations

H. S. Hudson

Most CMEs at solar maximum have closely-related flares occurring within active regions, and observations make it clear that the main energization of the CME coincides with the flare's impulsive phase, during which we see many radiative signatures of non-thermal energy release. In this talk I review the basic structures of active regions as inferred mainly from soft X-ray and EUV data, including a discussion of the differences between the states before and after the disruption, and of the dynamics of the eruption as seen in the stable parts of the region. The new observations from RHESSI are now giving us a better view of the radiative signatures at high temperatures and in the hard X-ray and gamma-ray bands. I will discuss how these results fit in with our current ideas of CME energetics

45. Filament Evolution in CMEs and Implications for ICMEs

Nancy Crooker, R. M. Suleiman, and J. C. Raymond

In the classic three part structure of CMEs, the bright core is usually associated with the filament, but this association raises unsettled issues about filament structure, flux rope formation, and signatures of filaments in the solar wind. What is assumed to be solar wind evidence of cool filament material from the chromosphere, for example, the presence of He⁺, is only rarely found in ICMEs, yet bright cores are common phenomena and can be a substantial fraction of the volume of a CME. The CME observed by LASCO

and UVCS on 12 September 2000 is a good example and suggests the possibility that filament material can gain access to the larger CME volume through reconnection. As its bright core of this CME expanded, it became clear that it resided on tightly coiled field lines, a configuration considered by some to be uncharacteristic of filament field lines. These coiled fields may have formed through partial disconnection as part of the CME process, evidenced in an accompanying X-ray arcade event. Thus the filament may have lost both its magnetic coherence and the imprint of its origin. Still puzzling, however, are the UVCS observations that indicate cool plasma in the expanding coil. Exactly how cool and what compositional and charge-state characteristics solar wind instruments might measure will be one of the topics open for discussion.

46. The AR-ICME Topology Connection

Richard Canfield

A distinctive characteristic of interplanetary magnetic clouds is their rope-like magnetic structure, i.e. their smoothly-varying helical field lines whose pitch increases from their core to their boundary. Because this regular structure helps to make MCs particularly geo-effective, it is important to understand how it arises. Many MCs are associated with solar filament eruptions, and their magnetic field properties follow rather predictably from those of the associated filament and the large-scale solar dipole. However, a comparable number of MCs are associated with the eruption of solar active regions, particularly sigmoids. These do not show the same solar--terrestrial correlations as those associated with filaments. For example, I am unaware of any model of the magnetic fields of sigmoids and their eruption that gives a demonstrably reliable prediction of the leading field orientation of their associated MC.

I will discuss recent work which relates the magnetic and topological parameters of MCs to associated solar active regions. This work strongly supports the notion that MCs associated with active region eruptions are formed by magnetic reconnection between these regions and their larger-scale surroundings, rather than simple eruption or entrainment of pre-existing structures in the corona or chromosphere. However, it also opens up interesting questions regarding the interpretation of both solar and interplanetary data. I will attempt to identify at least some of these questions and the work that has been done to address them up to the present time.

47. Compositional Signatures of ICMEs

Thomas Zurbuchen and Susan Lepri

The solar wind composition is routinely measured by the Solar Wind Ion Composition Spectrometer (SWICS) on ACE and Ulysses. We now recognize that there are compositional signatures in most ICMEs that clearly distinguish ICME associated plasma from solar wind. We will briefly review recent work providing the experimental evidence. We will then discuss the connection between ICME associated plasma and solar flares. We will also discuss discrepancies of ICME boundaries identified by compositional signatures and suprathermal electron signatures.

48. Solar Origins of the Extreme Events

Nat Gopalswamy, NASA/GSFC, Greenbelt, MD 20771, USA

Extreme events, when compared to other events in their class, are profoundly unique either in their origin or in their consequences. For extreme solar energetic particle (SEP) events, the properties of the active region or the solar eruptions (flares and coronal mass ejections) could be considered as part of the origin. The intensity of the ensuing SEP event or the strength of the geomagnetic storm could be considered as consequences. The October-November 2003 CMEs accompanied by X-class flares fit with this definition of extreme events in terms of their origin as well as their impact. We compare the statistical properties of these extreme CMEs with those of the general population of CMEs observed during cycle 23. We also compare them with other extreme events reported in the literature.

49. An Overview of SEPs During the October-November 2003 Storms

C.M.S. Cohen, R.A. Mewaldt, G. M. Mason, M.I. Desai, A.C. Cummings,
R.A. Leske, E.C. Stone, T.T. von Rosenvinge, M.E. Wiedenbeck

The October-November 2003 solar energetic particle (SEP) events were some of the largest in solar cycle 23. Measurements of the heavy ion composition and spectra were made throughout the events from energies of 0.1 to 100 MeV/nucleon by the Solar Isotope Spectrometer and the Ultra Low Energy Isotope Spectrometer on ACE, yielding valuable information regarding the energy and time dependence of the composition. We will present these measurements and compare them to similar ones made in other large SEP events from this cycle, such as the Bastille Day event and the April 2002 storms period. In addition, we will examine characteristics of the locally accelerated energetic particles (e.g., the maximum energy and flux increase) at the time of the shock passage for these and other big events.

50. New Radiation Belts and Other Effects of Cycle 23 SEP Events

Joe Mazur, The Aerospace Corporation

A wide range of instrumentation on spacecraft such as SAMPEX, Polar, and HEO vehicles has been sampling the diverse trapped and transient particle populations in the Earth's magnetosphere during solar cycle 23. We will discuss the observational facts of the intriguing phenomenon of the creation of new radiation belts near L-shells of 2-3 during intense SEP events and CME-related shocks. This particular form of geospace impact had been glimpsed with shorter-lived missions decades ago, although its association with shocks and SEP events was not as clear as it is today. We will discuss the late 2003 and the SHINE campaign events in this context, and will also touch upon some of the documented impacts of the most intense cycle 23 events on space systems.

51. Observations and Historical Context of the late October 2003 Geoeffective Halo CMEs

David Webb, Institute of Space Research, Boston College and AFRL/VSBXS

Eleven major (X-class) flares with accompanying coronal mass ejections (CMEs) occurred over the 2-week period in late October and early November. These were part of a series of major events centered around 3 huge sunspot groups. The largest geoeffective event occurred on Oct. 28, had the third highest peak X-ray flux (X17) ever recorded, and was followed by another energetic event (X10) on Oct. 29. . The largest ever recorded, an X28 flare, occurred on Nov. 4 when the source region was at the west limb and not Earth-directed. At least 3 of the CMEs from this activity were Earth-directed ("halos"), erupting when the sunspot regions were near Sun center, and caused geomagnetic storms. The strongest storms occurred on Oct. 28-30 yielding peak Dst values of -308 and -347 (preliminary), resp. The 28 and 29 October events were associated with large particle events at Earth peaking on 29 October. The peak flux of the first, larger particle event was similar to that of the Bastille Day event, 14 July 2000, a similar Sun-centered halo CME and, thus, is tied for the second highest peak flux among particle events in this solar cycle. The fast shock waves driven by the CMEs from the 28 and 29 October events arrived at Earth only 19 hours after their flares, and are among the fastest events ever observed. The two intense geomagnetic storms were among the 14 strongest storms dating back to 1932. These caused a host of satellite, aircraft and ground-based anomalies, FAA issuance of the first-ever alert for airplane passengers of high radiation doses, and a power system failure in Sweden.

The earliest halo CME was launched on Oct. 22 and was associated with M-class flares and at least two erupting filaments. It produced only minor storminess at Earth because its magnetic field was mostly northward. The Air Force Solar Mass Ejection Imager (SMEI) on the Coriolissatellite captured images of two of the 3 halo CMEs, on Oct. 23 and 29. These results are compared with SOHO LASCO coronagraph and EIT observations of the events. SMEI observed these halo CMEs starting at angular distances of 28 and 21 deg. from the Sun, or about 1/3 of the way from the Sun to Earth. We compare the SMEI observations with SOHO LASCO coronagraph and EIT observations near the Sun and Interplanetary Scintillation (IPS) and Wind/WAVES radio emission observations of the events to study their structure and kinematics.

52. Extreme events impact on geospace from a modeler's perspective

Frank Toffoletto

I describe the various ways extreme events can impact the near-Earth space environment from the perspective of a modeler. One well-known measure of geoeffectiveness is the Dst index, which is roughly a measure of the average perturbation of the southward component of the magnetic field at the Earth's surface. However, with the maturity of large-scale models in recent years it has become apparent that the Dst index is an overly simplistic representation of a richly complex and dynamical system. I will attempt to address the question of geoeffectiveness from the perspective of large-scale modeling using examples, both from large-scale simulations and from regional modeling such as the

inner magnetospheric and ionospheric models, to illustrate how other regions of the geospace environment are influenced by extreme events. I will finish with an outline of what needs to be done in order for further progress to be made.

53. CME Eruption Onset Observations from EIT and SXT

Alphonse Sterling

Why CMEs erupt is a major outstanding puzzle of solar physics. Signatures observable at the earliest stages of eruption onset may hold precious clues about the onset mechanism. We present observations in EUV from SOHO/EIT and in soft X-rays from Yohkoh/SXT of the pre-eruption and eruption phases of CME expulsion, along with the eruption's magnetic setting found from SOHO/MDI magnetograms. Most of our events involve clearly-observable filament eruptions and multiple neutral lines, and we use the magnetic settings and motions of the filaments to help infer the geometry and behavior of the associated erupting magnetic fields. Pre-eruption and early-eruption signatures include a relatively slow filament rise prior to eruption, and intensity "dimming" and brightenings, both in the immediate neighborhood of the "core" (location of greatest magnetic shear) of the erupting fields and at locations remote from the core. These signatures and their relative timings place observational constraints on eruption mechanisms; our recent work has focused on implications for the so-called "tether cutting" and "breakout" models, but the same observational constraints are applicable to any model.

54. Dimmings and Related X-ray Structures Following CME Onset

T.G. Forbes, University of New Hampshire

Dimming of the corona following the onset of a CME is likely to result from two different effects. The first is a relatively weak dimming which results from the rarefaction wave that develops behind the outward propagating wave (or shock) generated by the CME. The second is the a relative strong dimming which results from the loss of the coronal matter ejected by the CME itself. The areas of strong dimming constitute the transient coronal holes where field lines have become highly extended (i.e. opened). Rough predictions of the degree of dimming at any one time can be obtained by assuming that mass is conserved and distributed uniformly along the field lines as they evolve. With such an assumption one finds that the dimming within the transient holes can be discontinuous if the topology of the field prior to eruption has discontinuities in it, in other words, if it contains separatrix surfaces. Models of CMEs which incorporate magnetic flux ropes typically have a separatrix surface which separates field lines within the flux rope from those which overlie it. Several researchers have proposed that slow reconnection at this surface prior to eruption can account for the X-ray sigmoid structures associated with some CMEs. If this is so, then there should be a close correlation between the location of the sigmoid and the region of strongest dimming.

55. Non-Axisymmetric and Multi-tube Magnetic Flux Ropes in the Solar Wind

Qiang Hu, Charles Smith, Norman Ness, and Ruth Skoug

We will present a review of the Grad-Shafranov (GS) reconstruction technique and its applications to the interplanetary magnetic flux ropes at 1 AU. These structures were identified from magnetic field measurements by primarily looking for signatures of smooth rotation of magnetic field direction. Magnetic clouds constitute a subset of them, and they generally belong to ICMEs. The GS reconstruction technique is capable of generating a 2 1/2 D cross section of a cylindrical flux rope objectively and self-consistently from in-situ spacecraft data. Results from Wind and a survey of ACE data in the years 1998-2002 will be reported. They show the pronounced non-axisymmetry of single cylindrical flux ropes. Some exhibit more complexity with multiple single flux ropes embedded within one boundary. This analysis will aid in the interpretation of data, numerical modeling, the propagation and interaction of CMEs, and their solar sources.

56. Evolutionary Signatures in Complex Ejecta and Their Driven Shocks

Charlie Farrugia and Daniel Berdichevsky

We examine interplanetary signatures of ejecta-ejecta interactions. To this end, two time intervals of inner-heliospheric (≤ 1 AU) observations separated by 2 solar cycles are chosen where ejecta/magnetic clouds are in the process of interacting to form complex ejecta. At the Sun, both intervals are characterized by many coronal mass ejections (CMEs) and flares. In each case, a complement of observations from various instruments on two spacecraft are examined in order to bring out the *in situ* signatures of ejecta-ejecta interactions and their relation to solar observations. In the first interval (April 1979), data are shown from Helios 2 and ISEE 3, separated by ~ 0.33 AU in radial distance and 28° in heliographic longitude. In the second interval (March-April 2001), data from the SOHO and Wind probes are combined, relating effects at the Sun and their manifestations at 1 AU on one of Wind's distant prograde orbits. At ~ 0.67 AU, Helios 2 observes two individual ejecta which have merged by the time they are observed at 1 AU by ISEE 3. In April 2001, on SOHO, two distinct Halo CMEs (H-CMEs) are observed on March 28-29, approaching each other with a relative speed of 500 km s^{-1} within 30 solar radii. At Wind, a complex ejecta structure was observed where the interplanetary manifestations of these two H-CMEs have practically coalesced. In order to isolate signatures of ejecta-ejecta interactions, the two event intervals are compared with expectations for pristine (isolated) ejecta near the last solar minimum, extensive observations on which were given by *Berdichevsky et al.* (2002). The observations from these two event sequences are then intercompared. In both event sequences, coalescence/merging was accompanied by the following signatures: heating of the plasma, acceleration of the leading ejecta and deceleration of the trailing ejecta, compressed field and plasma in the leading ejecta, disappearance of shocks and/or the presence of shocks in the evanescent stage which were originally driven by the trailing ejecta, and the strengthening of shocks driven by the accelerated ejecta. These processes altered interplanetary parameters considerably,

leading to contrasting geoeffects despite broadly similar solar activity. The complex ejecta on March 31, 2001 caused a double - dip ring current enhancement resulting in two great storms (Dst, corrected for the effect of magnetopause currents, ~ -450 nT), while the merger on April 5, 1979 produced only a corrected Dst of ~ -100 nT, mainly due to effects of magnetopause currents.

57. Fitting Flux Ropes to a Global MHD Solution: A Comparison of Techniques

Pete Riley

Flux rope fitting (FRF) techniques are an invaluable tool for extracting information about the properties of a sub-class of CMEs in the solar wind. However, it has proven difficult to assess their accuracy since the underlying global structure of the CME cannot be independently determined from the data. In contrast, large-scale MHD simulations of CME evolution can provide both a global view as well as localized time series at specific points in space. In this study we apply 5 different fitting techniques to 2 hypothetical time series derived from MHD simulation results. Independent teams performed the analysis of the events in "blind tests", for which no information, other than the time series, was provided. From the results, we infer the following: (1) Accuracy decreases markedly with increasingly glancing encounters; (2) Correct identification of the boundaries of the flux rope can be a significant limiter; and (3) Results from techniques that infer global morphology must be viewed with caution. In spite of these limitations, FRF techniques remain a useful tool for describing in situ observations of flux rope CMEs.

58. Sun-Climate Connections on Decadal to Millennial Timescales

Gerard Bond

TBA

59. COSMIC RAY MODULATION AND SEP EVENTS, 850-1950AD

Ken McCracken

Instrumental measurements of the cosmic radiation date from 1933, and satellite data from the 1960s, both being restricted to periods of high solar activity. The cosmogenic be sequestered in polar ice provides a record of the temporal variability of the low energy cosmic radiation (~ 2 GeV), and nitrate in the ice provides a record of the occurrence of high fluence SEP events. Both allow us to extend our study of solar activity beyond the commencement of the sunspot record in 1600. Examination of the ^{10}Be data obtained in the Arctic and Antarctic shows that the cosmic ray intensity is now at one of the lowest levels attained in the past 1150 years. The data show that the modulating effects of the heliospheric magnetic fields were reduced substantially during the Oort solar minimum ($\sim 1050\text{AD}$), during the Spoerer minimum 1420-1530AD, and in the latter half of the Maunder Minimum (1645- 1715). Nevertheless, strong 11 and 22 year periodicities continued throughout both the Spoerer and Maunder Minima, the cosmic ray modulation potential typically varying by 300MV at times of very low sunspot numbers (annual sunspot numbers <1). The persistent modulation of the cosmic radiation shows that there

were substantial heliomagnetic fields throughout these minima, and that they were still under solar control. Using the cosmic ray transport equation, the ^{10}Be data have been inverted to yield the time dependence of the interplanetary magnetic field near Earth since 850AD. This indicates that it may have been as low as 1nT during portions of the Spoerer and Maunder Minima. SEP events produce thin layers of enhanced nitrate concentration in polar ice, and these show that there were >121 SEP events with a 30MeV fluence $>10^9$ /cm²s in the interval 1561-1950. The frequency of occurrence of high fluence SEP events was highest during the last 15 years of the Maunder Minimum, and during the Gleissberg minimum near 1900. These and other data suggest that the observation of large SEP events near Earth is facilitated by low values of the interplanetary magnetic field.

60. The Value of Old Geomagnetic Records toward Space Climatology

Leif Svalgaard, AFRL

That there is a relationship between solar and geomagnetic activity has been recognized since about 1850. After the initial excitement wore off and since progress in understanding the complex relationship was slow, interest waned and the regular measurements of geomagnetic variations were often discontinued or curtailed. The IGY and the ensuing space age provided new impetus to geomagnetic research. Today, our understanding of the complex relations is rapidly improving. We are now in the position of being able to disentangle many of the simultaneously occurring causes and effects. This new knowledge makes it possible to view the older observations in a new light and to extract real physical meaning and parameters from the old records. This talk will demonstrate how to determine the solar wind speed, the strength of the interplanetary magnetic field, and the EUV-flux from geomagnetic observations going back to 1843. The variability of the geomagnetic field on time-scales of a few hours correlates well with BV^2 (B = IMF Total Magnitude, V = Solar wind Speed). We define a simple variability index for a day as the sum of the unsigned differences between successive hourly averages for six hours around local midnight. This sum averaged over a month or longer has a high correlation with BV^2 ($R^2=0.9$ for yearly averages). The index can be defined for any of the geomagnetic field components with essentially the same result. The variability of the geomagnetic field from day to day may be measured as the (monthly or yearly) average of the unsigned differences between nighttime values between successive days. This quantity correlates well with B ($R^2=0.8$ for yearly averages), but has no correlation with V ($R^2=0.0$). Combining the two indices allows us to estimate B and V separately since 1843. Using nighttime hours only greatly diminishes any contamination from the regular daily S_q variation.

The product VB determines the polar cap potential, which can be measured as the amplitude of the diurnal variation of the horizontal components at stations inside the polar cap. The values of VB so produced compare well with the product VB calculated from the separately determined values of V and B . We have data for Thule (Greenland)

back to 1932, Godhavn (Greenland) back to 1926, and for Gjoahavn (Canadian Arctic) 1904-05, and Scott Base (Antarctica) 1902-03, all showing good agreement.

Using the Wolf relationship between sunspot number and daily range of the declination one can reconstruct the sunspot number for periods where it is poorly known. We discuss measurements by Canton (1759-60) and by Gilpin (1786-1805) that allow us to reconstruct and crosscheck the yearly sunspot number during these intervals. Other old data exists (e.g. Hjorter 1740s, Arago 1820s, and data from early observatories [Oslo, Helsinki, Prague,...]) and we should collect these early observations, evaluate, and (possibly) calibrate them in light of our modern understanding.

At times in the past (e.g. around 1901 and 1912) geomagnetic activity was very low. The empirical relationships that we find based upon modern data refer to a period with generally higher activity. It is always dangerous to extrapolate an empirical relationship outside of the range on which it is based (as we - and others) have done in reconstructing B and V for earlier times. To put the empirical relationships on a firmer ground we need modern data for a period of very low activity. There are indications that the coming solar cycle (#24) will be a very low activity cycle ($R_{\max} \sim 70$) comparable to the cycles in the early part of the 20th century. Of so, we should soon have low-activity modern data. The prediction of a low cycle 24 is based on the observed variation of the magnetic field in the polar caps of the sun. We briefly discuss the strength of this prediction. The various time series that can be (and have been) constructed can be intercompared and checked against each other. This includes a re-calibration of the aa-index. We find that the aa-index is too low before 1957 and lower yet before 1925. The discrepancy reaching about 25%. This has implications for studies that use the aa-index as a proxy for solar conditions. We are moving towards a "climatology of solar wind (and thus solar) properties".

**61. Solar system environment effects on cosmic-ray propagation in the heliosphere:
Consequences for cosmogenic isotope production**
Vladimir Florinski, University of California, Riverside

The solar system is traveling through highly inhomogeneous interstellar medium. Our local interstellar environment consists of low density hot regions, evacuated by supernova explosions, and of interstellar clouds of varying density and temperature. During its journey around the center of the Galaxy, the Sun was likely to encounter at least several such clouds and is currently traveling through a warm, relatively tenuous Local Cloud. The properties of the cloud control the size and shape of the heliosphere and, therefore, the amount of modulation experienced by galactic cosmic rays (GCRs) by the time they reach Earth, as they propagate through the irregular magnetic field embedded in the solar wind flow. GCRs produce cosmogenic isotopes in the Earth's atmosphere in spallation reactions, providing an important record of heliospheric and geomagnetic effects in the past. Previously, we showed that increasing the density of the cloud surrounding the solar system by a factor of 30 leads to an increase in 1 AU GCR fluxes by a factor of 1.5-3, and that cloud encounters may have been responsible for the observed peaks in Be-10

records 35 and 60 thousand years ago. Here we present initial results from a more comprehensive investigation of the global structure of the heliosphere embedded in clouds of varying density, from the present conditions in the Local Cloud with $n=0.3 \text{ cm}^{-3}$ to the extreme case of dense molecular clouds with $n=5000 \text{ cm}^{-3}$. We now derive GCR distribution from the solution of the 2D Parker equation using the global magnetic field as a background to determine the diffusion parameters, which is a significant improvement over our earlier model.

POSTER ABSTRACTS

Campaign Events

1. Overview of Recent Results from the Solar MURI Project

George H. Fisher, UC Berkeley

The Solar MURI project, is a DoD funded multi-disciplinary effort to understand the origins of magnetic eruptions on the Sun. This poster will review highlights of research done over the past year.

2. TBA

Dusan Odstreil, CU/CIRES & NOAA/SEC

TBA

3. Comparison of the Stream Structure and Coronal Sources of the Solar Wind During the April 7th and May 12th, 1997 Halo CMEs

C. Nick Arge, AFRL/Space Vehicles Directorate

We report on our efforts to model the ambient solar wind out to 1 AU around the times of the April 7 and May 12, 1997 halo coronal mass ejections (CMEs) and to identify their coronal source regions. We use the simple physics and empirical based Wang-Sheeley-Arge (WSA) model driven by daily updated photospheric field synoptic maps from Mount Wilson Solar Observatory. The results generated by the WSA model for each event are then compared with the WIND satellite observations near Earth, as well as with each other. We find that the model describes the observed ambient solar wind stream structure of the May 12, 1997 CME generally well, except for the ejecta itself, while it fails to capture the moderately high-speed ambient stream that followed behind the April 7th CME ejecta. In this investigation, we attempt to understand these findings by comparing in detail WSA modeling results, solar observations, and solar wind data at L1.

4. Active Regions, Halo CMEs and Geomagnetic Storms

Yang Liu, Stanford University

TBA

5. Observational Evidence for Velocity Convergence Toward Magnetic Neutral Lines as a Factor in CME Initiation

Yan Li, SSL/UCBerkeley

One of the major challenges of space weather research and modeling is the identification of the mechanism(s) for coronal mass ejections (CMEs). A leading candidate tested in several recent numerical simulations is photospheric magnetic flux cancellation by velocity convergence toward the neutral line of an active region having sheared or

twisted magnetic fields. These attributes have been assumed in various combinations in modeling studies, but little observational work has been done that demonstrates their presence. In this paper we show observational evidence that this process is at work in two different types of repetitively eruptive active regions in late 1996 and early 1997. The horizontal velocity field is obtained by applying Local Correlation Tracking (LCT) technique to sequences of photospheric line of sight magnetograms.

6. Quantifying Flux Convergence and Cancellation Rates

Xavier Bonnin, Space Sciences Lab, UC Berkeley

Martin (1998) describes flux cancellation as an essential process in the formation of prominences, which have been observed to erupt as coronal mass ejections (CMEs). Li et al. (2004) report steady flux convergence and cancellation was present in NOAA AR 8038 prior to the eruption on 12 May 1997, a SHINE event. Using local correlation tracking (LCT) and feature tracking (FT) applied to time series of MDI low-resolution magnetograms in which flux cancellation is observed by eye, we have developed automated, quantitative measures of the rates of flux convergence and cancellation, and present our results here. It is hoped these methods can help predict eruptive events.

7. Using Vector Magnetogram Data to Infer a Photospheric Velocity in AR 8210

Dana Longcope, Montana State University

Active region AR 8210 exhibited complex photospheric evolution including sunspot rotation and flux emergence, and was also observed to host numerous flares and coronal mass ejections during its disk passage. The Imaging Vector Magnetograph at the University of Hawaii/Mees Solar Observatory obtained a long, high-cadence sequence of vector magnetograms of AR 8210 on May 1, 1998. We introduce a technique for inferring a photospheric velocity from a sequence of vector magnetograms. The technique, called The Minimum Energy Fit, demands that the photospheric flow agree with the observed photospheric field evolution according to the magnetic induction equation. It selects, from all consistent flows, that with the smallest overall flow speed by demanding that it minimize an energy functional. We apply this technique to the IVM magnetogram sequence for AR 8210. The result is the flow field with the lowest overall speed which is consistent with the observed magnetic evolution. The inferred flow field includes an upflow along the polarity inversion line. This work was supported by AFOSR under a DoD Multi-Universities Research Initiative (MURI) grant, "Understanding Solar Eruptions and their Interplanetary Consequences".

8. SHINE SEP Campaign Events: Detailed Comparison of active regions AR9906 and AR0069 in the build-up to the SEP events of 21 Apr 2002 and 24 Aug 2002

David Alexander, Rice University

The SEP signatures of the solar flares occurring on 21 Apr 2002 and 24 Aug 2002 show marked differences in their compositions above 10 MeV/nucleon yet at the Sun the events themselves show very little differences in either their hard X-ray chromospheric emission or their coronal signatures. The purpose of this and related posters is to

investigate the prior evolution of the SEP-event active regions to look for possible signatures in the ambient corona, magnetic connectivities (within the active region, within large-scale closed field, and the open field distributions), and flare/activity history which may differentiate the solar conditions which led to such disparate particle signatures at 1 AU. In this paper, we summarize the results from the detailed data analyses and discuss their implications for SEP events

9. Transient activity in regions AR9906 and AR0069 in the build-up to the SEP events of 21 Apr 2002 and 24 Aug 2002

DAOU, Antoun G., RICE UNIVERSITY

The SEP signatures of the solar flares occurring on 21 Apr 2002 and 24 Aug 2002 show marked differences in their compositions above 10 MeV/nucleon. Yet, at the sun, the events themselves show very little differences in either their hard X-ray chromospheric emission or their coronal signatures. One of the interesting questions raised was whether the compositional differences observed could be the result of different activity histories of the active regions in question. In this paper, we chart the flare, CME and associated activity of each active region (AR9906 and AR0069) using GOES, RHESSI, TRACE and radio data. We will relate the observed activity to the magnetic field connectivity (see paper by Liu et al.) and assess whether significant differences in the development of these active regions could contribute to different signatures seen in the particle compositions of the events of Apr 21 and Aug 24 2002.

10. SHINE SEP Campaign Events: Global and Local Magnetic Field Evolution in Build-up to the SEP events of 21 Apr 2002 and 24 Aug 2002

Rui Liu, Rice University

The SEP signatures of the solar flares occurring on 21 Apr 2002 and 24 Aug 2002 show marked differences in their compositions above 10 MeV/nucleon yet at the Sun the event themselves show very little differences in either their hard X-ray chromospheric emission or their coronal signatures. A key factor in linking the solar activity with that observed in the interplanetary medium is the magnetic field connectivity. The events in question both occurred near the West limb and so little or no information about the surface magnetic fields can be obtained at the time of the event. In this paper, we follow the magnetic developments in the SEP events producing activity regions for 7 days prior to the events themselves to explore the role that the magnetic field plays in the observed interplanetary differences. We employ the Potential Field Source Surface (PFSS) model devised by DeRosa and Schrijver to obtain an estimate of the global and local connectivities and their evolution at the active regions progress from disk center to the limb.

11. SHINE SEP Campaign Events: Long-term development of solar corona in build-up to the SEP events of 21 Apr 2002 and 24 Aug 2002

Aaron Coyner, Rice University

The SEP signatures of the solar flares occurring on 21 Apr 2002 and 24 Aug 2002 show marked differences in their compositions above 10 MeV/nucleon yet at the Sun the

events themselves show very little differences in either the hard X-ray chromospheric emission or their coronal signatures. In this paper, we investigate whether the two active regions demonstrated notably different coronal development as they progressed from disk center to the limb prior to each of the events they spawned. We utilize TRACE, EIT, and LASCO data to map out the coronal activity, connectivities, and heating of these active regions in the seven day period prior to the events in question.

12. Coronal and Interplanetary Shocks of 2002 April Nat Gopalswamy, NASA/GSFC, Greenbelt, MD 20771, USA

The solar eruption of 2002 April 21 at 01:27 UT has some unusual properties, including the association with radio bursts. The first instance of radio emission at metric wavelengths did not start until about 01:17 UT although the associated soft X-ray emission started at 00:43 UT. In this paper, we investigate the unusual delay in the onset of metric radio emission. The starting frequency and onset times of the associated metric and Wind/WAVES type II bursts suggest that the CME onset immediately precedes the metric type II burst and that the earlier flare emission observed by RHESSI and GOES may represent a separate energy release. We present various observations which seem to support this scenario, rather than a single eruption with a complicated CME acceleration profile. Research supported by NSF/SHINE (ATM 0204588) and NASA/LWS programs.

13. The role of CMEs and their shocks in determining SEP abundances Hilary Cane, NASA/GSFC

High energy particles are generated close to the Sun in processes that accompany CME onsets but are unlikely to be initially accelerated by CME driven shocks. Flare processes are most likely because of a) a correlation between initial intensities and peak flare soft X-ray intensities, b) a lack of correlation between initial intensities and CME speeds, and c) an organization of properties based on flare longitude. Further confirmation of the importance of flares is the observation that the majority of events have Fe to O ratios above ~ 25 MeV/nuc. that are larger than the ratios of the ambient corona and solar wind. Some high energy events with ambient or lower ratios (during all or part of the event) occur when CMEs are very fast and drive strong shocks that accelerate any particles they encounter. At the same energy/nuc. O ions have a lower rigidity than Fe ions (because they are more stripped) and are shock accelerated more efficiently. The observed characteristics depend on the speed of the shock and the location of the observer relative to the shock. (The lower speed shock in the August 24 2002 event relative to that of the April 21 2002 event is the major reason these events have such different abundances.) Location is also important for intercepting the flare contribution and determining its intensity. In this respect CMEs play another important role by providing a relatively turbulence-free conduit in the interplanetary medium along which flare particles may freely propagate. More than 30% of the >25 MeV/nuc Fe events detected by SIS occurred when ACE was inside an ICME.

14. Shock Geometry, Seed Populations, and the Origin of Variable Elemental Composition at High Energies in Large Gradual Solar Particle Events

A. J. Tylka , US Naval Research Laboratory

A.J. Tylka, C.M.S. Cohen, W.F. Dietrich, M.A. Lee, C.G. MacLennan, R.A. Mewaldt, C.K. Ng, and D.V. Reames. Above a few tens of MeV per nucleon, large, gradual solar energetic particle (SEP) events are highly variable in their spectral characteristics and elemental composition. The origin of this variability has been a matter of intense and on-going debate. In this paper, we propose that this variability arises from the interplay of two factors -- shock geometry and a compound seed population, typically comprising both solar-wind and flare suprathermals. Whereas quasi-parallel shocks generally draw their seeds from solar-wind suprathermals, quasi-perpendicular shocks -- because of their higher injection threshold preferentially accelerate seed particles from flares. Solar-wind and flare seed particles have distinctive compositional characteristics, which are then reflected in the accelerated particles. We first examine our hypothesis in the context of particles locally accelerated near 1 AU by traveling interplanetary shocks. We illustrate the implications of our hypothesis for SEPs with two very large events, 2002 April 21 and 2002 August 24. These two events arise from very similar solar progenitors but nevertheless epitomize extremes in high-energy SEP variability. We then test our hypothesis with correlation studies based on observations of 43 large SEP events in 1997-2003 by ACE, Wind, IMP8, and GOES. We consider correlations among high-energy Fe/O, event size, the presence of GeV protons, spectral characteristics, and event duration at high energies. The observed correlations are all qualitatively consistent with our hypothesis. We also examine the alternative hypothesis in which a direct flare component -- rather than flare particles subsequently processed through a shock -- dominates at high energies. This alternative would produce the same compositional characteristics as our hypothesis. However, the observed longitude distribution of the enhanced Fe/O events, their spectral characteristics, and recent timing studies all pose serious challenges for a direct flare component. We also comment on measurements of the mean ionic charge state of Fe at high energies. We conclude that shock geometry and seed population provide a viable framework for understanding the overall high-energy variability in large SEP events.

15. Validation of Heliosphere Models

Kristi Keller, NASA Goddard Space Flight Center

The Community Coordinated Modeling Center (CCMC) performs validation studies for a variety of space weather models. In this presentation, we will present results on the validation of the Heliospheric Tomography Model developed by Bernard Jackson and Paul Hick. The Heliospheric Tomography Model makes use of interplanetary scintillation (IPS) to tomographically reconstruct the global structure of the solar wind density and velocity. We will present comparisons of the model results to ACE plasma data. In addition, we will present results from the model for the August 24, 2002 SHINE event.

16. Spaceship Earth Observations of the 24 August 2002 Event

Paul Evenson

The 24 August 2002 SHINE campaign event was observed as a small (five percent or less) ground level enhancement by several of the Spaceship Earth neutron monitor stations. This event was much smaller than any other analyzed to date, so our typical approach is hampered by statistical errors. Nevertheless, since this is a SHINE campaign event, we present our best estimates as to particle acceleration timing and other propagation parameters. John Bieber and others will be co-authors.

POSTER ABSTRACTS

Working Group 3

Energetic Particles

17. Solar Energetic Particle Isotopic Composition During Extreme SEP Events

Richard Leske, California Institute of Technology

Measurements from NASA's Advanced Composition Explorer (ACE) during large ("gradual") solar energetic particle (SEP) events have demonstrated that isotopic abundance ratios can vary considerably from event to event. Comparison of isotopic and elemental abundance variations suggests that the fractionation is governed (at least to first order) by the ionic charge to mass ratio, Q/M . It is unclear exactly how this mass fractionation occurs, or even to what extent it is the result of particle acceleration, particle transport, or admixtures of flare material in the source population being accelerated. In general, the very largest SEP events, such as the extreme events of October and November 2003, tend to show less elemental and isotopic fractionation than small or moderate-sized events. We present a survey of isotopic measurements for elements from C to Ni at energies of tens of MeV/nucleon made with the Solar Isotope Spectrometer on ACE during more than 40 large SEP events in solar cycle 23, with particular emphasis on the extreme events. We illustrate the correlations in abundance variations between various species, and we attempt to characterize the mass fractionation dependence on Q/M .

18. MARIE Observations of Solar Particle Events

Ronald Turner, ANSER

MARIE, an instrument on the Odyssey spacecraft, collected data on energetic particles (protons from 20-30 MeV about 100 MeV; He3 and He4; some sensitivity up to C12) in Mars orbit from mid-March 2002 to late October 2003. This poster describes the MARIE instrument and compares the MARIE data collected during solar active periods with similar data collected near Earth orbit. It also discusses lessons learned as they apply to future opportunities to make multipoint observations of solar particle events.

19. EFFECTIVE DRIFT VELOCITY AND INITIATION TIMES OF INTERPLANETARY TYPE-III RADIO BURSTS

Dennis Haggerty, JHUAPL

We derive an “effective drift velocity” (EDV) from dynamic WIND/WAVES spectrograms of interplanetary type-III fast-drift radio bursts associated with 171 near-relativistic electron events observed at 1 AU during the past 6 year (1997-2003). The EDV should be regarded as a phenomenological parameter that characterizes the burst drift rate. A frequency-time contour at a constant observed intensity is a sample of emission from an irregular volume within which the extended exciter region encounters plasma frequency corresponding to the observing frequency. Therefore the contour of the spectrogram that defines the “leading edge” of the emission is produced by the earliest exciter electrons to reach regions with that particular plasma frequency in sufficient numbers to produce type-III emission measurable at the WIND spacecraft. The “leading edge” is established by a best fit of multiple time-frequency points obtained from different frequency cuts. The onset point for each given frequency is determined when the intensity curve rises above background. The same analysis technique also yields an estimate of the time at which the interplanetary type-III radio burst was initiated in the low corona. In this sense, the EDV and initiation times derived from the “leading edge” of the type-III bursts is a useful phenomenological parameter for the characterization of burst propagation. It is certainly a more robust a parameter than the ill-defined “transit time”, when a contour of the emission pattern reaches the local plasma frequency. We examine the EDVs and initiation times with respect to the delayed injection of near-relativistic electrons, measured at ACE, to determine whether the EDVs are correlated with the observed delays.

20. A study of the injection of electrons in solar impulsive events observed from $<\sim 0.4$ to $>\sim 200$ keV by WIND

Linghua Wang, SSL & Physics Department at UC, Berkeley

We analyzed three solar impulsive electron events detected from a few hundred eV to >200 keV by the WIND 3D Plasma and Energetic Particle experiment. Previous studies show that in these events, high energy electrons (>38 keV) appear to be released later than type III radio burst. We studied electron injections in the three events with WIND/3DP measurement, which can cover the entire energy range of solar energetic electrons. We assume that electron injection profiles at the sun are triangle-shaped pulses, propagation is scatter-free and the travelling length is 1.2 AU. We vary electron injection times to best fit the onset times observed at 1AU. The fits show that low energy electrons ($<\sim 6.0$ keV) may be released around the start time of type III radio burst at the sun, but high energy electrons ($>\sim 10$ keV) may be released $\sim 8-15$ minutes later. It may suggest that in these events, low energy electrons are the electrons associated with type III burst and there may exist at least two separate acceleration processes. We also try to trace the topology of magnetic clouds with solar impulsive energetic electrons.

21. A Survey of Solar Electron Bursts at Energies Below 1.4 keV

Curt A de Koning, Los Alamos National Laboratory

The SWEPAM experiment aboard the ACE spacecraft has observed more than 375 solar electron bursts below 1.4 keV since 1998. These low energy solar electron bursts are detected on interplanetary field lines connected to, or surrounding, solar active regions. Statistical analysis of the rise time of solar electron bursts can potentially provide insight into the physical processes occurring at the sun (energy dependent extended injection profile with possible particle storage near the sun) and in the heliosphere (pitch angle scattering, focusing, and energy loss). In this report, we present statistics relating to the onset and peak times of solar electron bursts with clear energy dispersion observed by ACE and Genesis.

22. Stochastic Acceleration in Solar Flares: Case for Electron Acceleration

Vahe Petrosian, Siming Liu

In this poster we will briefly review the mechanism of stochastic acceleration by plasma waves or turbulence in solar flare and present the possible characteristics of the accelerated electrons for waves propagating along the magnetic field lines. We will use recent result from RHESSI satellite which support such a mechanism and discuss how the details of the mechanism can be determined by these and other observations. We will also contrast the electron acceleration vis-a-vis acceleration of protons and heavier ions.

23. The delayed arrival of low-energy particles in gradual SEP events

Joseph Dwyer, Florida Tech

Using 0.2-10 MeV/nucleon ion data from the Ultra-Low-Energy-Isotope-Spectrometer (ULEIS) onboard the Advance Composition Explorer (ACE), we have found that the low-energy particle components of a substantial number of large, gradual solar energetic particle (SEP) events, arrived later than the expected travel time of these particles from the sun to the 1 AU orbital distance. Indeed, for some events, after correcting for the velocity dispersion, the low energy component, $E < 0.1$ MeV/nucleon, is almost completely absent while the high-energy component, $E > 5$ MeV/nucleon, has very large enhancements. The events generally have elevated Fe/O ratios and large enhancements of the low-energy particles in coincidence with the arrival of the interplanetary shock a day or two after the start of the event. We will report on a study of about a dozen of these events observed by ULEIS, and we will discuss whether the observations can be explained by interplanetary scattering and/or by the trapping of particles with low-rigidity in the vicinity of the shock by magnetohydrodynamic waves, possibly generated by the high energy protons.

24. The adiabatic cooling effects in solar energetic particles transport

G. Qin, J.R. Dwyer, M. Zhang, H.K. Rassoul, and M. Al-Dayeh, Florida Inst. of Technology

Solar energetic particles (SEP) experience the effect of adiabatic cooling because of the

differential solar wind convection. This effect should be described in an anisotropic formula. We find that the adiabatic energy loss is significant in short solar distances and it can not be ignored in the study of SEP events, especially for SEP gradual events where particles lose more energy due to the long duration of the events. In this paper, we will discuss the influence of adiabatic cooling effect on the behavior of large gradual SEP events. We think this work might enhance our understanding of the phenomena of invariant energy spectra of large SEP events.

25. Parametrization of Shock Acceleration

Ilan Roth, UC Berkeley

Formation of inhomogeneous electromagnetic structures with strong gradients in magnetic field and intrinsic electric field is commonly observed in magnetized plasmas. When the magnetic ramp of an obliquely propagating heliospheric shock narrows to a size of a fraction of ion skin depth, the trajectories of some ions exhibit a non-adiabatic characteristics. A subset of ions are energized while surfing along the shock due to the combined forces of magnetic fields and cross-shock electric potential, and form a high energy tail after traversing the shock multiple times as a result of scattering and reflection due to turbulent diffusion in the vicinity of the shock. We follow the orbits of thermal solar wind ions in a presence of a model shock based on data and simulation results with self-consistent electric and magnetic fields, and investigate their non-adiabatic behavior for a variety of plasma parameters and geometries.

26. Acceleration of He⁺ Pickup Ions at CME-Driven Shocks

Elena Moise, University of Michigan & University of Arizona

The heliosphere is impenetrable to interstellar plasma, except for high-energy galactic cosmic rays. Neutral components of the local interstellar medium (LISM), however, do enter at the speed of Sun's relative motion to LISM. On their journey through the heliosphere, interstellar neutrals are subject to ionization by solar wind protons and electrons, solar photons, and are also affected by the gravitational pull of the Sun. Once ionized, the newly created ions, called "pickup ions" (PUIs), are swept out by the solar wind toward the termination shock (TS). Recent theories suggest that PUIs are the seed particles for the detected anomalous cosmic rays (ACRs). To reach such high energies, it would be necessary that the PUIs be pre-accelerated before reaching the TS, where the ions are finally accelerated to become ACRs. We investigate this aspect of the PUIs life cycle by using the data gathered by Solar Wind Composition Spectrometer (SWICS) on the Advance Composition Explorer (ACE). This is a study of pre-acceleration of He⁺ PUIs up to 100keV, by shocks generated by coronal mass ejecta. Our results imply that quasi-parallel shocks are more efficient at accelerating He⁺ PUIs in this energy interval than quasi-perpendicular shocks.

27. Spectroscopic Investigations of High-energy Protons from CME Shocks and Flare Sites

J. Lin, J. C. Raymond, S. R. Cranmer, and J. L. Kohl

The longest-duration phase of solar energetic particle (SEP) activity is believed to come from the CME shock as it propagates through the extended corona and heliosphere. Ultraviolet spectroscopy by SOHO has revealed a means for: (1) detecting and characterizing CME shocks in the corona, and (2) determining the plasma conditions in the pre-CME corona which are needed to understand the formation and evolution of shocks. Such remote sensing combined with models of SEP acceleration and transport can be used to predict the strength, duration, and production sites of the radiation.

This poster describes the specific means by which ultraviolet spectroscopy and other remote-sensing data can be used to determine the inputs and boundary conditions for individual events (such as the October-November 2003 storms) in existing SEP model codes. We also discuss an additional potential source of SEP radiation associated with electric fields in the current sheets that form in flare regions in the wake of CME. Both observations and model calculations show that the reconnection-induced electric field can reach a maximum strength of a few V/cm within tens of minutes after the onset of the eruption, then decreases gradually over several hours. SEPs produced in these regions may account for X-rays and gamma-rays observed prior to the formation of CME shocks. Ultraviolet spectroscopy has been shown to provide constraints on the plasma properties in all of the above CME features.

28. ACE Observations of Elemental and Isotopic Composition in Impulsive Solar Energetic Particle Events

Mark Wiedenbeck, Jet Propulsion Laboratory, Caltech

TBA

29. Interacting Coronal Mass Ejections and the Release of Solar Energetic Particles

Säm Krucker, Space Science Lab, UC Berkeley

Gopalswamy et al. (2001) reported that interacting Coronal Mass Ejections (CME) are producing radio signatures in interplanetary space. Furthermore, they also reported that Solar Energetic Particles (SEP) events are very often associated with interacting CMEs. How are SEP events associated with interacting CMEs? Are SEPs produced by the interaction of the CMEs, or are the SEPs accelerated independently of the interaction? This poster investigates these questions by analyzing the timing of WIND/3DP electron (1keV-1MeV) and proton (<6MeV) observations and compare it with the timing of the CME and the associated radio emissions as observed by SOHO/LASCO and WIND/WAVES.

30. Solar cycle variations of the elemental abundances of gradual SEP events as measured by ACE/ULEIS and WIND/STEP

Maher Al-Dayeh, Florida Institute of Technology

Solar energetic particles (SEPs) can be used to probe the composition of the solar corona, independent of spectroscopic or solar wind measurements. However, previous studies have shown that SEPs elemental abundances in large gradual events can vary considerably (by factors of >10) from event to event, which must be taken into account when using SEP measurements to deduce the coronal composition. Unfortunately, the causes of these variations are still not clear, and 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 the solar cycle dependence in abundance ratios. Using the Ultra Low Energy Isotope Spectrometer (ULEIS) onboard the Advanced Composition Explorer (ACE) and the STEP instruments onboard the WIND spacecraft, we have measured the fluxes of iron (Fe) and the averaged C-N-O at high and low energies ranging between 0.02-2 MeV/nucleon. In this study, we report measurements of the compositional changes for a survey of gradual events between 1995 and 2003.

POSTER ABSTRACTS

Working Group 1

Solar Group

31. Solar Origin of the Radio Characteristics of a Complex Type III Burst Observed on April 11, 2001

M. J. Reiner, K.-L. Klein, M. Karlicky, A. Klassen, M. L. Kaiser, J.-L. Bougeret
CUA/ GSFC

We report here on the solar origin of the unusual radiation characteristics observed for a complex decametric type III solar radio burst that was associated with a major solar flare and CME on April 11, 2001. The associated decimeter (Ondrejov) and meter (Potsdam) wavelength spectral radio emissions indicate that there were two different populations of electrons accelerated during this solar eruptive event. The Nancay radioheliograph images and additional evidence of plasmoid propagation suggest that the secondary electron acceleration event resulted from coronal reconfigurations probably due to the erupting CME. These observations provide new insights into the origin of the unusual characteristics of complex type III-like radio emissions that are typically observed at decameter wavelengths during major solar eruptive events

32. Active-region structure and type II bursts

Hugh Hudson, UC Berkeley

Solar magnetic active regions consist of magnetic fields originating mostly in subphotospheric current systems. The bulk of the structure is invisible at most

wavelengths, but there are some massive loops at elevated gas pressure. In general plasma beta is low and the inferred Alfvén speed large. Eruptive flares (CMEs) disrupt segments of this magnetic field, forming temporary sources of solar wind. They also launch blast waves that are now detectable in soft X-rays and other wavelengths in addition to the traditional Moreton wave and meter-wave type II bursts. The blast waves, in the best cases, can be imaged directly in soft X-rays as they leave the flare core at the onset of the eruption. We find that these blast waves commonly occur (12/30 cases) in conjunction with the TRACE "kink mode" loop oscillations catalogued by Schrijver, Aschwanden, and Title. The oscillating loops occur, of course, in those parts of the active region not participating in the CME (or "dimming").

33. Geoeffective CMEs, Filaments, and Sigmoids

David McKenzie, Montana State University

Coronal mass ejections--particularly those with flux rope structures--have the potential to trigger geomagnetic storms, depending on the properties of the flux ropes. Eruptions of both filaments and coronal sigmoids have been indicated as important drivers of space weather, and both filaments and sigmoids have been modeled with flux rope structure. However, the analysis reported by Leamon et al. (2002) suggested that magnetic clouds associated with filament eruptions are different from magnetic clouds associated with erupting sigmoids. In this investigation, we are exploring the possibility of predicting the geoeffectiveness of CMEs through analysis of the pre-eruption magnetic structures.

34. Complexity of Photospheric Magnetic Fields versus Parameters of the CME Eruption

Valentyna Abramenko, Big Bear Solar Observatory of NJIT

Eruptive phenomena in the solar atmosphere are thought to be caused by reconnection processes in complex magnetic structures. Therefore, the complexity of the magnetic field should be closely related to the eruption activity. We use a statistical approach to determine the measure of complexity of the line-of-sight magnetic field in active regions of different level of flare activity. We then compare the time variations of our statistical parameters with timing and parameters of flares and associated CMEs. We will show that the measure of complexity correlates with the speed of the CME and the X-ray class of the flare.

35. Forecasting Coronal Mass Ejections from

David Falconer, MSFC/NSSTC/UAH

We report further results from our ongoing assessment of magnetogram-based measures of active-region nonpotentiality (magnetic shear and twist), and size as predictors of coronal mass ejections (CMEs). From a set of 36 vector magnetograms of predominantly bipolar active regions (Falconer, Moore, & Gary 2004, ApJ, submitted), we have found: (1) Each of five different measures of active-region nonpotentiality has a 75-80% success rate (with correlation confidence level > 95%) in predicting whether an active region will produce a CME within 2 days after the magnetogram. (2) One of these measures with the

highest success rates can be obtained from a line-of-sight magnetogram without use of a vector magnetogram. Hence this measure appears to be the best practical measure of active-region nonpotentiality for operational CME forecasting. (3) Our measure of active-region size has a 65% success rate in predicting CMEs in this window, but the correlation is not statistically significant (confidence level $\sim 80\%$) for our sample size. We have now also applied measures of nonpotentiality and size to multi-bipolar active regions to assess their CME-prediction ability for these more complicated active regions. The preliminary results indicate that our nonpotentiality measures are about as successful as CME predictors for multi-bipolar active regions as for bipolar active regions. Further, we have found that the multibipolar active regions are more likely to be CME productive than bipolar active regions. This suggests that some measure of active-region magnetic complexity might also be a significant CME predictor. We are developing quantitative measures of complexity and testing their CME-prediction ability. 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.

36. Preflare Phenomena in Eruptive Flares

Angela Des Jardins, Montana State University

We report the results of a statistical study of the relationship between eruptive solar flares and an observed H alpha preflare phenomenon we call moving blue shift events (MBSEs). The H alpha data were gathered using the Mees Solar Observatory CCD imaging spectrograph (MCCD). The 16 events in our dataset were observed by both the MCCD and the Yohkoh Soft X-Ray Telescope (SXT), typically for at least three hours prior to the flare, and in some cases repeatedly for several days prior to the flare. The dataset contains both eruptive and non-eruptive flares, without bias. Focusing on three-hour periods before and after the flares, we found the average rate of MBSEs prior to the flares was about 5 times greater prior to the 11 eruptive flares than prior to the 5 non-eruptive ones. Also, the average rate of MBSEs dropped by a factor of about 6 after the eruptive flares. Earlier studies inferred that MBSEs reflect motions that originate in the readjustment of magnetic fields after magnetic reconnection. From the high correlation between eruptive flares and preflare MBSEs in the several hours prior to such events, we conclude that reconnection in the chromosphere or low corona plays an important role in establishing the conditions that lead to solar flare eruptions.

37. High Time Resolution EUV Spectroscopy of Solar Flares With and Without Associated CMEs

J. W. Brosius, CUA at NASA's GSFC

We present light curves and Doppler velocity measurements for two M-class GOES flares observed at high time resolution with SOHO's CDS (9.8 s). One event, observed in NOAA Region 9502 on 2001 June 15, was associated with a CME; the other event, observed in NOAA Region 9433 on 2001 April 24, was not. Emission lines of He II, O III - V, Ne VI, Mg X, and Fe XIX are analyzed, and provide diagnostics of plasma dynamics for $5 < \log T < 7$. The June 15 event reveals multiple, highly blueshifted emission line components that correspond to upflows approaching 900 km/s during the

flare impulsive phase. The April 24 event reveals that the entire profile is blueshifted, with upflows approaching 70 km/s during the impulsive phase. Associated downflows are interpreted in terms of "warm rain" or momentum balance during chromospheric evaporation. This work is supported by NASA.

38. How to determine the CME onsets and their errors

S. Yashiro, N. Gopalswamy, O. C. St.Cyr, R. A. Howard, CUA

In order to obtain the CME onset times, the following assumptions are made: (1) the CME trajectories can be fitted by 1st or 2nd order polynomials, and (2) CMEs are launched from solar limb (1Rs). We have provided these information in the SOHO/LASCO CME catalog, and catalog users use these onsets to compare CMEs with other associated phenomena such as flares. Obviously, this method is not good for events occurring close to the disk center. Therefore, we need to have a more accurate method with good estimate of errors for the study of CME - flare relationship. The main difficulty to determine the error in onset times lies in locating the leading edge of CMEs in each LASCO frame. Therefore, the regular method (propagation of errors) can not be used for this problem. We present a new way to estimate the CME onsets and their errors, using which we reexamine the CME - flare timing. We also evaluate how the results are affected by our assumptions.

39. Properties of CME Acceleration in the Low Corona

Jie Zhang, George Mason University

CMEs are well known to propagate at a more or less constant speed in the upper corona, or the field of view of most space-based white-light coronagraphs. However, for the purpose of understanding CME origin, the key issue is to observe CME initiation/acceleration in the low corona. In this presentation, we review the progress made on this issue in the past several years, in particular, the observations provided by LASCO/C1 (1.1 to 3.0 R_{sun}). We show complete kinematic evolution of CMEs, which demonstrates different phases that may correspond to different dynamic processes in the corona. The CME acceleration duration, magnitude and height range will be discussed. A statistics on CME acceleration will be presented. We will also discuss the possible relationship between CMEs and flares.

40. STATISTICAL DISTRIBUTIONS OF SPEEDS OF CORONAL MASS EJECTIONS AND DIFFERENT TYPES OF CMEs

Vasyl Yurchyshyn, Big Bear Solar Observatory

We studied the distribution of plane of sky speeds determined for 4315 coronal mass ejections (CMEs) detected by Large Angle and Apectrometric Coronagraph Experiment on board Solar and Heliospheric Observatory (SOHO/LASCO). We found that the speed distributions for accelerating and decelerating events are nearly identical and to a good approximation they can be fitted with a single log-normal distribution. This finding implies that, statistically, there is no physical distinction between the accelerating and the decelerating events. The log-normal distribution of the CME speeds suggests that the

same driving mechanism of a non-linear nature is acting in both slow and fast dynamical types of CMEs.

41. Main-Sequence CMEs as Magnetic Explosions: Compatibility with Observed Kinematics

Ron Moore, NASA/MSFC/NSSTC

We examine the kinematics of 26 CMEs of the morphological main sequence of CMEs, those having the classic three-part bubble structure of (1) a bright front enveloping (2) a dark cavity within which rides (3) a bright blob/filamentary feature. Each CME is observed in Yohkoh/SXT images to originate from near the limb (>0.7 R_{Sun} from disk center). The basic data (from the SOHO LASCO CME Catalog) for the kinematics of each CME are the sequence of LASCO images of the CME, the time of each image, the measured radial distance of the front edge of the CME in each image, and the measured angular extent of the CME. About half of our CMEs (12) occur with a flare, and the rest (14) occur without a flare. While the average linear-fit speed of the flare CMEs (1000 km/s) is twice that of the non-flare CMEs (510 km/s), the flare CMEs and the non-flare CMEs are similar in that some of each have nearly flat velocity-height (radial extent) profiles (little acceleration), some of each have noticeably falling velocity profiles (noticeable deceleration), and the rest of each have velocity profiles that rise considerably through the outer corona (blatant acceleration). This suggests that in addition to sharing similar morphology, main-sequence CMEs all have basically the same driving mechanism. The observed radial progression of each of our 26 CMEs is fit by a simple model magnetic plasmoid that is in pressure balance with the radial magnetic field in the outer corona and that propels itself outward by magnetic expansion, doing no net work on its surroundings. On average over the 26 CMEs, this model fits the observations equally well as the ad hoc assumption of constant acceleration. This is compatible with main-sequence CMEs being magnetically driven, basically magnetic explosions, with the velocity profile in the outer corona being largely dictated by the initial Alfvén speed in the CME (when the front is at ~ 3 R_{Sun}), analogous to the mass of a main-sequence star dictating the luminosity.

42. CME Energetics of the SHINE Campaign Events

Angelos Vourlidas, Naval Research Laboratory

I will discuss the energetics associated with the CME events during the active period of October-November 2003. I will also describe the methods used to obtain information on the energy content of CME in general.

43. Determining CME Mass vs. Coronal Height

Joan Burkepile, High Altitude Observatory / NCAR

The total mass content of solar Coronal Mass Ejections (CMEs) can vary greatly between events. Most CMEs have estimated masses between 10^{14} and 10^{16} grams of material. It is believed that most of the CME material is coronal in origin (Hildner et al. 1975) but the source of the mass remains largely undetermined. The large fields-of-view

of the LASCO C2 and C3 coronagraphs coupled with observations of the low corona from the MK4 K-Coronameter at the Mauna Loa Solar Observatory provide the observations needed to examine CME masses over a wide range of coronal scale heights. We utilize these observations to estimate both the amount of material which is ejected from the very low corona and the amount of mass which is 'swept up' by the CME as it propagates outward.

44. Transient Coronal Holes: EUV and IR HeI 1083nm Observations

Giuliana de Toma, NCAR/HAO

We present cases of transient coronal holes following a CME observed simultaneously by EIT and the ground instruments at Mauna Loa Solar Observatory (MLSO). We describe the formation of the transient coronal holes and their relationship to the flare evolution, filament eruption, and CME, taking advantage of the high 3-minute cadence of the MLSO observations. We find that transient coronal holes in the HeI 1083nm observations correspond well to the EUV ones, both spatially and temporally.

45. On the Origin and Configuration of the March 20, 2003 Interplanetary Shock and Magnetic Cloud at 1 AU

S. F. Martin, D. B. Berdichevsky, I. G. Richardson, R. P. Lepping

The passage of shock and a rare "hot" interplanetary magnetic cloud (IMC) were observed in the near-Earth solar wind on March 20, 2003. These were parts of a discrete 38-hour interval of solar outflow preceded and followed by a high-speed flow characteristic of a coronal hole. We deduce that the 38-hour active interval came primarily from a series of flare-related coronal mass ejections (CMEs) from an active solar area that contained AR 10314. The whole active solar area had remarkably well-delineated boundaries because it formed within a large coronal hole in the southern solar hemisphere. The most likely solar source for the IMC was part, but not all, of a CME on March 17 associated with an X1.5/1B solar flare with maximum brightness at 19:13 UT. We show evidence that the solar source area for the CME was an isolated peninsula of chromosphere that formed within the coronal hole because of growth of two or more active bipolar regions designated as AR 10314. The bright core of AR 10314 remained on the northeast side of the peninsula. We provide three types of evidence that the CME straddled the entire width of the peninsula and was not centered over the bright core of AR 10314. This example confirms earlier research by others suggesting that the CME solar source sites are large and encompass multiple bipolar regions.

46. 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 show a strong correlation with CMEs. Even the masses of prominences involved in CMEs remain largely uncertain,

although the determination of such masses may help in assessing the relative roles of potential and kinetic energies in CME events. In the technique used to derive prominence mass introduced in the present work, 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, and it can be applied to both quiescent and erupting prominences using two versions which we label the "spatial-interpolative" (applied to quiescent prominences) and the "temporal-interpolative" (applied to erupting prominences). We show the highest accuracy follows for the temporal-interpolative approach. We have applied both versions of the technique to a particular erupting prominence, and we find that both techniques result in similar mass determinations (3.5×10^{14} g) with the highest accuracy method yielding an uncertainty of $\pm 0.5 \times 10^{14}$ g.

47. Magnetic Topologies Due To Four Balanced Flux Sources

Colin Beveridge, Montana State University

Magnetic charge topology is used to find the key features - the skeletons -of quasi-static magnetic fields. This work considers the arrangements due to four discrete flux sources on a surface considered locally as a plane. Seven distinct topological states are found, and the six possible bifurcations between them are studied; these are compared to those found by Brown and Priest (1999) in an unbalanced three-source case. We show how our analysis can be extended to more complicated scenarios, including a shift to a spherical surface.

48. Energy Balance in Active Region Coronae

Loraine Lundquist, Space Sciences Laboratory

We have developed a steady-state energy balance model of the solar corona, which calculates coronal magnetic field structure and thermodynamics from a photospheric magnetogram. Our method involves a solution of energy and momentum equations along individual coronal loops, allowing for flows, gravity, non-uniform heating, and cross-sectional area variations. The model yields predicted plasma emissivities which are interpolated to a 3-d grid and used to create synthetic X-ray and EUV emission images. Such images can be generated using different heating term approximations and compared with observed coronal images from satellite data to get observational constraints on coronal heating mechanisms.

49. Quantifying the Performance of Coronal Extrapolations: Just Because It Looks Good, Is It?

Graham Barnes, HAO/NCAR & CoRA/NWRA

The magnetic field in the corona is interesting in its own right for understanding the magnetic topology relevant to reconnection, as well as serving as an initial condition for MHD simulations. Due to the difficulties of directly measuring the coronal magnetic field, it is common to extrapolate the field there using a photospheric vector magnetic

field map as a boundary condition. Probably the most common technique for extrapolating the field is to solve for a linear force-free field using an FFT, which can sometimes produce field lines which match the expectations of the observer. Does this mean the extrapolation has truly done a good job of reproducing the actual magnetic field? To answer this, we examine several extrapolation techniques in the context of both the locations of individual field lines, and in the topological properties of the field, particularly in the form of separatrix surfaces. We outline quantitative measures that can be used to evaluate the performance of an extrapolation, using both observations at multiple heights and a numerical simulation in which the field is known everywhere.

50. Testing Methods of Deriving Photospheric Velocities

Brian Welsch, Space Sciences Lab, UC Berkeley

To infer photospheric velocities from magnetograms, researchers have developed several techniques, including feature tracking (FT), local correlation tracking (LCT), inductive local correlation tracking (ILCT), and minimum energy fitting (MEF), which have not been rigorously tested against realistic simulated data sets. We present results from tests of several velocity inversion codes on synthetic data sets, generated from: 1. artificially evolved MDI hi-res data; and 2. 3D MHD simulations of an emerging, large-scale flux tube in the presence of magnetoconvection. We find that these velocity inversion routines generally fair poorly at recovering velocities from the MHD simulations.

51. A Comprehensive Array of Diagnostic Tools for the Analysis of Solar Active Region Vector Magnetograms

Manolis K. Georgouli, The Johns Hopkins University Applied Physics Laboratory

We synoptically present an integrated array of individual techniques that can be applied to vector magnetogram measurements of solar active regions. The above task has been one of the goals of the solar physics section at JHU/APL. The toolbox aims at (i) resolving the azimuthal 180-degree ambiguity in solar vector magnetograms, (ii) calculate the vertical Lorentz force and the associated non-field-aligned currents on the plane of the magnetograms, (iii) provide a unique solution for the photospheric velocity field vector consistent with the ideal MHD induction equation, (iv) calculate the magnetic helicity variations from the above information, and (v) estimate the total helicity budget in the active region's corona. The outcome of the analysis can be used to monitor the energy and helicity build-up in solar active regions and hence to provide early indicators of flares/CMEs, as well as quantitative diagnostics of the energy/helicity and the geo-effectiveness of the subsequent events. Particular emphasis is given to the automatic implementation of the above techniques and to the total computing time, so that to apply the various tools in real time, upon acquisition of the magnetic field observations. The above toolbox is currently fully operating for vector magnetograms taken from the data archive of the Imaging Vector Magnetograph (IVM) of the University of Hawaii, and we have proposed to collaborate with the observing team of the Synoptic Optical Long-Term Investigation of the Sun (SOLIS) in order to place the IDL code structure into the SOLIS data pipeline. The results and the codes themselves will be openly accessible to any interested researcher, while the experience gained will allow us to apply these tools to

future space-based solar vector magnetograms obtained by the Solar-B and the SDO missions.

52. The Photospheric Vector Magnetic Field Under Low-Lying Active Region Filaments

Bruce W. Lites, High Altitude Observatory/NCAR

The Advanced Stokes Polarimeter has been used to simultaneously measure the photospheric vector magnetic field (Fe I 630 nm) and chromospheric structure (H α) in a number of active regions. These data have been examined for the possible occurrence of low-lying filaments which might be associated with flux ropes at the photospheric level. Presented here are high-resolution measurements of the photospheric vector magnetic field that suggest such occurrence is rather common. I examine regions where 1) the active region vertical magnetic field component has a significant length of contiguous opposite polarities (a “polarity inversion line”), 2) that is accompanied by a filament observed in H α along this polarity inversion line, 3) that occurs in plage and not in sunspots or large pores, and 4) that is not accompanied by an H α “arch filament” system running perpendicular to the polarity inversion line. In nearly every case examined, the horizontal photospheric field vector is aligned along the length of the polarity inversion line, in agreement with the widely-accepted flux rope picture of the overlying chromospheric filament. In several cases the photospheric vector field takes on the character of a “concave-upward”, or “inverse polarity” geometry in the immediate vicinity of the inversion line. This finding suggests that the flux ropes that support active region prominences are generated in the solar interior and rise through the photosphere into the corona to form filaments.

53. Numerical Simulations of 3D Coronal Magnetic Fields Resulting from the Emergence of Twisted Magnetic Flux Tubes

Yuhong Fan, HAO/NCAR

We present MHD simulations in the low-beta regime of the evolution of the 3D coronal magnetic field as an arched, twisted magnetic flux tube is transported into a pre-existing coronal potential magnetic arcade. It is found that the line-tied emerging flux tube becomes kink unstable when a sufficient amount of twist is transported into the corona. For an emerging flux tube with a left-handed twist (which is the preferred sense of twist for active regions in the northern hemisphere), the kink motion of the tube and its interaction with the ambient coronal magnetic field lead to the formation of an intense current layer which displays an inverse-S shape consistent with the X-ray sigmoid morphology preferentially seen in the northern hemisphere. Our simulation results may explain the X-ray sigmoid brightenings that are observed during eruptive flares and confirm the prediction by previous topological studies that magnetic tangential discontinuities (or current sheets) should form along the so called “bald-patch” separatrix surface, across which the connectivity of the coronal magnetic field with the dense photosphere undergoes a sharp transition. Finally, we will also present simulations in a 3D spherical geometry of a CME-like eruption of the twisted emerging magnetic flux rope as it loses confinement by the ambient arcade field.

54. The Relation between subphotospheric magnetic structure and coronal magnetic structure

Tetsuya Magara , NRL/UCB

A limited number of simulations have shown that a flux tube composed of twisted field lines emerges into the photosphere, forming sheared magnetic structure in the corona (Fan 2001; Magara and Longcope 2001, 2003). The next step is to investigate several key properties of flux emergence such as the initial twist, radius, and the perturbed shape of an emerging flux tube, and find out how they are related to the activity of sheared magnetic structure. We present the results of this exploration which are recently obtained by using ARMS (Adaptively Refined Magnetodynamic Solver).

55. FORMATION OF TWISTED AND KINKED FLUX TUBE FOR A LONG-LIVED ACTIVE REGION: AR 9632

Tian, Lirong, Rice University

We have traced long-term evolution of an non-Hale active region composed of NOAA 9604-9632-9672-9704-9738, which produced more strong solar activities and geomagnetic effect from September to Dectober, 2001. By studying development of spot groups and magnetograms in line-of-sight in the photosphere, and evolution of $H\alpha$ filaments and 171Å images in the corona, we have found that the magnetic structure of the active region had been suffered from continuous clockwise rotations. Both twist parameter α_{best} and systematic tilt angle (proxy of writhe) of magnetic fields had been positive values in the main terms, calculated by vector magnetic data obtained from Huairou Solar Observing Station (HSOS) and full disk magnetograms of MDI/SOHO. On the other hand, soft X-ray coronal loops from SXT/Yohkoh displayed a pronounced right-handed writhe and forward-Sigmoid structure in the terms of NOAA 9672 and 9704. These imply that the magnetic loops existed in the solar atmosphere have same handedness of the writhe and the twist. We speculate that the magnetic configuration of the long-lived active region was resulted from rising of a highly twisted and kinked flux tube through the photosphere into the corona, which was formed from an Ω -tube with high inherent twist, and deformed by a kink instability in the convection zone.

56. What is necessary to constrain 3D density models of coronal cavities using the Low & Hundhausen model?

David Foster, HAO/NCAR

The purpose of this poster is to examine the Low & Hundhausen model (1995) and constrain it using available data. Or if this is not possible, using determining what is necessary and what future instrument might provide that. The Low & Hundhausen model has many parameters that may be adjusted to create a physically consistent model flux rope with arbitrary characteristics. It constructs the magnetic field and a corresponding density and pressure field. I will use data from the Mark IV white-light coronagraph, magnetograms, and H-alpha images to constrain these parameters. This will enable us to

better answer questions about the actual magnetic field and quantities associated with it, of magnetic flux ropes and coronal cavities.

57. A Topological Analysis of the Magnetic Breakout Model

Rhona Maclean, Montana State University

The magnetic breakout model gives an elegant explanation for the onset of a solar flare. In it, reconnection at a coronal null point allows initially enclosed flux to "break out" to infinity. We discuss here a simple model of a delta sunspot, and analyse changes to its topological structure produced by the motions or emergence of flux. Both potential and linear force-free models are found to exhibit breakout-type behaviour, most commonly (although not always) resulting from a global spine-fan bifurcation.

58. Comparison of Flux Cancellation and Breakout Simulations of CMEs

Jon Linker, SAIC

Comparison of Flux Cancellation and Breakout Simulations of CMEs Jon A Linker, Zoran Mikic, Roberto Lionello, and Pete Riley SAIC Both the flux cancellation (van Ballegoijen and Martens, ApJ, 361, 971, 1989; Forbes and Isenberg, ApJ 373, 294, 1991) and "breakout" (Antiochos, ApJ, 502, L181, 1998) MHD simulations performed to date of the breakout model have used rather simple models of the corona (Antiochos et al, ApJ, 512, 985, 1999) while flux cancellation simulations have included the important effect of the solar wind (Linker et al, Phys. Plasmas, 10, 5, 1971). In this poster we will describe MHD simulations of the breakout model in which we include the effect of the solar wind, and compare the results with flux cancellation simulations. We will discuss the prospects that either model can explain fast CMEs.

59. 3D Breakout

Ben Lynch, Univ. of Michigan / Naval Research Lab

We present preliminary results of the breakout model for solar coronal mass ejections in 3D. The multi-polar flux system now has finite azimuthal extent. We plan on demonstrating a fully 3D breakout eruption. Observational implications are discussed.

60. Evidence of "tether-cutting" reconnection in the onset of a quadrupolar solar magnetic eruption

Debi Prasad Choudhary, Research Associate

Extensive study of the near-limb solar filament eruption event on 2000 February 26, involving coronal images from YOHKOH, SOHO EIT and photospheric magnetogram from MID have shown that that both "runaway-tether-cutting-type reconnection" and "fast breakout-type reconnection" may have occurred early in the fast phase of the eruption and may have played an important role in unleashing the explosion (Sterling & Moore 2004). That study did not identify which or if either of these types of reconnection actually triggered the fast phase. Here, together with a magnetogram and HeI 10830 Å C5 filtergram from NSO/KP, we present Ha filtergrams from Big Bear Solar

Observatory, that show evidence of "tether-cutting-type reconnection" before and during the eruption of the southern filament, situated at one of the neutral lines of the quadrupole magnetic structure.

61. TRACE Observations of Voids in Coronal Current Sheets

Daniel Seaton, University of New Hampshire

Over the past few years TRACE has observed dark, downward-propagating features that we call 'coronal tadpoles' over the flare arcades of several large flares. We analyzed these features in several events and determined their distinguishing characteristics. We find that they have a relatively low density compared to the surrounding corona. These observations suggest that the tadpoles are regions of strong magnetic field created by a turbulent reconnection process.

62. Energetics Associated With a CME Model

Kathy Reeves, University of New Hampshire

We investigate the energetics of the Lin and Forbes (2000) CME model by calculating the Poynting flux in the current sheet. We calculate the total energy in the system, which can be divided into magnetic energy, kinetic energy of the flux rope and thermal energy in the current sheet. We find that thermal energy in fast CMEs is a higher percentage of the total energy than in slow CMEs, and that the thermal energy release rate is faster for fast CMEs. We also present preliminary calculations of TRACE and SXT flare light curves using the Poynting flux calculations and a simple cooling model. Based on these results, we conclude that this model predicts that there would not be an observable flare associated with the CME for weak magnetic field regions.

63. On Filaments, Flux Ropes, and Three-Part CME Structure

Raid Suleiman, BU/CfA

On Filaments, Flux Ropes, and Three-Part CME Structure R. M. Suleiman, N. U. Crooker, J. C. Raymond and A. van Ballegoijen The coronal mass ejection (CME) observed on 12 September 2000 by the instruments aboard the Solar Heliospheric Observatory (SOHO) provides new insights into the origin of the classical three-part structure and its relationship to magnetic flux rope formation. A complex helix was measured by the Ultraviolet Coronagraph Spectrometer (UVCS) at heliocentric distances of 3.5 and 6 R_{sun} . A difference of 300 km/sec in line-of-sight velocities for two segments of the helix obtained from Doppler measurements implies expansion and allows one to distinguish which segment was closest to the observer. Knowledge of the different tilts of the leading and trailing segments provides one of two components needed to derive magnetic chirality. Obtaining the second component from a magnetogram, we show agreement with the chirality predicted from filament properties. The leading field of the helix matches the old-cycle dipole, consistent with eruption from a switch-back in the neutral line. Observed Ly-alpha and C III line emissions indicate that the helix was threaded with filament plasma of varying density. While the helix constituted the bright core of filament plasma, the helix itself was most likely not the pre-existing filament. EIT

data show a concurrent arcade event, implying that the helix formed by reconnection as part of the CME lift off process, in the course of which the pre-existing filament lost its magnetic coherence.

POSTER ABSTRACTS

Working Group 2

Interplanetary Group

64. Solar and Heliospheric Models at the Community Coordinated Modeling Center

Michael Hesse, NASA GSFC

The CCMC provides, to the science community, access to state of the art space environment models. After starting with magnetospheric models, CCMC is now expanding the solar and heliospheric model base. In this poster, we will present an overview of models residing at CCMC, demonstrate how to use these models, how to analyze model results, and discuss future plans for solar and heliospheric models. In addition, CCMC solicits input on how to further improve customer service to the research community.

65. The radial expansion of ICMEs at 1 AU

Mathew Owens, Center for Space Physics, Boston University

The Center for Integrated Space-weather Modelling (CISM) is attempting to improve prediction of geomagnetic activity driven by the solar wind, via the use of both empirical and physics-based models. As the strongest geomagnetic disturbances are triggered by the arrival of a coronal mass ejection (CME) at 1 AU, prediction of CME arrival times and properties in near-Earth space highly is highly desirable. The interplanetary manifestations of CMEs (ICMEs) at 1 AU frequently exhibit a smoothly declining speed profile, interpreted as an expansion in the radial direction, which has implications for both the transit time and the magnetic properties of the ejecta and the disturbed solar wind. We perform linear fits to the radial speed profiles of a large number (62) of ICMEs at 1 AU, and find that the fastest travelling ICMEs are also expanding the fastest. Causes and consequences of this relation are discussed.

66. The AR-ICME Topology Connection

Richard Canfield

A distinctive characteristic of interplanetary magnetic clouds is their rope-like magnetic structure, i.e. their smoothly-varying helical field lines whose pitch increases from their core to their boundary. Because this regular structure helps to make MCs particularly geo-effective, it is important to understand how it arises. Many MCs are associated with solar filament eruptions, and their magnetic field properties follow rather predictably from those of the associated filament and the large-scale solar dipole. However, a

comparable number of MCs are associated with the eruption of solar active regions, particularly sigmoids. These do not show the same solar--terrestrial correlations as those associated with filaments. For example, I am unaware of any model of the magnetic fields of sigmoids and their eruption that gives a demonstrably reliable prediction of the leading field orientation of their associated MC.

I will discuss recent work which relates the magnetic and topological parameters of MCs to associated solar active regions. This work strongly supports the notion that MCs associated with active region eruptions are formed by magnetic reconnection between these regions and their larger-scale surroundings, rather than simple eruption or entrainment of pre-existing structures in the corona or chromosphere. However, it also opens up interesting questions regarding the interpretation of both solar and interplanetary data. I will attempt to identify at least some of these questions and the work that has been done to address them up to the present time.

67. A Generalized Flux Rope Fitting Technique Incorporating kinematic distortion effects

Pete Riley, SAIC

Flux rope fitting techniques are an invaluable tool for inferring information about the properties of a sub-class of interplanetary CMEs, known as magnetic clouds. In this poster we discuss the basic features and limitations of several of these methods. Guided by global MHD simulations as well as simple kinematic arguments, we propose a generalization to these techniques that incorporates the basic distortion of the ejecta. Specifically, we include the effects of: (1) spherical expansion; and (2) uniform expansion due to pressure gradients between the ejecta and the ambient solar wind. Using both real and simulated in situ observations of magnetic clouds, we assess to what extent this new method provides a more accurate determination of the flux rope parameters, including: orientation, impact parameter, width (both radial and transverse), and sign of helicity.

68. The Solar Mass Ejection Imager (SMEI) Mission

Bernard V. Jackson , CASS/UCSD

The Solar Mass Ejection Imager (SMEI) was launched in January 2003 into Earth orbit. It observes sunlight that has Thomson-scattered from heliospheric structures of time-varying density. SMEI is designed to observe heliospheric structures such as coronal mass ejections (CMEs), corotating structures and shock waves to elongations greater than 90° from the Sun. Such a near-Earth imager can provide up to three days warning of the arrival of a CME from the Sun. In combination with other imaging instruments in deep space, or alone by making some simple assumptions about the outward flow of the solar wind, SMEI can provide 3D reconstructions of the heliospheric structures that it observes. We show images of several CMEs observed with this instrument and low-resolution reconstruction analyses using the SMEI data for each event. The 3D reconstructions and heights for these events are compared with elongation-time plots of the same CMEs to estimate true speeds and line-of-sight locations for each CME.

69. Performance of SMEI during its first year in orbit

Joel Mozer, US Air Force Research Laboratory

The performance of the Solar Mass Ejection Imager (SMEI) is presented, both in terms of the quality of data produced by the instrument and its ability to accomplish the primary mission: to detect and track coronal mass ejections in the heliosphere. Photometric white-light data from SMEI has been available since the instrument was put in regular operation mode on 2 February, 2003. These data are investigated by analyzing standard stellar sources over time in order to develop photometric calibrations for the three SMEI cameras and to monitor the performance of the CCDs and optics over time. Furthermore, these performance metrics are interpreted in terms of the inherent ability of SMEI to remotely sense CMEs and other structures in the solar wind and its prospects for the future.

70. What Defines an Interplanetary Coronal Mass Ejection?

A. A. Shinde, C. T. Russell and L. Jian

Because the majority of spacecraft that observe Interplanetary Coronal Mass Ejections (ICMEs) reside in the neighborhood of the Earth while the best coronagraph observations of Coronal Mass Ejections (CMEs) are of eruptions orthogonal to the Earth-Sun line, the observation of a causative CME on the Sun is not a prerequisite for defining an ICME seen in space. Several observers have compiled lists of ICMEs for the ascending and maximum phase of solar cycle 23 based on varying criteria but derived from a common database: Wind and ACE solar wind and IMF measurements. Some of the criteria include a stronger than ambient magnetic field, rotating magnetic field, low beta, low ion temperature, declining velocity profile and other characteristics. We intercompare these lists and a similar list of our own in an attempt to determine what properties are possessed by consensus ICMEs and what produces an ambiguous identification. Not all ICMEs that have been identified are low beta structures, not all of them are expanding and not all produce shocks. At times the magnetic field strength profiles of ICMEs are quite flat. With this variety of possible combination of signatures it is not surprising that these various lists differ considerably. Of the 240 events identified on one or more lists only 22 are consensus identifications. Even when the groups do agree on the identification of an event, they do not agree on when the event starts and stops. Sometimes these differences are of only a few hours but at times there can be up to a day difference.

71. A New Parameter for Characterizing ICMEs

C. T. Russell, A. A. Shinde and L. Jian

Interplanetary Coronal Mass Ejections (ICMEs) consist of a complex array of plasma signatures. The magnetic field becomes stronger and weaker. The density increases and decreases. The plasma becomes hotter and colder. These signatures often appear to have a random relationship to each other or at least one that is inscrutable. It would be most helpful if a single parameter could be found that by itself characterized the nature of an

ICME. Two such parameters that have been proposed are the beta of the plasma and the Alfvén Mach number. Both of these parameters relate the strength of the magnetic field and a plasma parameter, the density in case of the Alfvén Mach number and plasma thermal pressure in the case of the plasma beta. One parameter that seems not to have been proposed is the perpendicular pressure in the plasma, $B^2/2\mu_0 + nkT$. If magnetic field lines are straight (no magnetic curvature force) this quantity should tend to a constant value (through the action of compressional waves) in the absence of an interaction with an obstacle. If there is a collision of the plasma with an obstacle, a gradient in the pressure will occur that will deflect the plasma around the obstacle. Regions of constant plasma pressure and increasing and decreasing plasma pressure could be quite diagnostic. Certainly field lines are not always straight, and twisted field in plasmas do exert pressure too, so such regions may be recognizable in pressure plots. In this study we examine examples of ICMEs as seen in perpendicular pressure. We use the 45 events we have been studying in our quest to find what solar wind parameters are diagnostic of ICMEs.

72. Interplanetary Coronal Mass Ejection Identification at 1 AU Using Multiple Solar Wind Plasma Composition Anomalies

Ian Richardson, Goddard Space Flight Center

We investigate the use of multiple simultaneous solar wind plasma compositional anomalies, relative to the composition of the ambient solar wind, for identifying interplanetary coronal mass ejection (ICME) plasma. We first summarize the characteristics of several solar wind plasma composition signatures (O⁺⁷/O⁺⁶, Mg/O, Ne/O, Fe charge states, He/p) observed by the ACE and WIND spacecraft within the ICMEs during 1996 - 2002 identified by Cane and Richardson [2003] (CR03). We then develop a set of simple criteria that may be used to identify such compositional anomalies, and hence potential ICMEs. To distinguish these anomalies from the normal variations found in ambient solar wind composition, which depend on the wind speed, we compare observed compositional signatures with those "expected" in ambient solar wind with the same solar wind speed. This method identifies anomalies more effectively than the use of fixed thresholds. The occurrence rates of individual composition anomalies within ICMEs range from ~70% for enhanced iron and oxygen charge states to ~30% for enhanced He/p (>0.06) and Ne/O, and are generally higher in magnetic clouds than other ICMEs. Intervals of multiple anomalies are usually associated with ICMEs, and provide a basis for the identification of the majority of ICMEs in the solar wind. We estimate that CR03, who did not refer to composition data, probably identified ~90% of the ICMEs present. Around 10% of their ICMEs have weak compositional anomalies, suggesting that the presence of such signatures does not provide a necessary requirement for an ICME. We note a remarkably similar interdependence between the Mg/O and O⁷/O⁶ ratios in hourly-averaged data both within ICMEs and the ambient solar wind, suggesting a "universal" relationship between the processes producing the first-ionization potential bias and ion freezing-in temperatures in the source regions of ICMEs and the ambient solar wind.

73. Combining remote and in situ observations of CME ejecta

Alysha Reinard, NRL/Artep

We describe a study of the compositional properties of heliospheric CME ejecta within the context of solar CME observations. In this study, we first examine CME-ICME pairs to determine if a given CME is associated with a flare or a prominence event. For each of these pairs the charge state ratios are averaged over the event and compared. We find that events originating near the central meridian are more likely to contain significantly higher charge state ratios. In those events that are associated with prominences we find that both oxygen and iron charge states increase with X-ray flare magnitude.

74. An Improved Expected Temperature Formula For Identifying ICMEs

Heather A. Elliott, Southwest Research Institute

The speed and temperature of the solar wind are typically well correlated. Often linear or quadratic fits are done to large data sets of speed and temperature. Then an expected temperature is derived using the fit function and speed measurements. Times when the expected temperature differs substantially from the observed temperature are rare and have been shown to be associated with interplanetary coronal mass ejections. In this study we improve the expected temperature formula by removing ICMEs prior to fitting and by fitting compressions and rarefactions separately.

75. The October/November 2003 Solar Events: Heliospheric Disturbances

Russell, C.T., Janet Luhmann, C. W. Smith, R. Skoug, M. Dougherty,
D. Lario and L. Jian

The well documented October/November solar events provide new understanding of the heliosphere propagation of such large disturbances and their effects on the planets especially the Earth. The arrival times of several of the events at Earth approached historic minimum values. The Earth's magnetosphere was rapidly compressed but the low density of the solar wind at the time and the modest IMF prevented the resultant storms from reaching historic maxima. Measurements at Earth and Mars suggest that either the shock associated with the October 28 (X17) flare decelerated or the front was non-spherical. Measurements at Ulysses and Cassini after the November 4 (X28) event cannot be interpreted in terms of deceleration and can only be interpreted in terms to a non-spherical wavefront. The event at Cassini at 8.4 AU was large and disturbed the solar wind for almost a month. No event that large had ever been seen at Cassini before. We believe that if the November 4 event had been directed toward the Earth catastrophic consequences would have resulted.

76. The October/November 2003 Solar Events: Demonstration of how the Solar Wind Controls the Radiation Belts

M. Cartwright, C. T. Russell, R. Skoug, C. W. Smith, S. Kanakal and L. Jian
The solar events of October and November 2003 provided an unusual set of solar wind conditions that eventually led to the formation of a new radiation belt near L=2. The

major changes in the radiation belts occurred when the magnetosphere became highly agitated with compressional waves at the drift period of relativistic particles. These periods were neither correlated with southward IMF nor with simply the fast streams but must have been driven by intervals of fluctuating plasma density within the streams. Wave powers were enhanced by up to a factor of 2000 compared to measurements made in the previous year in the same region of space.

77. Variation of ICMEs with Heliocentric Distance

Lan Jian

Interplanetary coronal mass ejections evolve as they propagate outward. Their transit speed from the Sun indicates that their velocities tend to approach the speed of the solar wind in which they are embedded. Their profile of decreasing velocity shows that they are expanding. Observations of the same event at two different distances also reveal that they are expanding as they move outward. To determine if the evolution of ICME structure consists of more than changes in just velocity dimensions, we examine ICMEs from 0.7 AU on Pioneer Venus, at 1 AU on ISEE, IMP8, ACE and Wind, and beyond 1 AU on NEAR and Cassini. We find that by 5 AU the stream structure generally dominates the ICME structure and discrete ICMEs are difficult to identify.

78. Successive CMEs and Long Lived Geomagnetic Storms

H. Xie, N. Gopalswamy, P. K. Manoharan, S. Yashiro, A. Lara, and S. Iepri, CUA

Coronal mass ejections (CMEs) are major solar events that are known to cause geomagnetic storms. Isolated geomagnetic storms typically have a recovery phase less than ~ 1 day. There are some storms with a recovery phase exceeding ~ 3 days. We call them long lived geomagnetic storms (LLGMS). We identified more than 30 events with $Dst < -100$ during 1998-2003. We studied the relation between front-side CMEs and LLGMS. The CMEs were observed by the Solar and Heliospheric Observatory (SOHO) mission. We use the Fe charge state data measured on the Advanced Composition Explorer (ACE) to identify the associated interplanetary coronal mass ejections (ICMEs). The possible link between LLGMS, successive CMEs, and the effect of interacting CMEs has been investigated. We found that LLGMS with a recovery phase > 3 days are caused by successive CMEs, which may or may not interact with each other when traveling toward Earth. By using empirical CME propagation model incorporated with cone model projection correction we investigate the effect of interacting successive CMEs on the intensity of LLGMS.

79. A numerical study of the interaction between two ejecta in the interplanetary medium: one and two dimensional hydrodynamic simulations

A. Gonzalez-Esparza, UNAM

We studied the heliospheric evolution in 1 and 2 dimensions of the interaction between two ejecta-like disturbances: a faster ejecta overtaking a previously launched slower

ejecta 1. The study is based on a hydrodynamic model using the ZEUS-3D code. The simulation shows that when the faster ejecta 2 overtakes ejecta 1 there is an interchange of momentum between the two ejecta, the leading ejecta 1 accelerates and the trailing ejecta 2 decelerates. Both ejecta tend to arrive at 1 AU having similar speeds, but with the front of ejecta 1 propagating faster than the front of ejecta 2. The momentum is transferred from ejecta 2 to ejecta 1 by the shock wave driven by ejecta 2 when it passes through ejecta 1. The shock waves driven by the two ejecta merge together into a single stronger shock. The 2-D simulation shows that the evolution of the dynamics can be very complex and there are very different signatures of the same event at different viewing angles.

80. Spectral Properties of Interplanetary Type II Radiobursts

Ernesto Aguilar-Rodriguez, CUA/NASA-GSFC/UNAM

We present preliminary results of some spectral properties associated with interplanetary Type II radio emission. Type II radio bursts are signatures of violent eruptions from the Sun that result in shock waves propagating through the corona and the interplanetary medium. We investigated the relative bandwidth of all the type II bursts observed by the Radio and Plasma Wave Experiment (WAVES) on board the Wind spacecraft. We obtained three sets of events, based on the frequency domain of occurrence: 149 events in the low frequency domain (30 KHz to 1000 kHz detected by the RAD1 receiver), 218 events in the high frequency domain (1-14 MHz, observed by the RAD2 receiver), and 81 events that spanned both domains (RAD1 and RAD2). We present statistical results for the bandwidth-to-frequency ratio in the three subsets as well as a comparison of our results with the Type II solar radio bursts observed by ISEE-3 radio experiment, which is similar to WAVES/RAD1.

81. The Cassini Solar Faraday Rotation Experiment

E.A. Jensen, UCLA/IGPP

The Cassini Solar Faraday Rotation Experiment was conducted during the spacecraft's solar conjunctions in 2002 and 2003. A total of 160 hours of open-loop radio science data was collected at frequencies of 8 and 32 GHz (X- and Ka-bands), i.e., frequencies much higher than the plasma frequencies, but sufficiently low to undergo measurable Faraday rotation in the solar corona. During the 2002 experiment, four Coronal Mass Ejections crossed the signal ray path between Cassini and the Earth, each one imparting a different signature in the radio sounding data. The first occurred during the day of conjunction when the spacecraft's signal ray path passed to within approximately 2 solar radii of the Sun's center. The second occurred 1 day later at a solar offset distance of 3 solar radii. As shown by the EIT imager on SOHO, this event was oriented almost perpendicular to the first CME. It had a significant impact on the signal, causing the Ka-band translator on Cassini to lose lock on the uplink signal from Earth. The 3rd and 4th CMEs occurred 2 days later as a paired event when the Cassini solar offset was roughly 5 solar radii. The data received during the minimum solar elongation attained during the 2003 conjunction (proximate ray path point: 1.25 solar radii) were highly variable and represent the closest radio occultation measurement to the surface of the Sun. We discuss the Cassini Faraday

Rotation data and develop models of the coronal electron density and magnetic field to simulate the measurements.

82. Wind Satellite Observations of Interplanetary Magnetic Holes

M. Stevens, J. Kasper, A. Lazarus, MIT Center for Space Research

A search for magnetic holes (MHs) was conducted over an eight year period of WIND magnetic field data. From early 1995 to late 2002, about 20,000 linear, isolated magnetic holes were observed in the solar wind with durations of 60 ms to 300s. Ion distributions measured by the WIND/SWE Faraday Cup instrument provide a first look at the plasma parameters for a statistical sample of this magnitude. The parameters of holes with sizes on the order of the proton inertial length are of particular interest for understanding the mechanisms behind of MHs. Evidence that MHs originate in mirror-mode unstable regions will be discussed.

83. Coronal Mass Ejections and Galactic Cosmic Rays

Alejandro Lara, Catholic University of America

We present the results of a study on the evolution of the occurrence rate of coronal mass ejections (CMEs) and its impact on the galactic cosmic ray (GCR) flux. We use CME data from the Solar and Heliospheric Observatory (SOHO) mission and the GCR data from the Climax and IMP-8 spacecraft. The period of study is the entire mission life period of SOHO from 1996 to the present, which corresponds to the ascending, maximum and part of the descending phases of the solar cycle 23. We discuss the possibility that CMEs are the building blocks of the global merged interaction regions which are thought to block the GCRs and hence cause the long term GCR modulation. We also discuss the role of CMEs in the long lasting Forbush decreases observed at 1 AU. Work supported by NSF's SHINE (ATM 0204588) and NASA's Living With a Star (LWS)

84. Solar system environment effects on cosmic-ray propagation in the heliosphere: Consequences for cosmogenic isotope production

Vladimir Florinski, University of California, Riverside

The solar system is traveling through highly inhomogeneous interstellar medium. Our local interstellar environment consists of low density hot regions, evacuated by supernova explosions, and of interstellar clouds of varying density and temperature. During its journey around the center of the Galaxy, the Sun was likely to encounter at least several such clouds and is currently traveling through a warm, relatively tenuous Local Cloud. The properties of the cloud control the size and shape of the heliosphere and, therefore, the amount of modulation experienced by galactic cosmic rays (GCRs) by the time they reach Earth, as they propagate through the irregular magnetic field embedded in the solar wind flow. GCRs produce cosmogenic isotopes in the Earth's atmosphere in spallation reactions, providing an important record of heliospheric and geomagnetic effects in the past. Previously, we showed that increasing the density of the cloud surrounding the solar system by a factor of 30 leads to an increase in 1 AU GCR fluxes by a factor of 1.5-3,

and that cloud encounters may have been responsible for the observed peaks in Be-10 records 35 and 60 thousand years ago. Here we present initial results from a more comprehensive investigation of the global structure of the heliosphere embedded in clouds of varying density, from the present conditions in the Local Cloud with $n=0.3 \text{ cm}^{-3}$ to the extreme case of dense molecular clouds with $n=5000 \text{ cm}^{-3}$. We now derive GCR distribution from the solution of the 2D Parker equation using the global magnetic field as a background to determine the diffusion parameters, which is a significant improvement over our earlier model.

85. Magnetic Effects Change Our View of the Heliosheath

Merav Opher

TBA

86. Solitary waves and weak double layers in the Heliosphere

Li-Jen Chen, University of Iowa

We combine results from our theoretical investigations and observations from the Cassini spacecraft to understand the properties of solitary waves and weak double layers in the heliosphere. We have derived the allowed parameter space for both the electron and ion mode solitary waves. In the case of electron (ion) mode solitary waves, our theory shows that the maximum allowed potential amplitude decreases with increasing T_e/T_i (T_i/T_e). The amplitudes of both the observed solitary waves and weak double layers are estimated to be much less than one percent of the plasma thermal energy per charge, and are larger at smaller heliospheric distances. The probability of finding solitary waves and weak double layers are about the same. We consider the weak amplitude property to be mainly due to the finite temperature ratio and the finite magnetic field strength. The dependence on the heliospheric distance is likely a consequence of the variation in the plasma density at different heliospheric distances.

87. MHD Modeling of Differential Rotation in Coronal Holes

Roberto Lionello, SAIC

Coronal holes are magnetically open regions from which the solar wind streams. Magnetic reconnection has been invoked to reconcile the apparently rigid rotation of coronal holes with the differential rotation of magnetic flux in the photosphere. This mechanism might also be relevant to the formation of the slow solar wind, whose properties seem to indicate an origin from the opening of closed field regions. We have used our MHD model in spherical coordinates to study the effect of differential rotation on coronal holes. We have started from a magnetic flux distribution as in Wang et al. (1996), which consists of a bipolar magnetic region superimposed on a background dipole field. We have applied differential rotation for the equivalent of 5 solar rotations. We will describe the evolution of the coronal holes in the model and the reconnection of the magnetic field lines driven by the differential rotation. Possible consequences for the origin of the slow solar wind will also be discussed.

88. Is there a chromospheric footprint to the solar wind?

Robert Leamon, NASA GSFC

S.W. McIntosh and R.J. Leamon Using time series of UV continuum oscillations of the chromospheric plasma observed by TRACE that are co-spatial with coronal holes observed in the EUV. We use a combination of Fourier and Wavelet methods to study the phase-differences and travel-times" between oscillations observed in the continuum filter band-passes that allow us to identify nascent coronal holes and provide information about their thermodynamic base; in the chromosphere. Outflows from coronal holes can be reliably identified the solar wind in situ from velocity, density, temperature and composition measurements. We demonstrate a double-blind test that can positively identify the solar wind outflows with the corresponding disk-center coronal hole, without looking at coronal data. Although limited by the statistics of a small data set, we present preliminary results correlating the stratification of the solar atmosphere to the properties of the solar wind at 1AU, and the implications to solar wind acceleration models.

89. The Fast Solar Wind Then and Now

Joseph Hollweg, UNH

Before the discovery of the fast solar wind in the mid - 1970s, it was known that even the average solar wind could not be well explained by models in which electron heat conduction was the energy source and the electron pressure gradient was the principal accelerating force. The Alfvén waves discovered around 1970 were thought for a while to provide the sought - after additional energy and momentum, but their wave pressure ultimately failed to explain the rapid acceleration of the fast wind close to the Sun. By the late 1970s, various in situ data were suggesting that protons and heavy ions were being heated and accelerated by the ion - cyclotron resonance far from the Sun. This notion was soon applied to the acceleration region in coronal holes close to the Sun. The models which resulted suggested that the fast wind could be driven mainly by the proton pressure gradient (which is mainly the mirror force if the anisotropy is large), and that the high temperatures and flow speeds of heavy ions could originate within a few solar radii of the coronal base; these models also emphasized the importance of treating the extended coronal heating and solar wind acceleration on an equal footing. By the mid 1990s, SOHO, especially the UVCS (Ultraviolet Coronagraph Spectrometer), provided remarkable data which have given great impetus to studies of the ion cyclotron resonance as the principal mechanism for heating the plasma in coronal holes, and ultimately driving the fast wind. We will discuss the basic ideas behind current research, emphasizing the particle kinetics. We will discuss remaining problems such as the source of the ion - cyclotron resonant waves (direct launching, turbulence, microinstabilities), the roles of inward - propagating waves and instabilities, the importance of oblique propagation, and the electron heating. Some alternatives will also be mentioned.

90. Alfvén wave filamentation with application to solar wind turbulence and coronal heating

R.P.Sharma, Indian Institute of Technology, New Delhi, India

This work presents the nonlinear effects associated with the Alfvén wave having finite transverse wave number. Ponderomotive and nonlinear electron heating nonlinearities have been considered and model equations for the dynamical evolution of the Alfvén wave have been established. Semi-analytical and numerical solutions have been obtained to study the breaking of Alfvén wave into filamentary structures. Its effect on solar wind turbulence and coronal heating has been pointed out.

91. Factors controlling electron heat flux in the solar wind

Christina Pagel, Boston University

Suprathermal electrons ($E > 80 \text{ eV}$) carry heat flux away from the Sun. Their distributions can be separated into an isotropic halo and a focused strahl parallel or antiparallel to the solar wind magnetic field. Processes controlling the observed strahl are not well understood. Insight into these processes has important implications for models both of coronal expansion and of heliospheric magnetic flux. We define a parameter to characterise electron pitch angle isotropy and investigate its behaviour using data for 1995 from the Wind 3DP instrument. We show that the heat flux depends strongly on both the number of hot electrons streaming from the Sun, and on the local plasma conditions. We apply multiple linear regression to simulate both electron heat flux and pitch angle isotropy. Our analysis covers a range of electron energies and solar wind conditions. We show how the strength of the strahl, and the electron pitch angle distribution, depend on energy, and investigate differences between solar wind streams.
