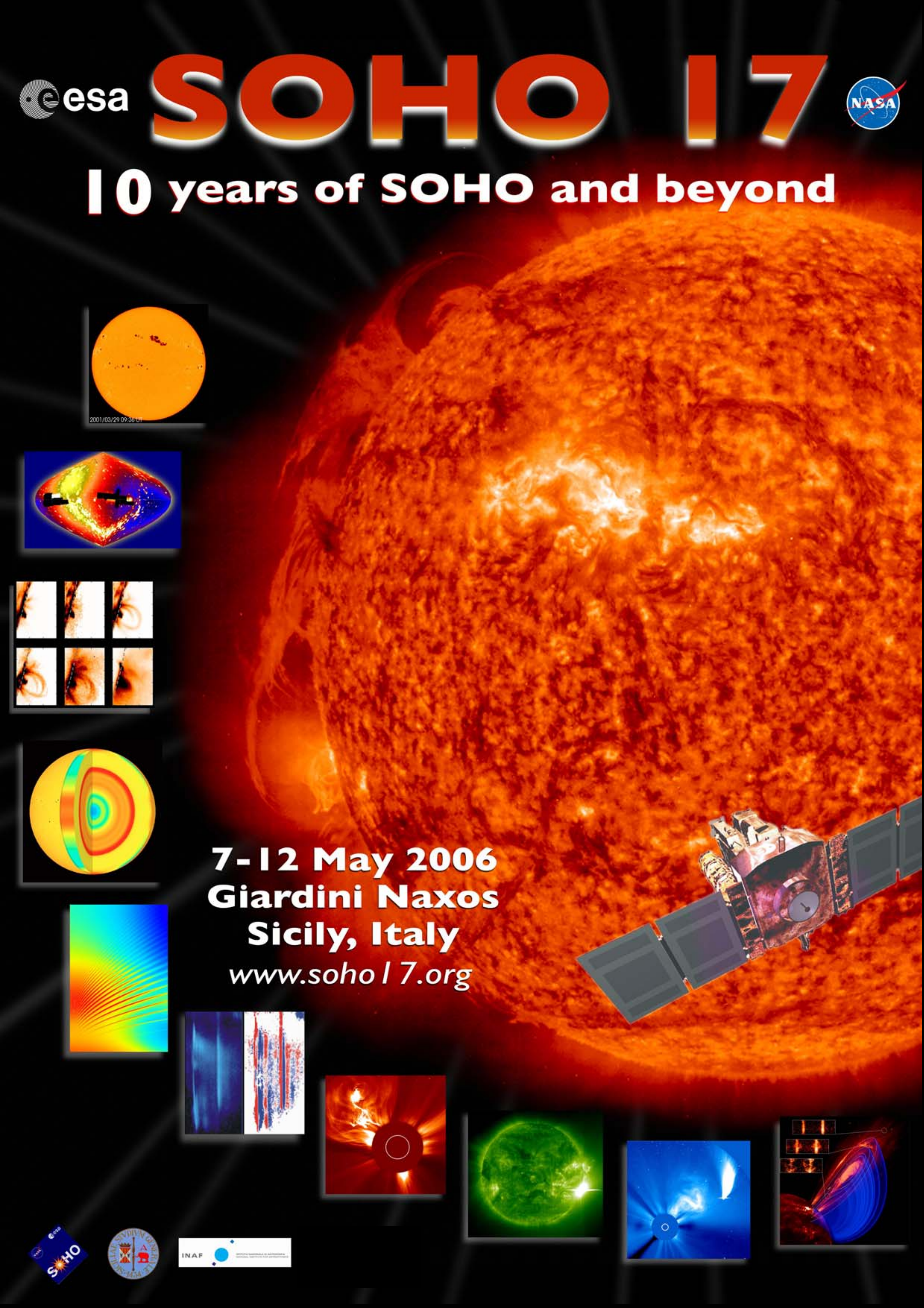
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SOHO 17
NASA
10 years of SOHO and beyond
2001/03/29 09:36 UT
7-12 May 2006
Giardini Naxos
Sicily, Italy
www.soho17.org
SOHO
INAF

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SOHO 17: 10 Years of SOHO and Beyond

Background:

The Solar and Heliospheric Observatory (SOHO) is a mission of international cooperation between ESA and NASA to study the Sun, from its deep core to the outer corona, the solar wind, and the interaction with the interstellar medium.
It was launched a decade ago on 2 December 1995, and in April 2006 it will have completed 10 years of successful scientific operations.

In celebration of this milestone, we are organizing a meeting to review the many and varied scientific accomplishments of SOHO. An important focus of the meeting will be the conceptual and theoretical advances that coordinated multi-instrument and multi-mission observations of the Sun have helped us make in the last decade, and to examine the role that the continued observations of SOHO will play within the context of future missions.

The meeting will cover the full breadth of SOHO science, organised around the following seven sessions:

1) Solar Interior: From Exploration to Experimentation
   Invited speakers: D. Gough, S. Basu, T. Corbard

2) Magnetic Variability: From the Tachocline to the Heliosphere
   Invited speakers: L. Gizon, S. Tobias, Z. Mikic

3) Atmospheric Heating and Solar Wind Origin: MHD vs. Plasma Physics
   Invited speakers: J. Klimchuk, V. Hansteen, G. Poletto

4) Solar Variability and its Effects on the Heliosphere and the Earth
   Invited speakers: P. Foukal, G. Simnett, B. Klecker

5) SOHO and the Solar System
   Invited speakers: R. Lallement, D. Biesecker

6) The SOHO Roller-Coaster: Mission History and Personal Memories

7) From SOHO to ILWS and Beyond: Visions for Solar Research from Space
   Invited speakers: K. Schrijver, J. Gurman, P. Cargill

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7 Centro Commerciale
8 Piscina Hotel
9 Auditorium
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11 Bar Stella di Mare
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14 Centro Velico
15 Beauty Center
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18 Palestra
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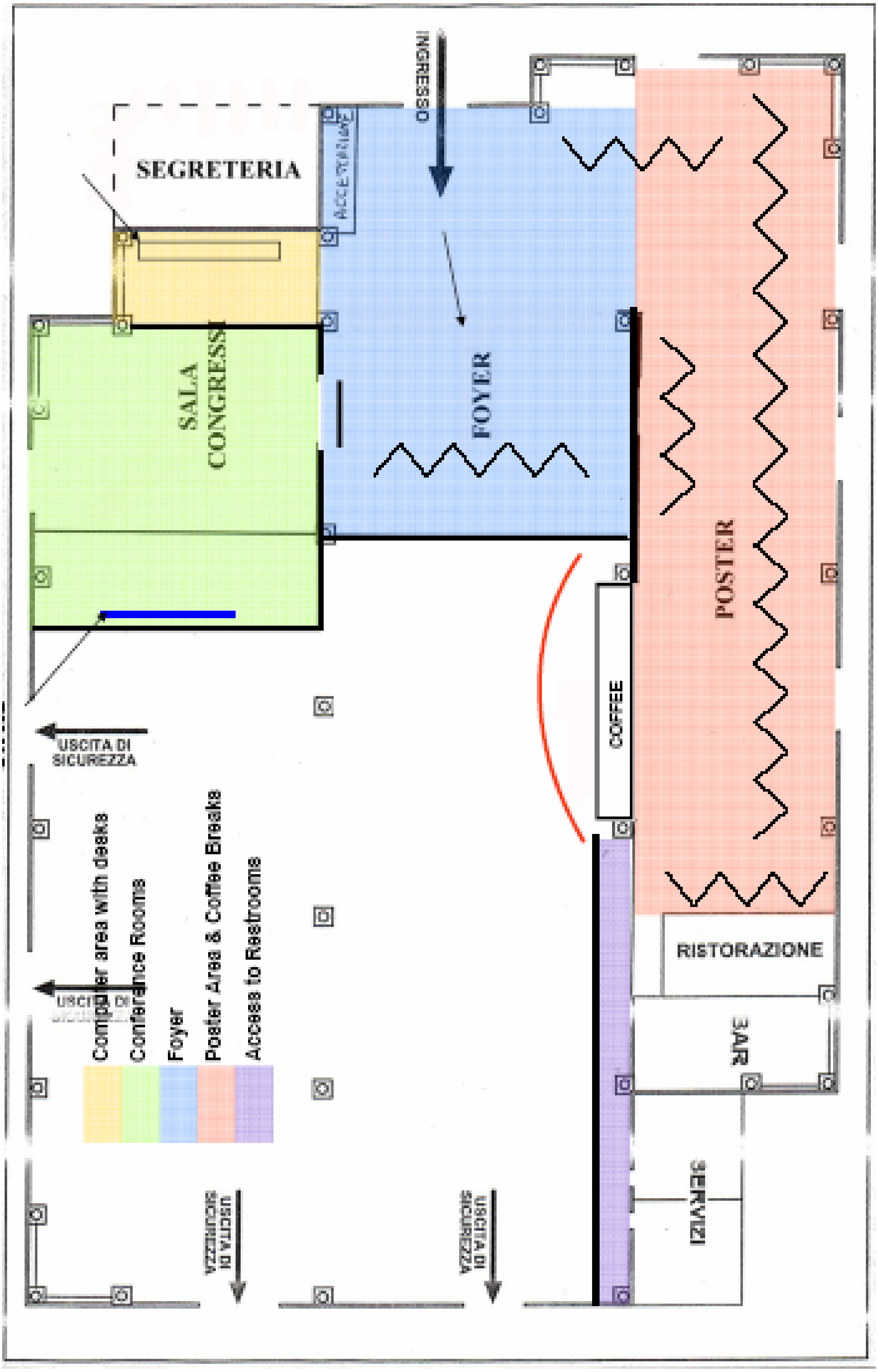

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Foyer
Poster Area & Coffee Breaks
Access to Restrooms

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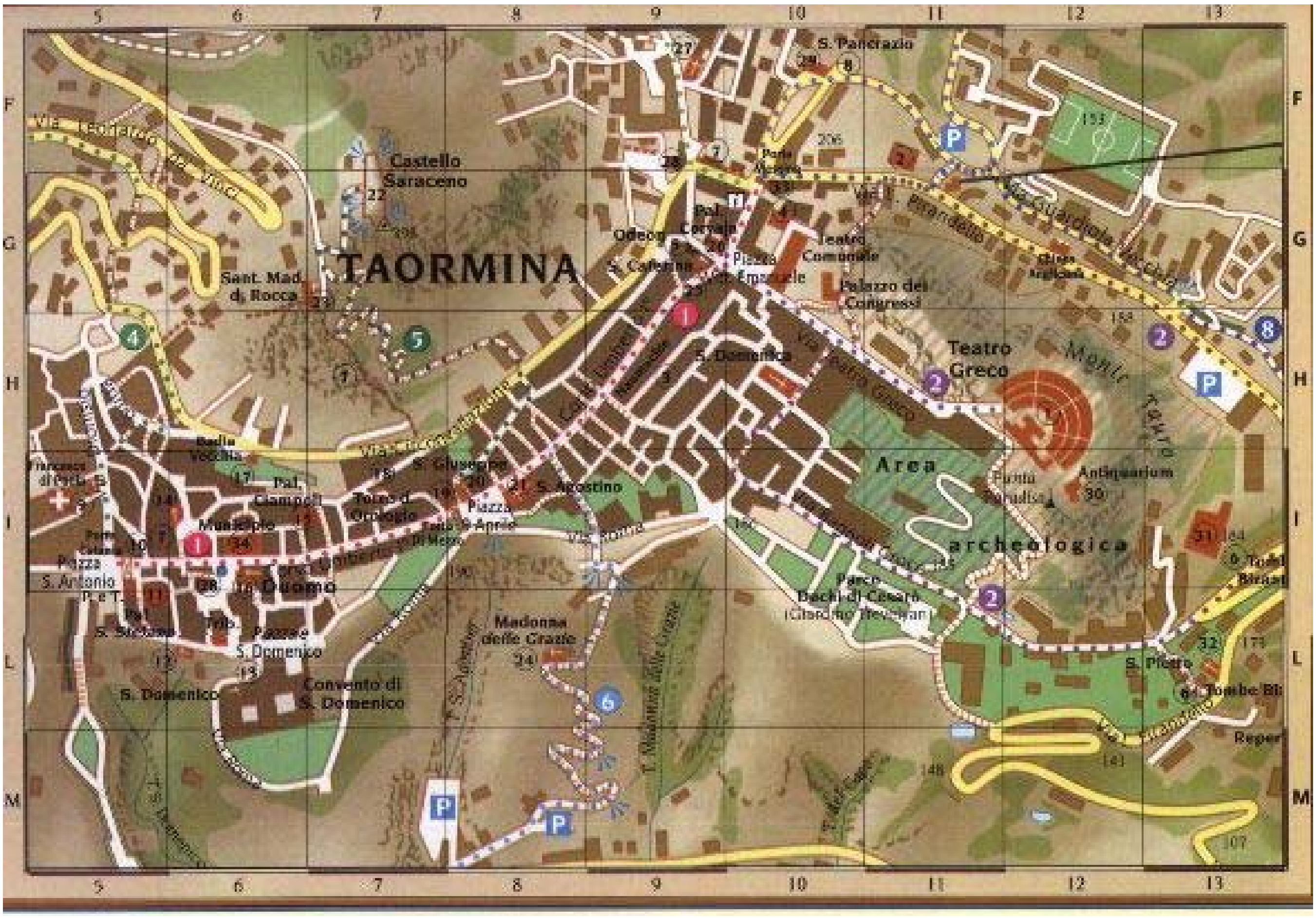

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SOHO 17

10 Years of SOHO and Beyond

7 – 12 May 2006 Giardini Naxos, Italy

Conference Social Programme

The social event programme has been designed to provide participants with an opportunity to relax, and to meet each other in a less formal environment.

Sunday, May 7th 2006, 7:00 p.m.

Welcome reception at the Naxos Beach Resort

Refreshments will be served on a beach patio facing the sea giving everyone the opportunity to introduce themselves and share time with colleagues in an informal and friendly atmosphere. In case of bad weather, alternative options will be available inside the resort.

Wednesday, May 10th 2006, 2:00 p.m.

Half-day Excursion to Alcantara Gorges/Tour & Wine-tasting at Castiglione di Sicilia

Along its course, in tens of thousands of years, the river Alcantara has created a valley that constitutes a geological landscape absolutely unique in the world. The river, flowing in the black Etna basalts and eroding them for thousands of years in various stretches, has created peculiar lavic ravines, locally referred to as "gorges", with vertical walls rising steeply tens of metres. Entering the narrow but spectacular gorges in the Larderia area, you can clearly see the result of the very slow cooling of thick lavic bodies which have generated unusual hexagonal basaltic prisms, commonly known as "columnar basalts".

This gorge can be reached on foot or by elevator and it is possible to walk along the river bed.

Then you will continue towards Castiglione di Sicilia (the area is renowned for its fine wines) where, after a guided tour of the medieval town, a wine-and food-tasting event will take place. Wines and local products will be also available for purchase from local wineries and shops. (Transfer by coach, 35 kilometres from Giardini Naxos).

Further info available at www.parks.it/parco.alcantara/Eindex.html or www.comune.castiglionedisicilia.ct.it/home.php

Thursday, May 11th 2006, 7:00 p.m.

SOHO 17 Conference Dinner

The Conference Dinner is set at the conclusion of the "SOHO reunion" on Thursday 11th May, at Hotel Villa Diodoro in Taormina, near the beautiful public gardens, with a magnificent view of Giardini Naxos Bay, Taormina and Mount Etna. Coaches will leave the hotel at 7.00 p.m. to reach Taormina. A group performing popular songs and music of southern Italy will give a concert during the dinner.

The Welcome Reception, Excursion/Tour & Wine Tasting and Conference Dinner will be free of charge for registered participants and registered accompanying persons.

Extra Tours for Accompanying Persons (not included in participation fees):

The excellent geographical position of Giardini Naxos is considered an ideal base for easy excursions to the whole territory of Sicily.

Optional tours to various tourist locations in Sicily will be organized on request by the hotel travel agency and can be purchased during the conference. Further information will be posted on the conference website or can be requested from the hotel when participants book their rooms.

SOHO 17: 10 Years of SOHO and Beyond
7 - 12 May 2006
Giardini Naxos, Sicily, Italy

Provisional Timetable *(subject to change)*

	Sunday, May 7th	Monday, May 8th	Tuesday, May 9th	Wednesday, May 10th	Thursday, May 11th	Friday, May 12th
Morning		800 Registration	800 Registration	800 Registration	830 Secretariat	830 Secretariat
		0900-1035 Welcome & Session 1a	0900-1030 Session 3a	0900-1030 Session 4a	0900-1015 Session 4c	0900-0930 Session 5b 0930-1035 Session 7a
		1035-1115 Coffee Break at Palanaxos	*1030-1115 Coffee Break at Palanaxos*	*1030-1100 Coffee Break at Palanaxos*	*1015-1100 Coffee Break at Palanaxos*	*1035-1105 Coffee Break at Palanaxos*
		1115-1230 Session 1b	1115-1230 Session 3b	1100-1230 Session 4b	1100-1130 Session 4d 1130-1230 Session 5a	1105-1145 Session 7b 1145-1300 Discussion
Mid-Day		*1230 - 1430 Luncheon*	*1230 - 1430 Luncheon*	*1230 - 1400 Luncheon*	*1230 - 1430 Luncheon*	*1300 Luncheon*
Afternoon		1430-1600 Session 2a	1430-1545 Session 3c	1400 - 2100 (approximately) Excursion to Alcantara Gorges and Tour & Wine-tasting at Castiglione di Sicilia	1430-1600 Session 6a	
	1600 - 1800 Early Bird Check-In	*1600-1630 Coffee Break at Palanaxos*	*1545-1615 Coffee Break at Palanaxos*		*1600-1645 Coffee Break at Palanaxos*	
		1630-1730 Session 2b	1615-1700 Session 3d		1645-1800 Session 6b	
Evening	1900 Welcome Reception at Naxos Beach Resort	1730-1930 Dedicated Poster Session and Reception	1700-1900 Poster Session and Reception		1900 Conference Dinner at Villa Diodoro, Taormina	

SOHO 17: 10 Years of SOHO and Beyond

7-12 May 2006, Giardini Naxos, Sicily

Sunday, 7 May 2006, AM

16:00-18:00 Early Bird Check-In at Naxos Beach Resort
19:00 Welcome Reception at Naxos Beach Resort

Monday, 8 May 2006, AM

08:00 Registration at Palanaxos

09:00 Welcome Address
Flamini, Enrico
Agenzia Spaziale Italiana

Session 1: Solar Interior: From Exploration to Experimentation
Time: 09:05 - 12:30

09:05 Helioseismological Determination of the State of the Solar Interior — p.1
Gough, Douglas
University of Cambridge

09:35 Interpreting Solar Frequencies: Methods and Techniques — p.2
Basu, Sarbani
Yale University

10:05 Recent Progresses on g-mode Search — p.3
Appourchaux, Thierry et al.
Institut d'Astrophysique Spatiale

10:20 Looking for Asymptotic G Modes using GOLF Aboard SoHO — p.4
Garcia, Rafael A. et al.
Service d'Astrophysique CEA/Saclay

10:35 – 11:15 Coffee Break and Posters at the Palanaxos

11:15 Helioseismic Determination of Subsurface Fluid Dynamics — p.5
Corbard, Thierry
Observatoire de la Cтte d'Azur, FRANCE

11:45 SOHO and Time-Distance Helioseismology — p.6
Duvall, Thomas[1] et al.
NASA/Goddard Space Flight Center

12:00 Subsurface Flows and the Evolution of Solar Filaments — p.7
Hindman, Bradley[1] et al.
University of Colorado

12:15 Resonant Oscillation Modes and Background in Realistic Hydrodynamical Simulations of Solar Surface Convection — p.8
Straus, T.[1] et al.
INAF - Osservatorio Astronomico di Capodimonte

12:30 – 14:30 Luncheon at the Naxos Beach Hotel

Monday, 8 May 2006, PM

Session 2: **Magnetic Variability: From the Tachocline to the Heliosphere**
Time: **14:30 - 17:30**

14:30	Probing Solar Activity and Convection with Local Helioseismology *Gizon, Laurent* Max-Planck-Institut fuer Sonnensystemforschung,	p.9
15:00	The Solar Dynamo: What we know, what we think we know and what progress can we make. *Steven, Tobias* University of Leeds	p.10
15:30	Does visibility effect fully explain a cycle variations of coronal bright points? *Sattarov, Isroil* et al. Tashkent State Pedagogical University	p.11
15:45	The Coronal Wave Damping Problem: Mechanisms for wave damping in the solar corona *Andries, Jesse*[1] et al. KULeuven	p.12

16:00 – 16:30 Coffee Break and Posters at the Palanaxos

16:30	MHD Modeling of the Solar Corona and Inner Heliosphere *Mikic, Zoran* et al. SAIC	p.13
17:00	Magnetic variability of the electron density in the solar corona *Lamy, Philippe* et al. Laboratoire d'Astrophysique de Marseille	p.14
17:15	Heliospheric constraints on the coronal magnetic field *Zurbuchen, Thomas H* University of Michigan	p.15

Poster Session: **Dedicated Poster Session and Reception**
See list of posters, beginning on page ix
Time: **17:30 - 19:30**

Tuesday, 9 May 2006, AM

08:00	Registration at Palanaxos	

Session 3: **Atmospheric Heating and Solar Wind Origin: MHD vs. Plasma Physics**

Time: **09:00 - 14:30**

09:00	Heating of the Magnetically Closed Corona *Klimchuk, James* Naval Research Lab	p.16
09:30	New models of the solar chromosphere and transition region determined from SUMER observations *Avrett, Eugene* Smithsonian Astrophysical Observatory	p.17
09:45	Results of the Analysis of Solar Active Regions and their Loops at Montana State *Martens, Petrus* et al. Montana State University	p.18
10:00	First VUV Sun-as-a-star spectrum compared to other cool stars *Peter, Hardi* Kiepenheuer-Institut	p.19
10:15	Damped coronal loop oscillations: time-dependent analysis *Terradas, Jaume* et al. Universitat de les Illes	p.20

10:30 – 11:15 Coffee Break and Posters at the Palanaxos

11:15	Heating of the Quiet Solar Corona *Brooks, David H.* et al. Naval Research Laboratory	p.21
11:30	Coronal heating and solar wind acceleration: SOHO observations and theoretical advances *Velli, M.* University of Florence	p.22
12:00	Plasma diagnostics of the large-scale corona with SUMER *Landi, Enrico* et al. Artep Inc.	p.23
12:15	Solar coronal-hole plasma densities and temperatures *Wilhelm, Klaus* Max-Planck-Institut fuer Sonnensystemforschung	p.24

12:30 – 14:30 Luncheon at the Naxos Beach Hotel

Tuesday, 9 May 2006, PM (Session 3 cont')

14:30	Solar Wind Forecasting from the Chromosphere *Leamon, Robert* et al. L-3 Communications/ NASA GSFC	p.25
14:45	Diagnostics and Modelling of the Solar Wind Source Regions *Poletto, Giannina* INAF - Arcetri Astrophysical Observatory	p.26
15:15	Coronal Hole Properties During the First Decade of UVCS/SOHO *Miralles, M. P.* et al. Harvard-Smithsonian Center for Astrophysics	p.27
15:30	Properties of Polar Plumes'Plasma from Coronal Emission Modelling *Raouafi, Nour-Eddine* National Solar Observatory	p.28

15:45 – 16:15 Coffee Break and Posters at the Palanaxos

16:15	Structure in the outflow of the solar wind *Gabriel, Alan* et al. Institut d'Astrophysique Spatiale	p.29
16:30	Slow wind in the extended corona *Abbo, Lucia* et al. INAF- Istituto Nazionale di Astrofisica	p.30
16:45	Solar Wind Heavy Ion Speed and Density Comparisons *Ipavich, Fred* et al. University of Maryland	p.31

Poster Session: **Dedicated Poster Session and Reception**
See list of posters, beginning on page ix

Time: **17:00 - 19:00**

Wednesday, 10 May 2006, AM

08:00 Registration at Palanaxos

Session 4: **Solar Variability and its Effects on the Heliosphere and the Earth**

Time: **09:00 - 12:30**

09:00	Solar Luminosity Variation: Implications for Stellar and Climate Physics *Foukal, Peter* Heliophysics, Inc	p.32
09:30	Helioseismic responses induced by the proton-rich flare of October, 28, 2003 *Zharkova, Valentina* et al. University of Bradford	p.33
09:45	Photospheric field evolution in the source regions of coronal mass ejections *Bothmer, Volker* et al. University of Goettingen	p.34
10:00	Using SOHO to Understand CME-Producing Quiet-Region Filament Eruptions *Sterling, Alphonse* et al. NASA/MSFC/NSSTC	p.35
10:15	Multiscale Optical Flow For Analysing The Dynamics In Solar EUV Images. Algorithm, Calibration And First Results *Hochedez, Jean-Franηois E.* et al. Royal Observatory Belgium	p.36

10:30 – 11:00 Coffee Break and Posters at Palanaxos

11:00	An Experiment in Forecasting the Eruption of Quiescent Prominences Using EIT 304A Images *Martin, Sara* et al. Helio Research	p.37
11:15	10 Years of CME Onset Studies with SOHO/CDS *Bewsher, Danielle* et al. CCLRC/RAL	p.38
11:30	SOHO Contributions to Understanding CMEs *Simnett, George* University of Birmingham	p.39
12:00	Paradigm Shifts Using LASCO Results *Howard, Russell* Naval Research Lab	p.40
12:15	Detections of Coronal Mass Ejection Shocks with Lasco *Vourlidas, Angelos* Naval Research Laboratory	p.41

12:30 – 14:00 Luncheon at the Naxos Beach Hotel

Excursion: **Excursion to Alcantara Gorges and Tour & Wine Tasting at Castiglione di Sicilia**

Time: **14:00 – 21:00 Approximately**

Thursday , 11 May 2006, AM

08:00 Registration at Palanaxos

Session 4 (con't): Solar Variability and its Effects on the Heliosphere and the Earth
Time: 09:00 - 11:30

09:00	SOHO UVCS and Mauna Loa Mark IV observations of a slow CME below 2 solar radii *Bemporad, Alessandro* et al. University of Florence	p.42
09:15	Studying Halo and partial Halo Coronal Mass Ejections through UV Spectra *Ciaravella, A* et al. INAF-Osservatorio Astronomico di Palermo	p.43
09:30	Solar Energetic Particles: Progress of Our Understanding in the SOHO Era *Klecker, Berndt* Max-Planck-Institut fὁr extraterrestrische Physik,	p.44
10:00	Progress Toward Measurements of Suprathermal Tails in Coronal Proton Velocity Distributions *Kohl, John* et al. Harvard Smithsonian CfA	p.45

10:15- 11:00 Coffee Break and Posters at Palanaxos

11:00	Particle acceleration in turbulent coronal loops: the role of intermittency *Malara, Francesco* et al. UnivarsitΓ della Calabria	p.46
11:15	Energetic Particles Measured by Ephin Instrument during the Last Solar Magnetic Field Polarlty Reversal *R.-Pacheco, Javier* et al. ASRG/UAH	p.47

Session 5: SOHO and the Solar System
Time: 11:30 - 12:30

11:30	1000 and counting: The Remarkable SOHO Contributions to Cometary Science *Biesecker, Douglas* NOAA/SEC	p.48
12:00	Helium/hydrogen fractionation in the solar wind – how much is due to inefficient Coulomb drag? *Bochsler, Peter* et al. University of Bern	p.49
12:15	SOHO/UVCS Observation of Sungrazing Comet C/2002 S2 *Giordano, Silvio* et al. INAF - Osservatorio Astronomico di Torino	p.50

12:30 – 14:30 Luncheon at the Naxos Beach Hotel

Thursday , 11 May 2006, PM

Session 6:	**The SOHO Roller-Coaster: Mission History and Personal Memories**
Time:	**14:30 - 18:00**

14:30	*Bonnet, R.M.*	
14:50	*Vandenbussche, F.*	
15:10	SOHO, what happened after 1999? *van Overbeek, Ton* European Space Agency	p.51
15:25	SOHO- Cleanliness in retrospect *THOMAS, Ronald* Ex-ESA	p.52
15:40	*Felici, Fabrizio*	

16:00 – 16:45 Coffee Break at the Palanaxos

16:45	SOHO - How it all began, almost 24 years ago. *Schwenn, Rainer* et al. Max-Planck-Institut fὀr Sonnensystemforschung	p.53
16:50	"Can't go sailing -- I'm SOL!" Some reminiscences about life in the early EOF *DeForest, Craig* Southwest Research Institute	p.54
16:55	How to see Northern Lights through the clouds in England *Del Zanna, Giulio* University College London	p.55
	Other contributions: M. Huber, M. Arduini, C. Holmes, D. Machi, J.-P. Olive, A. Poland, V. Domingo, A. Gabriel, P. Scerrer, R. Harrison, G. Noci, P. Brekke	

Conference Dinner:	**Villa Diodoro, Taormina**
Time:	**19:00 – 24:00 Approximately**

Friday, 12 May 2006, AM

08:00 Registration at Palanaxos

Session 5 *(cont')*: **SOHO and the Solar System**
Time: 09:00 - 09:30

09:00	SOHO and the HELIOSPHERE *Lallement, Rosine* CNRS	p.56

Session 7: From SOHO to ILWS and Beyond: Visions for Solar Research from Space
Time: 09:30 - 11:40

09:30	On the long-term future of solar and heliospheric physics *Schrijver, Carolus J.* Lockheed Martin Advanced Technology Center	p.57
09:50	SOHO: A look back from 2025 *Gurman, Joseph B.* NASA Goddard Space Flight Center	p.58
10:10	Prospects for coronal physics *Cargill, Peter* Imperial College	p.59

10:35 – 11:05 Coffee Break and Posters at Palanaxos

11:05	Solar Microscopy: Unveiling the Sun's basic physical processes at their intrinsic scales *Solanki, Sami K.* et al. Max Planck Institute for Solar System Research	p.60
11:15	Can we finally solve the problems of "Coronal Heating " and "Solar Wind Acceleration" in the Cosmic Vision era ? *Maksimovic, M.* et al. LESIA, Observatoire de Paris	p.61
11:25	A Very High Resolution Vision for Solar Physics *Damı, Luc* Service d'Aıronomie du CNRS	p.62
11:35	Imaging UV Spectroscopy of the Corona: from UVCS/SOHO to ILWS missions *Fineschi, Silvano* et al. INAF-Osservatorio Astronomico di Torino	p.63

Closing Session: Open Discussion
Time: 11:45 - 13:00
Chair: K. Schrijver

SOHO 17: List of Posters

1 Solar Interior: From Exploration to Experimentation

P1 **SEISMIC DETERMINATION OF SOLAR HEAVY ELEMENT ABUNDANCES**
Basu, Sarbani; Antia, H.M.

P2 **EVOLUTION OF ZONALLY STRUCTURED NEAR-SURFACE FLOWS AND THEIR RELATION TO THE THERMAL STRUCTURE**
Bogart, Richard; Rabello-Soares, M. C.; Basu, S.

P3 **CONSTRAINING THE FINE-STRUCTURE CONSTANT WITH HELIOSEISMOLOGY**
Bonanno, Alfio

P4 **G-MODES AND THE SOLAR CYCLE**
Gabriel, Alan

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HELIOSEISMOLOGICAL DETERMINATION OF THE STATE OF THE SOLAR INTERIOR

Gough, Douglas
University of Cambridge

Perhaps the most important inference we have concerning the state of the solar interior is the spherically averaged stratification of sound speed and density determined by helioseismology. From those quantities can be determined the pressure, and consequently the local convective stability parameter, the latter signifying more-or-less the extent of the convective envelope. These results can be compared with evolved theoretical solar models, particularly those dynamically simplistic models that have become known as standard models; and indeed the refinement of those models has to a great extent been guided by the seismological results. In the past much of the motivation for having highly honed standard models was the desire to understand, or in some cases remove, the apparent discrepancies between the predicted neutrino emission and the neutrino fluxes observed on Earth. Those discrepancies have largely disappeared since the measurement of the effect of neutrino transitions, although no doubt new ones will arise in the future when more-detailed neutrino energy spectra are in hand. The best evolutionary models of today, when calibrated with the latest photospheric abundance determinations, differ significantly from the seismic models, implying that the transport of energy through the radiative interior has been wrongly calculated, possibly because the chemical composition is wrongly predicted, possibly because the physics used to determine the opacity is inadequate. Macroscopic fluid motion is potentially important in transporting both chemical species and energy beneath the convection zone, but, aside from rotation, this cannot be measured directly and can therefore only be inferred from dynamical considerations. It may turn out that the days of the current generation of standard solar models are numbered, and that many of the dynaical processes that have been discussed over the years will need to be incorporated in a more coherent way.

INTERPRETING SOLAR FREQUENCIES: METHODS AND TECHNIQUES

Basu, Sarbani
Yale University

Helioseismology has proved to be an extremely important tool in determining the structure and dynamics of the Sun. I shall discuss the methods that have been used to interpret solar frequencies. I shall begin with the techniques that are used to determine the global properties of the Sun, and then proceed to discuss some of the methods and techniques of local helioseismology.

RECENT PROGRESSES ON G-MODE SEARCH

Appourchaux, Thierry[1]; Andersen, B.[2]; Barlow, A-M.[3]; Baudin, F.[1]; Chaplin, W.[3]; Corbard, T.[4]; Elsworth, Y.[3]; Finsterle, W.[5]; Gabriel, A.[1]; Gough, D.O.[6]; Garcia, R.[7]; Grec, G.[4]; Frφhlich, C.[5]; Kosovichev, A.[8]; Jimınez, A.[9]; Provost, J.[4]; Turck-Chiθze, S.[7]; Sekii, T.[10]
[1]Institut d'Astrophysique Spatiale; [2]Norwegian Space Center; [3]University of Birmingham; [4]Observatoire de Nice; [5]World Radiation Center; [6]Cambridge University; [7]CEA; [8]Stanford University; [9]Instituto de Astrofisica de Canarias; [10]National Astronomical Observatory

The Phoebus group is an international collaboration of helioseismologists, its aim being to detect low-frequency solar g modes. Here, we report on recent work, including the development and application of new techniques based on detection of coincidences in contemporaneous datasets, the asymptotic properties of the g-mode frequencies, and the use of novel g-mode excitation mechanism. Time series more than 10 years in length are now available to the community, and this has reduced significantly upper detection limits for the g-mode amplitude; furthermore, low-degree p modes can now be detected clearly at frequencies below 1000 μHz. Results, from the application of both old and new techniques, will be presented.

LOOKING FOR ASYMPTOTIC G MODES USING GOLF ABOARD SOHO

Garcia, Rafael A.[1]; Turck-Chieze, S.[1]; Jimenez-Reyes, S.J.[2]; Palle, P.L.[2]; Ballot, J.[3]
[1]Service d'Astrophysique CEA/Saclay; [2]IAC; [3]Max-Plank institut fur Astrophysik

Gravity modes have not yet been unambigously detected on the Sun. The lattest studies from the GOLF Team and the Phoebus and BiSON groups looked for individual modes and were concentrated on the region of mixed modes (above 150 μHz). An upper limit of 6 mm/s has been found for single peaks. Another study of the GOLF data was dedicated to the search of multiplets which has lowered the detection to 1-2 mm/s. Two candidates have been observed and followed with time with more than 90 % confidence level in 20 μHz (Turck-Chieze et al 2004a), one of them has been detected with 98% confidence level in 10 μHz after about 3000 days of integration (Turck-Chieze et al. 2004b). This year we have analyzed the lower region of the frequency spectrum correponding to pure gravity modes with a totally different strategy (Garcia et al. 2005). Instead of looking for individual modes we look for asymptotical properties in the region below 140 μHz using GOLF/SoHO data. In particular, we try to find a signature of the δP_1 (23-25 minutes). The power spectrum computed with nearly 10 years of GOLF velocity data presents a structure that could be explained by the presence of l=1 g modes in the data in the frequency range 20-140 μHz. Using Monte-Carlo simulations we will show that this structure found in the real GOLF data is not produced by noise with a confidence level higher than 98 %. Assuming that this peak is due to the signature of l=1 g modes we will try to infer some properties of these g-modes.

HELIOSEISMIC DETERMINATION OF SUBSURFACE FLUID DYNAMICS

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Observatoire de la Cτte d'Azur

One of the major goal of the three instruments dedicated to helioseismic measurements on board SoHO is to determine internal flows and charaterize the subsurface fluid dynamics. Precise frequency splitting measurements over 10 years allow us to study the internal rotation rate from the nuclear core frontier and the tachocline up to the photosphere and to follow its changes with the activity cycle. Moreover the high resolution data provided by MDI has permitted the development of local helioseismology technics probing the immediate subsurface layers with unprecedented spatial and temporal resolution. In this talk I will review the main observational results obtained in this field and present the related theoretical progresses in our understanding of the Sun and its activity cycle.

SOHO AND TIME-DISTANCE HELIOSEISMOLOGY

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[1]NASA/Goddard Space Flight Center; [2]Stanford University

Time-distance helioseismology invented shortly before the SOHO launch was rapidly developed and produced a completely new 3D view of the Sun's interior thanks to the uninterrupted high-resolution observations from SOHO. These observations provided the first images of sunspots and emerging active regions below the surface, 3D maps of subphotospheric supergranular flows and circulation cells below sunspots. The whole new world of complicated structures and motions inside the Sun was discovered. Time-distance analysis of SOHO observations also revealed how these motions are organized in large- and global scale patterns, associated with the activity cycle. We briefly review of the main time-distance helioseismology results obtained from SOHO, describe the most recent achievements, and discuss further steps in time-distance analysis of SOHO data.

SUBSURFACE FLOWS AND THE EVOLUTION OF SOLAR FILAMENTS

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Our recent development of High-Resolution Ring Analysis (HRRA) procedures now allow us to measure flows below the surface with a horizontal resolution of 2 degrees in heliographic angle (or 24.4 Mm). We have used this novel local helioseismic technique to deduce the flows underlying filaments and filament channels. Many models of filament formation and evolution are driven by converging and shearing flows within the photosphere and below. This talk will present our preliminary findings for a selection of filaments.

RESONANT OSCILLATION MODES AND BACKGROUND IN REALISTIC HYDRODYNAMICAL SIMULATIONS OF SOLAR SURFACE CONVECTION

Straus, T.[1]; Severino, G.[1]; Steffen, M.[2]
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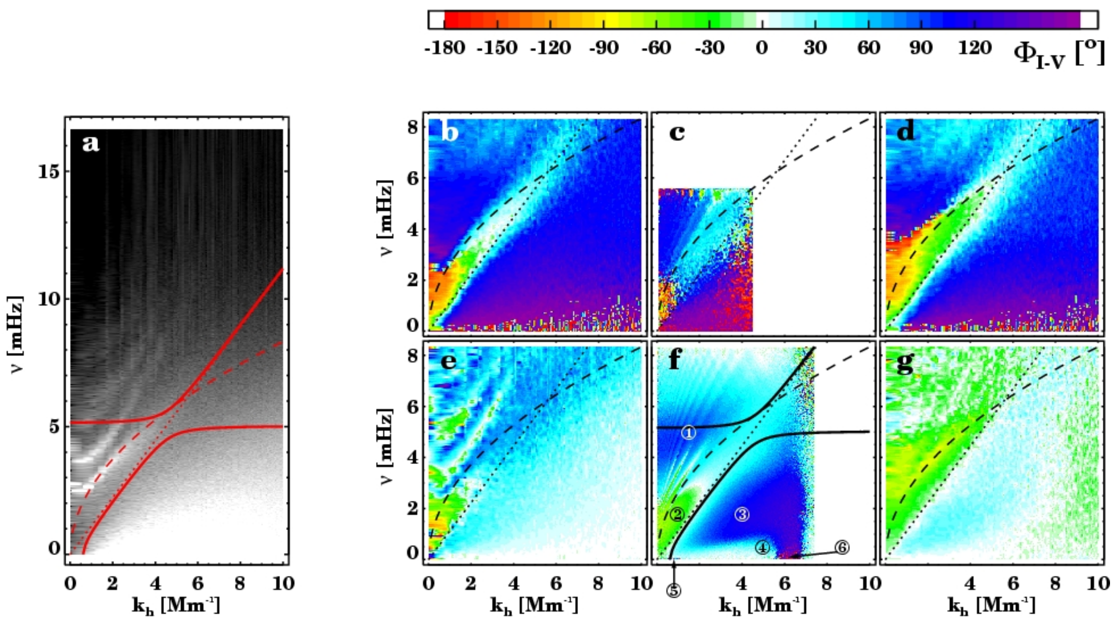
The solar background of the p-modes of the Sun and its interaction with the resonant modes has been extensively studied in the past with various methods. On the one hand, it has been related to the sources of the solar p-modes, and information on properties of the sources has been inferred from observations. On the other hand, phase difference spectra have been demonstrated to be an important tool for studying the dynamics of a complex system like the solar photosphere, and to be of great help for separating the background signal from the mode signal itself. With the availability of realistic hydrodynamical simulations of the surface layers of the Sun, this topic becomes now accessible to a detailed analysis of the involved physics.

We study the interaction between solar resonant oscillation modes and the associated background spectrum on the basis of a comparison of observations from MDI with a 3D numerical simulation which has a horizontal size of 11.2 x 11.2 Mm and covers a time span of about ten hours. This simulation is shown to reproduce the major observed properties of the modes and background regimes to an exciting level of agreement although only a tiny fraction of the Sun near the surface is described by our model box. To achieve this agreement, the physical parameters, like the vertical velocity and temperature, must be extracted at levels of fixed optical depth. We find that the results are fundamentally different when parameters are extracted at levels of fixed geometrical height, something observers implicitly believe to achieve by their measurements. Phase difference spectra are the most sensitive to these opacity effects.



The figure shows the comparison of I-V phase difference spectra at two different levels in the solar photosphere: the row (b)-(d) corresponds to the height of the sodium line, the row (e)-(g) to the height of the Nickel line used by MDI. Panels (c) and (f) are real observations, (b) and (e) simulations extracted at constant optical depth, (d) and (g) simulations extracted at constant geometrical height. Panel (a) shows the velocity power spectrum as a reference.

PROBING SOLAR ACTIVITY AND CONVECTION WITH LOCAL HELIOSEISMOLOGY

Gizon, Laurent
Max-Planck-Institut fuer Sonnensystemforschung

Local helioseismology is a set of tools that require surface observations of solar seismic waves to make three dimensional images of the solar interior. This is made possible by a careful analysis of the full wave field, not just the frequencies of the resonant modes of oscillation. In many respects, local helioseismology owes its fast development and its many successes to measurements of solar oscillations provided by the Michelson Doppler Imager on SOHO: with nearly continuous coverage for two to three months each year at unprecedented spatial resolution, the entire spectrum of solar waves is accessible for analysis. Using local helioseismology, it has been possible to map internal flows and magnetic structures over an extended range of spatial and temporal scales. I shall summarize what we have learnt about large scale flows and their solar cycle variations, localized subsurface flows, solar supergranulation, and magnetically active regions. Future progress is likely to come from improved models of the interaction of seismic waves with buried inhomogeneities and validation through realistic numerical simulations

THE SOLAR DYNAMO: WHAT WE KNOW, WHAT WE THINK WE KNOW AND WHAT PROGRESS CAN WE MAKE.

Steven, Tobias
University of Leeds

I shall review our current understanding of the processes that lead to dynamo action in the Sun. I shall describe the current scenarios for the operation of the solar dynamo and discuss why none of these is entirely satisfactory. Many of the current scenarios are described within the framework of mean-field-electrodynamics, but I shall describe how the theory is ill-constrained and how a naive interpretation can lead to erroneous conclusions. I shall finish by describing the important information that helioseismology can provide to constrain theories for the solar dynamo.

DOES VISIBILITY EFFECT FULLY EXPLAIN A CYCLE VARIATIONS OF CORONAL BRIGHT POINTS?

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Earlier studies have found that the number of Coronal Bright Points (CBPs) varies inversely with sunspot cycle. This finding prompted Davis (1983) to suggest the existence of a secondary cycle of magnetic activity running in opposite phase to the sunspot cycle. Later, however, Nakakubo & Hara (2000) found that the variation in number of CBPs might be explained by the visibility effect. The enhanced brightness of corona may mask dimmer CBPs, and hence, hinders their identification. Sattarov at al (2002) drew a similar conclusion on the basis of lack of solar-cycle variation in number of photospheric bipoles. The number of bright points in Sattarov et al (2002) data showed clear cyclic variations, while the number of magnetic bipoles with particular size and separation did not show such variations. Assuming that the fraction of magnetic bipoles associated with CBPs is independent of solar cycle, Sattarov et al (2002) concluded that cyclic variation of CBPs is apparent and is probably caused by changes in overall brightness of solar corona in agreement with Nakakubo & Hara (2000). On the other hand, our following research indicated that there may be some irregularities in temporal and spatial (latitudinal and longitudinal) variations of CBPs that cannot be fully explained by the visibility effect. In this report we present results of study of cycle variation of properties of CBPs using SOHO/EIT 195A observations from 1996-2005. We have applied the automatic procedure to identify CBPs (Sattarov et al 2005) and calculate their heliographic position, intensity, area, and background intensity around each CBP. Analizing this data, we found that the latitudinal-cycle variations of CBPs can not be completely explained by the visibility effect alone.

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THE CORONAL WAVE DAMPING PROBLEM: MECHANISMS FOR WAVE DAMPING IN THE SOLAR CORONA

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10 years of SOHO operation have provided us with clear evidence of the omnipresence of waves in the solar corona. The clear detection of these waves, many years after they were predicted on theoretical grounds in MHD, has finally opened up the field of coronal seismology. One of the puzzling facts is that any of the observed waves are either damped on short timescales (a few periods) if they are standing waves or either are seen to vanish after a short travelling distance if they are travelling waves. In the same way as the heating of the corona cannot straightforwardly be related to the dissipation of waves because of the very high Reynolds numbers in the solar corona, the damping of these waves as well cannot be attributed to direct dissipation. Much smaller length scales are needed for dissipation to be sufficiently effective. Various damping mechanisms have been proposed with varying success. In this contribution we will focus on some theoretical aspects of the mechanisms of phase mixing, resonant absorption and lateral (perpendicular to the magnetic field) wave leakage. In particular it is emphasized that these three processes are intimately related. Moreover we have to keep in mind, especially for the travelling waves, that the vanishing of the wave signal can also be merely an observational effect.

MHD MODELING OF THE SOLAR CORONA AND INNER HELIOSPHERE

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We describe the application of a three-dimensional magnetohydrodynamic (MHD) model to determine the structure of the solar corona and solar wind. The calculations use the observed photospheric magnetic fields as boundary conditions. This model makes it possible to determine the large-scale structure of the magnetic field in the corona, as well as the distribution of the solar wind velocity, plasma density, and temperature. We will focus on recent results obtained using an improved energy model in which we include parameterized coronal heating, radiation loss, and parallel thermal conduction. We will present results on the thermal structure of the corona on active-region scales, as well as the coupling to global scales. In particular, we will compare our results with EUV emission observations from SOHO and TRACE, and X-ray emission from Yohkoh.

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MAGNETIC VARIABILITY OF THE ELECTRON DENSITY IN THE SOLAR CORONA

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In January 2006, the LASCO-C2 coronagraph aboard SOHO will have performed 10 years of quasi-continuous observations of the solar corona from 2 to 6 solar radii, that is almost a full solar cycle. We study the temporal evolution of the electron density derived from the calibrated pB images over this unsurpassed time span, first globally and then by distinguishing different latitude intervals so as to characterize the equatorial and polar regions. While the electron ensity strongly varies with solar activity, the equatorial and polar regions exhibit very different behaviours. These variations are compared to different indices of solar magnetic activity in order to understand their origins.

HELIOSPHERIC CONSTRAINTS ON THE CORONAL MAGNETIC FIELD

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We summarize our understanding of the heliosphere and its connections to the dynamic corona. We first discuss potential field source surface models, with their usefulness and drawbacks. We then address constraints on these models based on heliospheric data. We argue that there are important limitations from our lack of detailed understanding of the physical processes, which heat the corona and accelerate the solar wind. Finally, we address recent attempts to address these limitations. These include: a) developing a novel model for the expansion of the open magnetic flux without the limitations from potential field assumptions, b) developing a theoretical framework to deal with time-dependences introduced due to motions introduced in the corona, and c) a theoretical framework for the interactions between open and closed field lines in the corona.

HEATING OF THE MAGNETICALLY CLOSED CORONA

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Coronal heating is one of the most challenging and important problems in astrophysics. A definitive explanation is not yet at hand, but several lines of reasoning point to the existence of sub-resolution strands that are impulsively heated. The photospheric magnetic field is observed to be concentrated in small kilogauss flux tubes that are randomly displaced by turbulent convection. The footpoint shuffling tangles the tubes, and they *must* reconnect in the corona to prevent a catastrophic build-up of complexity and stress. The secondary instability produces explosive energy release whenever adjacent tubes reach a critical misalignment angle. The observed under and over densities of hot and warm loops are best explained by impulsive heating and subsequent cooling in bundles of unresolved strands. The three-part light curves of loops can be reproduced by a self-organized criticality model based on tangled, reconnecting tubes. Finally, the observed symmetry of loops (i.e., the tendency for loops to have legs of similar width) might also be explained by tangled, reconnecting tubes. In this talk, I will review some general aspects of the coronal heating problem and highlight as many of the above points as time permits. I will also emphasize that a high speed, high spatial resolution imaging spectrometer should be a high priority for future missions.

NEW MODELS OF THE SOLAR CHROMOSPHERE AND TRANSITION REGION DETERMINED FROM SUMER OBSERVATIONS

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The SUMER atlas of Curdt et al.(2001) giving the solar disk-center spectrum between 67 and 161 nm, together with HRTS spectra to 173 nm, is an extremely valuable source of observational data that can be used to determine the structure of the upper photosphere, chromosphere, transition region, and low corona. The Pandora atmospheric modeling program is being used to determine atmospheric models and calculated spectra consistent with these observations, resulting in new models of the solar atmosphere in much better agreement with observations than before. We find that temperature variations of 400 K cause the computed chromospheric intensities to change by a factor of 4. This is greater than the intensity variations at chromospheric wavelengths 1) with time in quiet regions, and 2) with position from cell centers to bright network. These results appear to conflict with dynamical models that have time variations of 1000 K or more in the low chromosphere.

RESULTS OF THE ANALYSIS OF SOLAR ACTIVE REGIONS AND THEIR LOOPS AT MONTANA STATE

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I will summarize recent resuls on the analysis of coronal active regions and loops by the solar group at Montana State. Key results include the discovery of the Unresolved Active Region Corona (UARC), the derivation of analytical solutions for the temperature profile in loops for non-uniform heating functions, the derivation of Differential Emission Measure (DEM) profiles from these analytical and numerical solutions for multi-strand loops and their comparison with data, and the development of a new method to determine DEM's from observations. In our previous work we have heavily relied on data from SoHO-CDS and TRACE, and use EIT and MDI data for support. Using these we are preparing ourselves for XRT and AIA, and hopefully high resolution rocket data from Hi-C.

FIRST VUV SUN-AS-A-STAR SPECTRUM COMPARED TO OTHER COOL STARS

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This paper reports the first full-Sun vacuum ultraviolet (VUV) emission line profile originating from the transition region from the chromosphere to the corona. It is based on a raster scan of the whole solar disk using SUMER/SOHO. The full-Sun spectrum has a spectral resolution which allows an investigation of details in the line profile as well as a thorough comparison to stellar spectra as obtained, e.g. with FUSE or STIS/HST. The full-Sun spectrum shows enhanced emission in the wings, and is well described by a double Gaussian fit with a narrow and a broad component. It is shown that the broad component is due to structures on the solar surface. Thus it is proposed that the broad components of other solar-like stars are also a consequence of the mixture of surface structures, and not necessarily a signature of small-scale heating processes like explosive events, as it is commonly argued. A comparison to spectra of luminous cool stars shows that the line asymmetries of these stars might also be a surface structure effect and not or only partly due to opacity effects in their cool dense winds. These comparisons show the potential of high quality full-Sun VUV spectra and their value for the study of solar-stellar connections. As an example, this study proposes that alpha-Cen-A has a considerably higher amount of magnetic flux concentrated in the chromospheric magnetic network than the Sun.

DAMPED CORONAL LOOP OSCILLATIONS: TIME-DEPENDENT ANALYSIS

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The excitation and damping of transversal coronal loop oscillations is studied using a line-tied cylindrical loop model. By solving the time-dependent magnetohydrodynamic (MHD) equations we show how an initial disturbance produced in the solar corona induces kink mode oscillations. We analyse the effect of the disturbance on a loop with a non-uniform boundary layer and investigate the damping of such disturbance due to resonant absorption. We find that that this mechanism is capable of damping the oscillations almost immediately after the excitation. We study in detail the behaviour of solutions in the inhomogeneous layer and show how the energy of the global oscillation is converted into torsional oscillations in the inhomogeneous layer. In addition, we estimate that the amplitude of the torsional oscillations is, for large magnetic Reynolds numbers and for thick layers, between four and six times the amplitude of the initial transversal motions. The implications of these results and their relationship with the observations are discussed.

HEATING OF THE QUIET SOLAR CORONA

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SOHO/SUMER and CDS observations have revealed the isothermal nature of the solar corona well above the limb, and that the decrease in electron density with height is less than would be expected from an atmosphere in hydrostatic equilibrium. These properties show similarities to a class of active region loops which have been shown to be "overdense" relative to standard scaling laws by TRACE observations. Such properties suggest that the heating mechanism acts impulsively on multiple threads within these loops.

We use CDS observations to analyse the evolution from the usual on disk Differential Emission Measure (DEM) distribution to the off-limb near Gaussian DEM for several quiet solar regions selected from EIT observations. The emission from lines formed at transition region temperatures drops to less than the on disk average intensity within 4-6" of the limb brightened peak, so that the DEM develops into a narrow distribution with a peak at 1.2MK and a width of less than 0.1MK. We also measure the electron density variation with height, which falls to log N_e = 8.2 at 90" above the limb brightened peak. These results are consistent with those found by previous authors and appear to confirm that they are general properties of the quiet corona. The narrow range of temperatures and high densities also represent stringent constraints on models of coronal heating. To gain insight into which heating functions are consistent with the data, we use potential field extrapolations of high resolution MDI magnetograms to model a quiet coronal region, and populate the field lines with hydrostatic models derived from different heating functions. We use these models to attempt to reproduce both the on disk and off-limb behaviour of the CDS intensities. Our initial results suggest that impulsively heated hydrodynamic models are also required to understand the properties of the quiet corona.

CORONAL HEATING AND SOLAR WIND ACCELERATION: SOHO OBSERVATIONS AND THEORETICAL ADVANCES

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Experiments on the SOHO spacecraft have contributed in fundamental ways to our changing views of coronal heating and solar wind acceleration, in particular with reference to the temperature structure of coronal holes and the origins of the slow solar wind. Measurement of large minor ion temperatures and anisotropies coupled with sub-million degree electron temperatures have lead to a major revision of our theoretical understanding of heating and acceleration of the fast wind from coronal holes, while measurements of the helmet streamer variability and structure have given insight into the modes of slow solar wind generation. Here we summarize how these observations have stimulated the development of new classes of models, which in turn have lead to new views into the physics of the nascent heliosphere. In particular, we will discuss models of magnetically dominated turbulence in coronal magnetic field as the dominant coronal heating mechanism, and the role of kinetic processes at smaller scales in establishing the non-equilibrium distribution functions seen to persist out to large distances in the fast solar wind.

PLASMA DIAGNOSTICS OF THE LARGE-SCALE CORONA WITH SUMER

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In the present work we analyze the physical properties of the quiet Sun plasma measured in a 0.5 Rsun x 1.8 Rsun region above the west solar limb. We use large scans obtained with SUMER to build 2-D spatial maps of line intensities, electron temperature, emission measure, element abundances, line widths and non-thermal velocities, and photoexcitation effects coverting the entire field of view. Electron densities were measured in a more limited portion of the field of view. The aim of the paper is to identify tracers of coronal hole and quiet Sun plasma at high latitudes that allow us to measure the position of the coronal hole/quiet Sun boundaries, and to provide a comprehensive, empirical picture of the off-limb solar corona that can provide theoreticians with experimental constraints to their models of the large-scale coronal structure, coronal heating, and solar wind acceleration.

SOLAR CORONAL-HOLE PLASMA DENSITIES AND TEMPERATURES

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Polar plumes extending from coronal holes into the solar corona have long been seen during eclipses, and can now be studied without this restriction with telescopes and spectrometers on board of spacecraft. Despite the large amount of observational data available on this prominent phenomenon, it is not clear at this stage whether plumes contribute substantially to the fast solar wind streams emanating from coronal holes. An understanding of the processes leading to the formation of bright plumes and the surrounding darker inter-plume regions in coronal holes requires a good knowledge of the physical conditions in plumes and their environment. This investigation aims at measuring the electron densities and temperatures in these regions with the help of radiance ratios of ultraviolet emission lines, and finds densities of about 7 *10^7 cm^-3 in bright plumes and 1.3 *10^7 cm^-3 in inter-plume lanes at approx. 45 Mm above the limb. At this height, the total plume cross-section relative to the size of the coronal hole was found to be approx. 5 %. The densities drop by a factor of roughly two over the next 80 Mm in height; in lanes a little less than in plumes. The electron temperatures in plumes are approx. 7.5 *10^5 K and in inter-plume regions approx. 1.13 MK in this height range. The effective ion temperatures, deduced from the line widths, are higher and nearly independent of the altitude in plumes, whereas they increase in inter-plume regions, starting from an even higher level. No systematic dependence could be found for the line-of-sight bulk velocities of the coronal-hole plasma.

SOLAR WIND FORECASTING FROM THE CHROMOSPHERE

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The distinction between the chromosphere, transition region and corona is entirely artificial; the same magnetic field permeates the whole solar atmosphere and heliosphere and as such they form one complex physical system. However, we propose that it is exactly the magnetic field, or, more precisely, the balance of locally and globally open and closed magnetic structures in the photosphere and chromosphere that defines the properties of coronal holes, providing a realistic basis to explore the support and sustenance of the kinetic solar wind. Recently, we [McIntosh & Leamon, ApJL, 2005] correlated the inferred structure of the solar chromospheric plasma topography with in situ solar wind velocity and composition data measured at 1 AU. Specifically, the measured separation in height of the TRACE 1600E and 1700E UV band pass filters correlate very strongly with solar wind velocity and inversely with the ratio of ionic oxygen (O^{7+}/O^{6+}) densities. These correlations suggest that the structure of the solar wind is rooted deeper in the outer solar atmosphere than has been previously considered. We show here that the value of plasma β extrapolated from the photosphere up into the chromosphere correlates with TRACE UV band pass separation and thus to in situ solar wind velocity and composition. We present initial results of a model developed to so predict interplanetary solar wind conditions, using SOHO/MDI magnetograms with 96 minute cadence as input. Our model provides a near continuous range of solar wind speeds and composition quantities from the structure of the chromosphere and is more precise than the old ``fast/ coronal hole or slow/streamer belt'' estimate.

DIAGNOSTICS AND MODELLING OF THE SOLAR WIND SOURCE REGIONS

Poletto, Giannina
INAF - Arcetri Astrophysical Observatory

Before the advent of SOHO, we did not have much spectroscopic information on the behavior of coronal plasma over the first few solar radii, that is, information about the region where the heating and acceleration of coronal plasma is most likely to occur were scanty. With the advent of SOHO, and in particular with the Ultraviolet Coronagraph Spectrometer (UVCS) experiment, spectra of the extended corona have been acquired, out to several solar radii, and spectroscopic diagnostic techniques allowed us to increase our knowledge of this largely unexplored region. After a brief description of these diagnostic methods, I will focus on the identification and modelling of wind sources developed from SOHO data.

It has been known from about 30 years now that the fast wind originates from coronal holes: however, the areas, within holes, which are the sources of fast wind are still not unambiguously identified. The situation is even more complicated for the slow wind, which may originate from the hole/streamer boundaries, from small low-latitude holes, from above streamers, i.e. from the "streamer stalk/cusp". A further source of wind has been recently recognized as being located above active regions. As in fast wind, the unambiguous identification of the precise coronal origin of slow wind streams may be difficult to reach and I will show how a study of element abundance may help solve the problem.

Work done so far suggests that plasma acceleration occurs over a distance range that depends on the kind of wind, be it fast or slow. What precisely dictates the behavior of fast vs. slow wind is a matter of discussion and I'll review the two competing ideas which invoke either a relationship between wind speed and flux tube expansion or a relationship between wind speed and reconnection between open field lines and closed loops. Open problems and means to solve them will also be illustrated.

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CORONAL HOLE PROPERTIES DURING THE FIRST DECADE OF UVCS/SOHO

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We have measured with the SOHO Ultraviolet Coronagraph Spectrometer (UVCS) the physical properties of over 155 large coronal holes that produced a variety of high-speed solar wind conditions at 1 AU. This data set includes observations of coronal holes of different sizes and latitudinal locations present throughout solar cycle 23. Previous analyses of a subset of these UVCS observations have shown that polar and equatorial coronal holes produce different acceleration profiles and have different oxygen kinetic temperatures. These analyses also showed that a pattern is emerging, i.e., coronal holes with lower densities at a given heliocentric distance tend to exhibit faster ion outflow and higher ion temperatures. In 2005 and the beginning of 2006, the polar coronal holes have not yet evolved to the fully quiescent minimum state seen in 1996-1997, although the next solar minimum is expected to occur during 2006-2007. We will present the solar cycle dependence of the derived plasma parameters (densities, temperatures, velocity distribution anisotropies, and outflow speeds for O5+ and protons) from the last solar minimum in 1996 to present and compare them, where possible, with the in situ solar wind properties. This information is being used to set firm empirical constraints on coronal heating and solar wind acceleration in coronal holes. This work is supported by NASA under Grant NNG05GG38G to the Smithsonian Astrophysical Observatory, by the Italian Space Agency, and by PRODEX (Swiss contribution).

PROPRIETIES OF POLAR PLUMES' PLASMA FROM CORONAL EMISSION MODELING

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The plasma confinement in the magnetic lines of force and the EUV emission from the solar corona provide important and unique information on the plasma conditions in different structures. For instance polar coronal plumes are observed as bright channels in the coronal holes at the minimum of the solar cycle. The observed EUV profiles' characteristics (shapes, widths, amplitudes, ...) in the polar coronal holes are a unique tool to infer the physical processes taking place in the corona. We present a model for the polar coronal holes to study the properties of the plasma parameters (speed and turbulence) of different species in polar plumes compared to those of the inter-plume regions. Velocity distributions are assumed to be simple Maxwellian with different widths in both plume and inter-plume regions. Electron densities are considered to be greater in plumes and converge with height toward inter-plume values. We compute line profiles and total intensities of the H I Ly-α and the O VI 1032 and 1037 E lines by considering different combinations of the outflow and velocity turbulence in the plume regions. The comparison of the synthetic profiles with the observed ones yields information on the evolution of outflow speed and velocity turbulence of the plume's plasma as a function of height. We find that the observed profiles and intensities are reproduced better by considering a very small solar wind speed at low altitudes in the plumes that increases as a non-linear height-dependent fraction of the interplume speed to reach this latter value above roughly 6-7 R□ and also a similar variation for the width of the velocity turbulence of the scattering atoms/ions. We also find that plumes very close to the pole give narrow profiles at heights above 2.5 R□ that are not observed. This suggests either a tendency for plumes to be located away from the pole or only a rare occurrence of plumes right at the pole. The latitude distribution of plumes is studied by analyzing data from different instruments on SOHO and with SOLIS magnetograms.

STRUCTURE IN THE OUTFLOW OF THE SOLAR WIND

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With the analysis of observations from SOHO and Ulysses, we are now able to construct models of the structured outflow in the solar wind at different heights above the photosphere, on several spatial scales. These includes the global structures out to 1 A.U., velocities in different types of plume out to 4 Ro and detailed structures at the interface between the transition region and the corona. We are now in a position to discuss the integration of these into an overall 3-D model. This is a necessary step in understanding the real contribution of the different structures to the overall mass-loss in the solar wind.

SLOW WIND IN THE EXTENDED CORONA

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We present the results of a statistical study of the streamer boundary regions, performed on streamers observed at high spectral resolution during the minimum of solar cycle 23 with the Ultraviolet Coronagraph Spectrometer (UVCS) onboard SOHO. The solar wind parameters in the extended corona are inferred on the basis of a spectroscopic analysis of the O VI doublet 1032, 1038 E and H I Ly α emission lines, accounting for the coronal magnetic topology to constrain the mass flux along the flow tube connecting the coronal regions to the heliosphere. The results of the analysis allow the identification of the acceleration region of the slow coronal wind that is found to flow along the streamer boundary in the open magnetic field line region.

SOLAR WIND HEAVY ION SPEED AND DENSITY COMPARISONS

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We present comparative measurements of He^{+2}, O^{+6}, O^{+7} and Fe^{+7-16} from the ACE/SWICS instrument and H^{+} from the SOHO/PM sensor. While it has been well established that alpha particles generally have a higher flow speed than protons, little is known about the relative flow speeds of the heavier ions. Our preliminary results from a 5-year survey indicate that the average relative speeds of He, O and Fe are within about 5 km/s at the highest speeds, decreasing to near zero in the high-density low-speed solar wind. As expected, we find that the minor ions tend towards equal thermal speeds in high-speed coronal hole flows, and equal temperatures in low-speed flows. Finally, we demonstrate the systematic behavior of the abundance ratios He/H, He/O, and Fe/O as functions of the parameter O^{+7}/O^{+6} (a proxy for the coronal temperature where the solar wind ions freeze-in).

SOLAR LUMINOSITY VARIATION: IMPLICATIONS FOR STELLAR AND CLIMATE PHYSICS

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Small variations in total solar irradiance (TSI) are caused by the changing projected areas of dark (sunspot) and bright (faculae, network) magnetic structures on the photospheric disk. These fluctuations are more remarkable than they might seem – why doesn’t solar hear flow quickly re-adjust around these localized structures, with no luminosity variation at all? Increasingly sophisticated convection simulations indicate that the TSI fluctuations exist because the convection zone of a Sun-like star is essentially a thermal superconductor, with an enormous thermal inertia that damps any compensating brightness variations outside the magnetic structures. This inertia explains why no other deeper lying modes of TSI variation, or solar diameter changes, have been discovered by extensive photometry, heliometry, and helioseismology. Given this inertia, undiscovered TSI variations large enough to drive recent climate seem unlikely. Comparison of the temperature record with TSI driving of a climate model indicates that solar forcing may have contributed detectably to climate over the past millennium. But the correlation is both too low and too uncertain to provide convincing evidence for additional, larger- amplitude solar luminosity variations arising from mechanisms other than changes of photospheric magnetic structures.

HELIOSEISMIC RESPONSES INDUCED BY THE PROTON-RICH FLARE OF OCTOBER, 28, 2003

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In the past 7 years there have been many unsuccessful attempts to observe solar quakes associated flares similar to the one observed by Kosovichev and Zharkova (1998). The lack of success raises the question: was the observed quake unique and most solar flares are acoustically inactive, or is the background noise in the ascent and maximum phases of the solar cycle much higher than typical seismic signals? Recently, during the decline of solar cycle 23, new quakes were observed in association with solar flares on 2003 October 28 and 29 in active region NOAA 10486 using helioseismic holography (Donea and Lindsey, 2005). 5 seismic sources were found in these flares that are well co-aligned with hard X-ray emission. The observations suggest a direct link between energetic particles accelerated in these three flares and the acoustic waves generated by them. The fact that all the seismic flares occur near solar minimum suggests that the lack of seismic waves during solar maximum may be explained by obscuration of the seismic signals by a 'boiling' solar atmosphere. We investigate the new seismic sources using the time-distance method developed by Kosovichev and Zharkova (1998) and report recognisable ridges of 3 seismic waves in the flare 28 October 2003. The extracted start times and momenta are compared with the accelerated electron and proton parameters extracted from the hard X-ray and gamma-ray observations from the INTEGRAL, CORONAS and RHESSI satellites.

PHOTOSPHERIC FIELD EVOLUTION IN THE SOURCE REGIONS OF CORONAL MASS EJECTIONS

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For a unique set of coronal mass ejection (CME) events observed by SoHO/EIT/LASCO which had solar source regions near central meridian, SoHO/MDI data were analyzed in order to identify the possible physical mechanisms of CME onsets and subsequent activity processes in the low corona. The results show that CME onsets can sometimes be clearly related to small-scale short-term changes of the photospheric flux as evident from emerging/vanishing bipolar regions and/or magnetic restructuring processes in neighboring regions. Depending on which of those processes occur, flaring and coronal heating may or may not be observed subsequently.

USING SOHO TO UNDERSTAND CME-PRODUCING QUIET-REGION FILAMENT ERUPTIONS

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In recent years we have been studying solar eruptions in an attempt to determine their primary initiation mechanism. We have focused on events involving filaments, because motions of the filaments just prior to their violent eruption are indicative of changes in the entire magnetic field system involved in the eruption. When the pre-eruption filament resides in a quiet region, the motions leading up to eruption are slower than in similar eruptions in active regions due to the weaker magnetic field strength and correspondingly lower Alfven velocities. These early motions manifest themselves in a slow rise (a few km/s) of the filament, in some cases lasting several hours. After this the filament and associated magnetic structures erupt rapidly, accelerating to speeds of a few 10 km/s over a few minutes. Because of their slow evolution, quiet-region eruptions such as these can be effectively studied in EUV with SOHO/EIT, with its regular cadence of about 12 min. For several cases we have combined EIT images with SOHO/MDI magnetograms and data from other other instruments, and compared our observations with predictions from various eruption scenarios, in particular the "breakout" (Antiochos 1998), "tether cutting" (e.g., Moore et al. 2001), and MHD instability mechanisms. Here we present a representative example of a quiet-region eruption involving a filament ejection, that occurred on 2001 February 28 in a magnetically quadrupolar region and produced a halo CME in SOHO/LASCO images. In addition to EIT and MDI, we analyzed spectral data from SOHO/CDS and soft X-ray (SXR) images from Yohkoh/SXT. We found that flux emergence occurred near one end of the filament, and that both this emergence and resulting microflaring in SXRs and EUV were temporally and spatially closely related to the start of the filament's slow rise. Intensity changes (dimmings and brightenings) in the EIT and SXT images indicate that fields far removed from the erupting core were involved in the eruption, and that breakout-type reconnection did occur. Our observations allow us to investigate whether breakout was the trigger of the eruption, or merely a consequence of a more fundamental eruption process such as tether cutting or MHD instability occurring in a complex magnetic environment.

MULTISCALE OPTICAL FLOW FOR ANALYSING THE DYNAMICS IN SOLAR EUV IMAGES. ALGORITHM, CALIBRATION AND FIRST RESULTS

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Movies of the Solar atmosphere reveal velocity fields and brightness variations. Image sequences exhibit the plane-of-the-sky component of the speed. The present work focuses on solar extreme-ultraviolet images as produced in by EIT on board SoHO, TRACE or SPIRIT-CORONAS. To our knowledge and apart from our early results (Gissot et al 2003), dense velocity field estimation have not been calculated from EUV sequences of the corona. We present a multiscale optical flow algorithm derived from Lukas Kanade 1981, a local gradient-based technique. Our aim is to estimate both the fields of apparent displacement and brightness variation from two successive images. We demonstrate a new differential rotation measurement and the identification of coronal events as outliers to the differential rotation or as regions exhibiting a significant brightness variation. Space Weather services have motivated this study. The range of potential interests includes but also extends beyond early warnings of flares and Coronal Mass Ejection (CME) onsets. In future work, It could address nanoflares or spicules studies, coronal and prominence seismology, MHD and EIT wave investigations, etc.

AN EXPERIMENT IN FORECASTING THE ERUPTION OF QUIESCENT PROMINENCES USING EIT 304A IMAGES

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From using 304A images as an aid in choosing filament or prominence targets for our limited-field H alpha observations, we learned that many prominences, in 304A images, increase slowly in height 12-96 hours prior to erupting. To gain more specific knowledge about whether this slow rise could be easily measured and whether it could be useful in forecasting erupting prominences and CMEs, we embarked on a real-time experimental forecasting project. Written forecasts were made for all 304A prominences whose rate of change in height between 2 consecutive 304A images significantly exceeded the rate of change in height expected for 4a prominence of fixed height crossing the limb. The practical criteria for making a forecast was a 2mm (18Mm) increase in height over 6 hours as measured on EIT 304A images with a diameter of 15 cm. From 17 July to 28 December 2000, 80 forecasts were made that a given filament would erupt within the next 96 hours. 79 additional prominences erupted while crossing the limb and no forecast was made. Of these, 63 (80%) met our criteria for eruption and did erupt. No forecast was made for a variety of reasons but mostly because of a lack of timely availability of 304A images. Of the 80 forecasts, 60 (75%) were successful, 13 did not erupt and for 7, the eruption could not be confirmed. Of the 79 prominence eruptions without forecasts, 63 (80%) met our criteria and erupted, 6 (10%) met our criteria and did not erupt. Only 10 of the 79 did not meet our criteria and of these 7 erupted and 3 were questionable. Additional statistics on the limb location and rates of rise were compiled for presentation. We conclude that the slow rise in height is extremely common and precedes the eruption of at least 75% of all quiescent filaments. The statistical results presented here are unique to the availability of 304A images because this wavelength affords the clear visibility of the top of the spine (long axis) of prominences; the top of the spine is often not visible or not consistently and clearly defined in H alpha or in other wavelengths in which prominences have been most often observed in ground-based telescopes. Support from NASA grant NAG5-10852 is acknowledged.

10 YEARS OF CME ONSET STUDIES WITH SOHO/CDS

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Since the beginning of operations in 1996, SOHO/CDS has regularly run a CME onset study. Some of these datasets have been used to determine whether coronal dimmings are a signature of a CME occurring (Harrison & Lyons, 2000; Harrison et al., 2003). It has been claimed that the dimming is evidence of the removal of matter from the low corona. Results will be presented of a statistical study using the 178 datasets available (up to the end of 2005) to determine whether coronal dimming can be used as a tool to predict CME's. The results from CDS will be used in conjunction with lists of CME's created from SOHO/LASCO data and results from CACTUS (Computer Aided CME Tracking).

SOHO CONTRIBUTIONS TO UNDERSTANDING CMES

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The observations of the onsets of CMEs and their propagation into the inner heliosphere have been made with unprecedented detail by the imaging instruments on SOHO. We review the progress made in understanding the physical processes surrounding the initiation and propagation of CMEs based on observations by LASCO, EIT and CDS. We review the role of the prominence eruption as an integral part of the CME, and we find that although such eruptions often accompany large CMEs, they are incidental to the CME itself, and are therefore probably not directly involved in the dynamics of the CME. Statistical properties of large CMEs are discussed. For smaller events we review the acceleration of the material in the LASCO field of view. Bi-direction flows are freqently observed, which have a starting altitude in the plane of the sky at around 3-4 solar radii. Finally the relationship of CMEs to large flares is discussed to search for a possible causal relationship between the two.

PARADIGM SHIFTS USING LASCO RESULTS

Howard, Russell
Naval Research Lab

The first ten years of the SOHO mission has resulted in a major advance in our understanding of solar and heliospheric physics. This is partly due to the extremely stable pointing, which has, in turn, enabled extremely stable measurements of the Sun and its corona. This stable pointing combined with the continuous viewing of the Sun has resulted in many studies that were not anticipated during the conceptual and development phases. In this paper, we present a few results from LASCO that have been significant shifts in our understanding prior to SOHO. LASCO results can be broadly grouped into five categories (a) CME observations and Modeling (b) Interplanetary Effects (c) Outflows and Inflows (d) "Quiescent" Coronal observations and modeling and (e) Comet, Asteroid and Planet observations. In each of these categories, LASCO has made significant contributes. The observations of (a) "flux-rope" CMEs, (b) the relation between halos and geomagnetic storms, (c) the observations of small-scale outflows and in-flows, (d) the modeling of a streamer and (e) the observations of over 1000 comets are an example from each of these categories that were not what we expected prior to SOHO's launch, and thus represent a paradigm shift in each of these areas. We will briefly describe these observations.

DETECTIONS OF CORONAL MASS EJECTION SHOCKS WITH LASCO

Vourlidas, Angelos
Naval Research Laboratory

The direct detection of shocks driven by fast CMEs in white light images has always been a difficult task with ambiguous results at best. Only a couple of such detections have been documented so far despite the observations of thousands of CMEs. There are two reasons for the scarcity of shock detections: (1) the visibility function of white light shocks is not well understood, and (2) we do not know, with confidence, which of the observed structures in a CME image corresponds to a shock signature. There is hope, however. In this paper, I will show how the high quality LASCO observations and recent 3D MHD modeling results are helping us in understanding the origin of the various white light features seen in the CME images. I will discuss several more detections of shocks throughout the solar cycle and present an analysis for the visibility function for shocks in the LASCO images.

SOHO UVCS AND MAUNA LOA MARK IV OBSERVATIONS OF A SLOW CME BELOW 2 SOLAR RADII

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In this work we study the early evolution of a slow (~500 km/s) CME that occurred on January 31, 2000, and was observed by UVCS at 1.6 and 1.9 solar radii. The whole event turns out to be very faint in UV line emission: different CME structures are hardly identifiable even in the main spectral lines we detected (H Lyα, O VI and Si XII) whose intensities show, during the event, a change by only about 30-40% with respect to the value at the beginning of the observations, followed by some fluctuations. The CME structures, however, are better visible in the running difference images we made from UVCS data: taking advantage of the Mauna Loa white light data, we identified in the UV reconstructed CME images the typical three parts (front, void and core) of our CME, rarely observed at these low altitudes. The overall CME structure agrees with that envisaged by the Lin, Raymond & Van Ballegooijen (2004) CME model: this "loss of equilibrium" model predicts changes in the magnetic fields above the source active region (AR) over which a flux rope is initially "suspended", in agreement with the observed variation of the sunspot number and of total area in the AR we identified (from EIT and MDI data) as the CME source. From the Mauna Loa *pB* data we estimated the electron densities in the different parts of the CME and, by assuming two simple possible geometries for the CME bubble, we derived an order of magnitude value of their masses. Taking advantage of densities we derived from the *pB* (hence, independently of the unknown plasma temperature), we qualitatively discuss the temperature variations across the CME bubble needed to reproduce the observed Lyα, O VI and Si XII line intensity evolution. Temperature changes at the CME void and core seems to be confirmed by the variations of the O VI 1032 line widths observed at both heliocentric distances in these parts of the CME bubble.
A.B. and G.P. acknowledge support from ASI-INAF contract I/035/05/0.

STUDYING HALO AND PARTIAL HALO CORONAL MASS EJECTIONS THROUGH UV SPECTRA

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Ultraviolet spectra of about 300 hundred Coronal Mass Ejections have been detected by the UltraViolet Coronagraph Spectrometer (UVCS) Physical and dynamic properties such as temperature, ionization stage, density, bulk speed, line-of-sight speed obtained from UV spectra are important to understand the nature of CMEs and disentangle the projection effects of white light images from the true 3D structure of CMEs. Among the observed CMEs several halos and partial halos events were detected. The line-of-sight speeds, obtained from the Doppler shift, combined with the projected speed provide the angles between the motion and the plane of the sky, along with the actual heliocentric distances. Such distances are often much larger then the projected heliocentric distances. The typical broad line profiles at the CME front are signatures of bulk expansion and/or shock heating. A recent analysis of 22 events showed that in seven cases the line broadening is attributed to shock heating, and in three cases to the line of sight component of the CME expansion.

SOLAR ENERGETIC PARTICLES: PROGRESS OF OUR UNDERSTANDING IN THE SOHO ERA

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Over the last ~10 years, advanced instrumentation onboard several spacecraft inclusing SOHO extended our ability to explore energy spectra, elemental, isotopic, and ionic charge composition of solar energetic particle (SEP) events in a wide energy range from ~10 keV/nuc to ~ 100 MeV/nuc. Due to the much improved sensitivity of the instrumentation, spectral and compositional measurements are now available for a large range of particle intensities, i.e. not only for large SEP events generally associated with coronal mass ejections (CMEs) and coronal / interplanetary shocks, but also for small, flare associated events with enhancements in 3He and heavy ions. Originally, these two types of events were classified as gradual and impulsive, based on the duration of the associated soft X-ray emission. However, in the last few years, the two-class paradigm has been challenged by several observations, as, for example, significant enrichment of 3He and heavy ions and high Fe charge states of ~20 at high energies, found in interplanetary shock related events. In this paper the recent observations of elemental, isotopic and ionic charge composition obtained with SOHO and other missions will be reviewed and their implication for our understanding of the different acceleration scenarios will be discussed.

PROGRESS TOWARD MEASUREMENTS OF SUPRATHERMAL TAILS IN CORONAL PROTON VELOCITY DISTRIBUTIONS

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The Ultraviolet Coronagraph Spectrometer (UVCS) on SOHO is being used to measure precise H I Ly-alpha spectral line shapes out to several Doppler half widths.In some cases the spectral line profiles are fitted best with a gaussian curve, but there are many cases where the curve fit is much better to a kappa function. Observations have been made at heliocentric heights from 1.75 to 3.5 solar radii in helmet streamers, active region streamers and prior to and after flare/CME events. Observations at a single set of solar coordinates can exhibit significantly different kappa values over a period of a few hours. These observations may provide evidence for suprathermal tails in the coronal proton velocity distributions. Any successful theory of solar energetic particle (SEP) production by CME shocks must account for the large observed variations in SEP spectral characteristics and elemental abundances. Some have proposed that this variability arises from an inherently variable population of suprathermal seed particles (e.g., Mason et al. 2005): some that exist all the time in the solar wind (with varying properties depending on wind speed) and some that are associated with prior flares and CME shocks (e.g., Kahler 2004; Tylka et al. 2005). As yet, though, the suprathermal particle population in the solar corona has never been measured. In August 2005, the Ly-alpha channel of UVCS was recommissioned and used for these measurements.The holographically ruled diffraction grating provides a low stray light level that is useful for observing the tail of the line profile out to about 0.5 nm from line center. New observations as well as measurements from the original UVCS laboratory calibration and in flight measurements from earlier in the mission were used to characterize the instrument response to monochromatic light so that instrument effects can be removed. Measurements with the UVCS OVI Redundant Optical Path for this purpose are also being analyzed. The observations and a progress report on the analysis will be presented. This work is supported by NASA Grant NNG05GG38G to the Smithsonian Astrophysical Observatory Kahler, S. W. 2004, ApJ, 603, 330. Lee, M. A. 2005, ApJ Supp., 158, 38. Mason, G., Desai, M., Mazur, J., & Dwyer, J. 2005, COSPAR 35th Scientific Assemly, p. 1596. Tylka, A. J., et al. 2005, ApJ, 625, 474.

PARTICLE ACCELERATION IN TURBULENT CORONAL LOOPS: THE ROLE OF INTERMITTENCY

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MHD turbulence could be related to heating and to energy release events in corona. Models have been proposed for particle acceleration in turbulent plasmas. We perform a test particle numerical experiment to simulate particle acceleration in a low-frequency turbulence generated by footpoint motions. The turbulence is modelled within the reduced MHD theory. Only the effect of the resistive electric field Er is retained, which is mainly parallel to the axial magnetic field. In its spectrum the contribution of small scales is dominant. The spatial structure of Er is obtained by a synthetic turbulence method (p-model), which allows to reproduce intermittency. Solving the relativistic motion equations the time evolution of particle distribution is calculated. Electrons can be accelerated to energies of the order of 50 keV in less than 0.3 s, and the final energy distribution can exhibit a power-law range. A correlation is found between the heating events in the MHD turbulence and particle acceleration, qualitatively similar to what observed in solar flares. Spatial intermittency play a key role in acceleration, enhancing both the extension of power law range and the maximum energy.

ENERGETIC PARTICLES MEASURED BY EPHIN INSTRUMENT DURING THE LAST SOLAR MAGNETIC FIELD POLARITY REVERSAL

R.-Pacheco, Javier[1]; Blanco, J.J.[1]; Sequeiros, J.[1]; Kunow, H[2]; Mȯller Mellin, R[2]; Heber, B[2]; Gomez, R[2]; Kecskemıty, K[3]; Zeldovich, M[4]

[1]ASRG/UAH; [2]IEAP/Uni. Kiel; [3]KFKI; [4]Skobeltsyn Institute of Nuclear Physics

We present energetic particle data measured by the EPHIN instrument aboard SoHO spacecraft during the last solar magnetic field polarity reversal. We focused our attention on the search of anomalous low particle fluxes during that time. During the years of maximum solar activity, we have compared the energetic particle fluxes with the number of the solar energetic phenomena that traditionally have been associated with SEP events at 1 AU (i.e. CMEs and X-rays flares), with the aim of determining if they are just the manifestations of the same solar global event that is undergoing an anomalous behavior during the reversal period.

1000 AND COUNTING: THE REMARKABLE SOHO CONTRIBUTIONS TO COMETARY SCIENCE

Biesecker, Douglas
NOAA/SEC

On December 2, 1995 the number of comets discovered in satellite imagery was less than two dozen. As of March 1, 2006 that number has grown to over 1100. The SOHO/LASCO and SOHO/SWAN instruments have accounted for all of this growth. This growth far exceeded even the most optimistic expectations for the SOHO mission. The vast majority of the comets, almost 1000 of them, are members of the previously known Kreutz sungrazing family. About 125 of the comets belong to four new groups, or families, of 'sun-skirting' comets. Finally, about 50 unrelated comets have been identified. It was also possible to turn the SOHO/UVCS instrument to the task of observing Kreutz comets, acquiring much notable quantitative data. SWAN observations of a variety of previously identified comets provided significant new results. The SOHO comet observations have given us at least 33 papers in the refereed literature, with more certain to come. We will present these results and many others which have come out of the SOHO comet studies.

HELIUM/HYDROGEN FRACTIONATION IN THE SOLAR WIND – HOW MUCH IS DUE TO INEFFICIENT COULOMB DRAG?

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It is well known that helium is systematically depleted relative to hydrogen in the solar wind if compared to abundances in the outer convective zone of the Sun. The causes for this depletion, which is variable, are not well understood. One motivation for a continuous interest in this topic originates from the fact that estimates on the influence of inefficient Coulomb drag on systematic isotopic fractionation in the solar wind have been largely based on comparisons with the variability of the He/H ratio. However, it is also known that elemental fractionation can be caused by differences in ionization efficiency for different elements. 4He++ has the least favorable Coulomb drag factor of all solar wind species, and helium is the element with the highest first ionization potential.

Convolving a typical solar EUV-spectrum with cross-sections for first ionization of hydrogen and helium yields a ratio of ionization rates of approximately 2 with a variability of the order of a factor of 2, i.e., close to the observed average depletion of helium relative to hydrogen in the corona. This agreement points towards a coronal depletion of helium due to inefficient ionization. However, the apparent agreement is probably fortuitous since ionization of hydrogen and helium in the chromosphere is thought to proceed through at least two steps, i.e., through radiative excitation and subsequent collisional ionization by hot electrons.

Nevertheless, we have made an attempt to constrain the possible influence of coronal EUV-radiation on the He/H-fractionation and investigated a possible correlation between coronal EUV-radiation and the He/H-ratio in the solar wind using ACE/SWEPAM-measurements and the EUV-flux from SOHO/EIT at the presumable location of the source of the flow tubes. We found no correlation between the two parameters. Enhanced He/H-ratios in the record of ACE/SWEPAM are due to coronal mass ejections, and no clear evidence for enhanced EUV-flux at the source of these events was found. On the other hand, there is a weak indication for lower He/H-ratios originating from regions of enhanced EUV-flux, as one would expect for low He/H-flux ratios stemming from the streamer belt, but no sign of a direct influence of coronal EUV on preferential ionization of helium. Although at this time the relation of coronal EUV to the ionizing radiation in the chromosphere is not clear, these results seem to favor the conventional view of inefficient Coulomb drag as the cause for variable He/H. We will discuss the consequences for isotopic fractionation models for the solar wind.

SOHO/UVCS OBSERVATION OF SUNGRAZING COMET C/2002 S2

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The comet C/2002 S2, a member of the Kreutz family of Sungrazing comets, was discovered in the white light images of SOHO/LASCO instrument on 2002 September 18 and observed in H I Ly-alpha emission by SOHO/UVCS instrument at four different heights as it approached the Sun: 7.38, 6.82, 5.70 and 4.64 Solar Radii. The H I Ly-alpha line profiles detected by UVCS when the comet intersects the instrument slit are fitted to determine the spectral parameters: line intensity, width and Doppler shift with respect to the coronal background. Thus 2D comet images of these parameters are reconstructed at the different observed heights. The data show the presence of two tails at all observed heights, and in particular at 6.82 Solar Radii a well separated secondary tail is an evidence of a possible fragmentation event. The novelty of this comet data is that, while the emission from the main tail is red-shifted that from the secondary tail is blue-shifted, moreover this effect is visible also at different height where the two tails are not well separated. In order to find the explanation of the comet behaviour we developed a code based on Monte Carlo technique to simulate the H I Ly-alpha emission of a comet moving in a coronal plasma. The code aims at understanding the relationship between the UVCS observed H I Ly-alpha spectra and the cometary and coronal parameters such as the comet speed and outgassing rate, the solar wind velocity, coronal kinetic temperature and density.

SOHO, WHAT HAPPENED AFTER 1999?

van Overbeek, Ton
European Space Agency

This presentation/paper will try to bring you up-to-date with SOHO's current status.
Items that will be covered:

- ☐ The High Gain Antenna problem and the resulting work-arounds;
- ☐ Software changes: Intermittent Recording, Solid State Recorder, Star tracker;
- ☐ and some words about future plans (ground and on-board automation)

SOHO- CLEANLINESS IN RETROSPECT

THOMAS, Ronald
Ex-ESA

This short paper will describe the system level cleanliness activities which contributed to the successful performance of SOHO in the past decade. The main activity discussed will be that of the thermal vacuum exposures.

SOHO - HOW IT ALL BEGAN, ALMOST 24 YEARS AGO.

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The SOHO mission was accepted by ESA for an assessment study in 1982, then as the "Solar High Resolution Observatory". It was strongly focussed on optical observations of the Sun. I was lucky enough to be nominated by ESA management to help opening this mission to a wider community, in particular to the solar wind scientists. At that time, it was already clear to me that for really understanding the solar wind one must at first study its sources. That's why I became a passionate advocate for including a coronagraph on SOHO as well. After all, we got it! The Assessment Study team and later the Phase-A Study team were very careful in defining the science goals and the required instrumentation such that it could all be covered by European scientists alone. US participation was considered highly desired but unreliable, as a result of the ISPM shock. However, for keeping the participation of NASA and american scientists as an option there were two separate Phase A Studies fabricated: A "European Only" version and an ESA-NASA joint mission. It appears rewarding to me to revisit these and many more anecdotes, in the light of our present knowledge about this wonderful and most successfull mission.

"CAN'T GO SAILING -- I'M SOL!" SOME REMINISCENCES ABOUT LIFE IN THE EARLY EOF

DeForest, Craig
Southwest Research Institute

I came to GSFC to run SOHO/MDI just in time for launch -- even before conferral of my Ph.D. degree in 1996. While running a large spacecraft is a serious business, the EOF was also a rich and interesting social millieu. Scientists from all over the globe came together and interacted in ways that were at different times humorous and poignant. I will spend a few minutes relating a few of the lighter moments in the first two years of the mission: confusion across cultural lines, solar target selection, coffee in the morning meeting, and the eternal quest for a picture badge.

HOW TO SEE NORTHERN LIGHTS THROUGH THE CLOUDS IN ENGLAND

Del Zanna, Giulio
University College London

I briefly describe my personal memories on the solar flare of April 10 2001. I was running CDS observations that week and was closely following the evolution of the Sun. When the flare occurred (as I predicted) and the halo CME followed, the following day I alerted all my friends to go out and look for auroras. I then took my bike..

SOHO AND THE HELIOSPHERE

Lallement, Rosine
CNRS

SOHO has been an excellent tool for the study of the heliosphere (which can be viewed as the extended solar atmosphere), and its confinement under the pressure of the ambient interstellar medium. Neutral interstellar matter under the form of hydrogen and helium streams has been observed remotely by means of backscattered solar radiation, and ionized and subsequently accelerated interstellar neutrals have been detected in situ as pickup ions. I will illustrate the series of results on the heliosphere obtained by combining the data from at least five SOHO instruments, CELIAS-CTOF and CELIAS-SEM, SUMER, SWAN, and UVCS, with a particular emphasis on SWAN, which was for a large part devoted to this subject and has brought new constraints on the size and shape of our "solar wind bubble".

ON THE LONG-TERM FUTURE OF SOLAR AND HELIOSPHERIC PHYSICS

Schrijver, Carolus J.
Lockheed Martin Advanced Technology Center

The next five years are shaping up to be a golden era of solar and heliospheric physics, adding STEREO, Solar-B, and SDO to existing space- and ground-based observatories. Looking beyond that, however, the agency strategic plans show space-based observatories at intervals of a decade or more for both NASA and ESA, with no mission safely embedded in the predictable budget outlooks. The main cause for the paucity of frontier-breaking instrumentation beyond 2010 appears to be the high cost of the missions under consideration. It seems timely to consider how to adapt towards a leaner future on the one hand, while starting to reshape our community's mindset on how we plan and shape missions to drastically lower their costs on the other.

SOHO: A LOOK BACK FROM 2025

Gurman, Joseph B.
NASA Goddard Space Flight Center

The last twenty years have brought us a wealth of new information on the Sun, the heliosphere, and space weather, but all of the new understanding achieved with the Solar Polar Orbiter, Solar Sentinels, Solar Orbiter, Kua Fu, SDO, the mission formerly known as Solar-B, and STEREO have built on the foundation laid by the SOHO mission. Launched back in the closing years of the twentieth century, it provided measurements of conditions in the solar interior, outer solar atmosphere, heliopshere, and even the interstellar wind. Even the heliosynchronous activity monitors (HAM) mission now under development owes its origin to the continuous view of the Sun from the ecliptic plane first exploited by SOHO. I discuss how SOHO provided both a model for for international cooperation and the stepping stones to our current understanding of the Sun-heliosphere system.

PROSPECTS FOR CORONAL PHYSICS

Cargill, Peter
Imperial College

This talk will address the future prospects for coronal physics. Its content will be based on abstracts submitted to, and talks given at, this meeting, with a large dose of the speaker's prejudices folded in.

SOLAR MICROSCOPY: UNVEILING THE SUN'S BASIC PHYSICAL PROCESSES AT THEIR INTRINSIC SCALES

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[1]*Max Planck Institute for Solar System Research*

Many of the energetic processes acting in various astrophysical systems have considerable basic similarities. A paramount characteristic that many of them have in common is that the spatial and temporal scales at which the basic interactions and fundamental processes take place, are much smaller than the scales of the systems themselves. For example, in solar and stellar coronae the length scales of energy conversion (e.g. in thin electric current sheets or wave dissipation layers) are of order meters. Similarly, in the solar photosphere the physically relevant scales are set by diffusion and magnetic resistivity and lie at a scale on the order of a km.

Of all the relevant astrophysical systems by far the highest spatial resolution is presently achievable for the Sun. Only for it do we have the hope that in the coming dacades the spatial resolution can reach the natural physical scales.

One aim of a future solar mission should be to resolve the relevant spatial scales at which the key physical processes take place. Such observations need to be carried out from Space since many of these key processes manifest themselves at wavelengths not accesible from the ground.

In order to achieve the kind of resolution needed, instruments substantially larger than those currently being designed or built will be required. E.g., in order to resolve 1 km on the Sun at the wavelength of Ly alpha requires a 23 m diameter telescope in Earth orbit! At X-ray wavelengths, the telescope size is more managable, but in order to achieve a high S/N ratio and a high cadence (required since small features change faster), a larger telescope may be necessary than srictly needed to achieve the spatial resolution. It is clear that novel telescope designs will be necessary. It is time for the solar space community to start thinking about such concepts.

CAN WE FINALLY SOLVE THE PROBLEMS OF "CORONAL HEATING " AND "SOLAR WIND ACCELERATION" IN THE COSMIC VISION ERA ?

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Since the discovery of the corona’s million-degree temperature in the 1940s and the supersonic solar wind in the early 1960s major efforts have been made to discover the physical mechanisms that could explain these two observations. These efforts have led to a tremendous increase in our knowledge of our neighbour star, the inner heliosphere and the Sun-Earth connections. Unfortunately these efforts haven't allowed to provide a definitive answer to these questions. Why such a situation ? On one hand the remote-sensing strategy has tried to probe the coronal properties by basically analysing the photons emitted or absorbed by the Sun's atmosphere. With this regards, limitations occur on both theoretical ground (physics of the coupling between photons and plasma) and experimental ground (limited number of observables such as spectral lines or the hardly solvable problem of the line of sight integration) On the other hand solar wind in-situ measurements have had access to the very detailed state of the local plasma properties (full particles velocity distribution functions, observations of the electromagnetic plasma fluctuations over a huge frequency range ...) but at locations far from the corona and the solar wind acceleration regions. Moreover, it has been realized more recently that the magnetic field plays a fundamental role in shaping the low corona and channelling the energy inputs. Unfortunately the measurement of the full magnetic vector in the corona is a very difficult enterprise and this lack of information hampers all on-going modelling efforts. Given the above remarks, what is the best strategy, within the Cosmic Vision program, to try to solve the above-mentioned problems? Of course we need to study the essential role of the magnetic field, from its emergence to its coupling to the plasma, in a vast range of space and temporal scales. But we also need to study the essential role of the smallest plasma scales at which the energy, in whatever form, is finally released to the medium. In parallel we need to study the influence of these smallest scales on the larger observable ones, accessible from remote sensing, and which are governing the global behaviour of the corona. Concerning the solar wind acceleration region, we certainly need to understand and probe the physics of a semi-collisional medium, where the classical transport theory is probably not anymore valid The potential mechanisms that could explain our major questions are numerous : waves, electrical currents, micro or macro reconnection, MHD turbulence, non-thermal distribution functions ... Whatever is the final answer, it will probably arise only from SIMULTANEOUS remote sensing and in-situ measurements by: increasing the angular, spectral and temporal resolutions; attacking the difficult issue of continuous magnetic fields measurements in the corona and, approaching as close as possible the solar wind source regions.

A VERY HIGH RESOLUTION VISION FOR SOLAR PHYSICS

Damı, Luc
Service d'Aıronomie du CNRS

In 2006, the Solar Orbiter is still more than 10 years ahead, SOLAR-B and STEREO should start observing, and CORONAS-PHOTON, the Solar Dynamics Observatory (SDO), the 1 m Chinese Space Solar Telescope (SST) and the Sunrise balloon mission should occur in the next few years. This is appropriate time, then, to draw lessons from SOHO, TRACE and RHESSI, to account the potential of the ones to come and to define, from that outcome, the future needs, and review possibilities, for near future (not 2020), of very high resolution missions that could valuably complement flying and planned ones. It is clear, in that respect, following the development of several major high resolution projects on ground (NSST, GREGOR, ATST), that high resolution is the key to understand Solar Physics processes and that the next major step should be in Space: high resolution chromospheric, transition zone and coronal UV, FUV, EUV and X-ray imaging and spectroscopy together with magnetograms and 3D spectropolarimetry to attack the problem of magnetic coupling of the photosphere to the chromosphere, transition zone and heliosphere. An efficient way to address the longstanding issue of coronal and chromospheric heating. A FUV interferometric mission like SOLARNET, complemented by EUV and X-ray imaging and spectroscopy, and resolved and global helioseismology instruments, will be that mission capable of understanding physical processes at work in the structure and dynamics of the solar core, the mechanisms of evolution and generation of the solar magnetic field and the reconnection processes and energy release in the solar atmosphere.

IMAGING UV SPECTROSCOPY OF THE CORONA: FROM UVCS/SOHO TO ILWS MISSIONS

Fineschi, Silvano[1]; Giordano, S.[1]; Benna, C.[2]; Mancuso, S.[2]; Moses, J. D.[3]
[1]INAF-Osservatorio Astronomico di Torino; [2]INAF-Osservatorio Astrofisico di Torino; [3]Naval Research Laboratory

SOHO 17: List of Posters

1 Solar Interior: From Exploration to Experimentation

SEISMIC DETERMINATION OF SOLAR HEAVY ELEMENT ABUNDANCES

Basu, Sarbani[1]; Antia, H.M.[2]
[1]Yale University; [2]Tata Institute of Fundamental Research

The recent downward revision of solar phtospheric abundances of Oxygen and other abundance heavy elements has caused a serious discrepancy between standard solar models constructed with the new abundances and the seismically determined solar structure. In this work we attempt to determine the heavy element abundance in the solar convection zone, using the dimensionless sound-speed derivative in the solar convection zone. This should provide an independent check of the spectroscopically determined abundances.

TOPICS
01 Solar Interior: From Exploration to Experimentation

EVOLUTION OF ZONALLY STRUCTURED NEAR-SURFACE FLOWS AND THEIR RELATION TO THE THERMAL STRUCTURE

Bogart, Richard[1]; Rabello-Soares, M. C.[1]; Basu, S.[2]
[1]Stanford University; [2]Yale University

Untracked ring-diagram analysis permits us to resolve the zonal dependence of near-surface flows and thermal structure without mixing the two hemispheres. Ten years of dynamics campaigns with one or more solar rotations each of nearly continuous MDI Doppler data provide information on the evolution of near-surface dynamical structures over a solar cycle. We report here on the trends and variations in the near-surface flows, comparing them with sound-speed and adiabatic index structure variations inferred from the same data, with the mean flows obtained from traditional tracked ring-diagram analysis, and with the symmetric torsional oscillation structure inferred from global helioseismic analysis.

TOPICS
01 Solar Interior: From Exploration to Experimentation

CONSTRAINING THE FINE-STRUCTURE CONSTANT WITH HELIOSEISMOLOGY

Bonanno, Alfio
INAF OACt

We discuss the effect of a possible temporal variation of the fine-structure constant using the acoustic mode small frequency separation and SOHO data for modes with ll =0,1,2. We construct a grid of solar models obtained with the GARSOM stellar evolution code, for different values of the fine structure constant α. We use the more standard OPAL radiative opacities and the newly calculated radiative opacities from the Opacity Project with the recently determined (lower) heavy-element abundances. Our constraints are comparable with those obtained from hyperfine transitions of 87Rb and 133Cs in laboratory, at a redshift z =0.5, considering the most favoured LCDM cosmology.

TOPICS
01 Solar Interior: From Exploration to Experimentation

G-MODES AND THE SOLAR CYCLE

Gabriel, Alan
Institut d'Astrophysique Spatiale

It is widely accepted that solar g-modes have lifetimes much longer that the duration of current observations. Under these circumstances, complex data analysis techniques are unlikely to add significantly to the basic method of searching for notable spectrum peaks in the Fourier transform of the longest duration observations available. However, this argument does not take account of the possibility that the cavity resonating might change its frequency with time, for example as a result of solar cycle modulation or other temporal changes. Whilst such variations are theoretically unpredicted, it remains true that extremely small changes in resonant frequencies could be sufficient to spread a g-mode energy peak over several bins in the spectrum and thus render it undetectable. We are examining a number of techniques for recovering this dispersed energy in a search for g-modes resonances based upon the GOLF data set. We will present our latest results from this search.

TOPICS
01 Solar Interior: From Exploration to Experimentation

ON THE SEARCH FOR G-MODES

Gavryuseva, Elena
Arcetri Astrophysical Observatory

The analysis of GOLF data sets has been performed to search for g-modes on the base of the theoretical predictions for the g-modes excitation in the nuclear active core. Comparison with GONG data for low spherical degrees was made. The theoretical predictions for the excitation of gravity modes are discussed.

TOPICS
01 Solar Interior: From Exploration to Experimentation

SOLAR ACOUSTIC MODES : FREQUENCY VARIATION RELATED TO THE MAGNETIC ACTIVITY ALONG THE SOLAR CYCLE, DEDUCED FROM THE GOLF DATA.

Grec, Gerard[1]; Lazrek, M[2]; Fossat, E[3]
[1]Observatoire de la Cote d'Azur - CNRS; [2]Universite de Marrakech; [3]Universite de Nice

not yet available

TOPICS
01 Solar Interior: From Exploration to Experimentation

COMPUTATIONAL ACOUSTICS IN SPHERICAL GEOMETRY: STEPS TOWARDS VALIDATING HELIOSEISMOLOGY

Hanasoge, Shravan[1]; Duvall, T. L., Jr.[2]
[1]Stanford University; [2]NASA Solar and Space Physics Laboratory, NASA Goddard

Helioseismology is the study of the variations in the internal structure and properties of the dynamics of the sun from measurements of its surface oscillations. We are interested in validating and determining the efficacy of the helioseismic measurement procedure. To this end, we simulate acoustic wave propagation in a solar-like spherical shell that extends from $0.2R_\odot$ to about $1.0004 R_\odot$, where $R_\odot$ is the radius of the sun. We present results from simulations, and analyses applied to the simulations obtained thereof.

TOPICS
01 Solar Interior: From Exploration to Experimentation

SENSITIVITY OF SOLAR F-MODE TRAVEL TIMES TO INTERNAL FLOWS.

Jackiewicz, Jason[1]; Gizon, L[1]; Birch, A[2]
[1]Max Planck Institute for Solar System Research; [2]Colorado Research Associates

We compute f-mode travel-time sensitivity kernels for flows. Using a two-dimensional model, we show that it is important to account for several systematic effects, such as the foreshortening and the projection of the velocity vector onto the line of sight. Correcting for these effects is necessary before any data inversion is attempted. We also present full three-dimensional sensitivity kernels for flows, which do not however contain these corrections.

TOPICS
01 Solar Interior: From Exploration to Experimentation

GOLF: 10 YEARS OF OBSERVATION OF LOW DEGREE P-MODES

Jiménez Reyes, Sebastián[1]; García, R. A.[2]; Turck-Chieze, S.[2]
[1]Instituto de Astrofisica de Canarias; [2]Service d'Astrophysique, CEA/DSM/DAPNIA, CE Saclay, 91191 Gif sur Yvette, France

We present the latest analysis of the mode parameters variation of low-degree acoustic modes obtained from the observations made by the GOLF instrument on board the ESA/NASA SoHO satellite. Ten years of high quality data has been analyzed in order to study the solar activity cycle through the acoustic mode parameters.

TOPICS
01 Solar Interior: From Exploration to Experimentation

THE ROLE OF MULTI CELLULAR MERIDIONAL FLOWS IN SETTING THE CYCLE PERIOD AND FIELD PARITY IN SOLAR DYNAMO MODELS

Jouve, Laurène[1]; Brun, A.S.[2]
[1]DSM/DAPNIA/Service d'Astrophysique; [2]CEA/DSM/DAPNIA/Service d'Astrophysique

Inspired by recent observations and 3-D simulations that both exhibit multicellular flows in the solar convective zone, we seek to characterize the influence of such flows on the behaviour of solar dynamo models. We focused on two particular points: the role played by these flows in setting the cycle period and the so-called magnetic field parity issue, namely the field parity switching from an antisymmetric, dipolar field configuration to a symmetric, mostly quadrupolar one, that has already been discussed by several authors in the recent literature. Using a 2-D mean field Babcock-Leighton (B-L) model of the solar dynamo, we confirm that adding cells in latitude tends to speed up the dynamo cycle whereas we find that adding cells in radius increases the cycle period by more than 60%. Moreover, our studies show that adding cells both in radius and in latitude imposes a symmetry conservation: the presence of more complex mean meridional flows in the model suppresses the switching of the field parity from a dipolar configuration to a quadrupolar one, thus resolving the parity issue seen in classical B-L solar dynamo models.

TOPICS
01 Solar Interior: From Exploration to Experimentation

MDI AND GONG INFERENCES OF THE CHANGING SUN

Komm, Rudolf; Burtseva, O.; Gonzalez Hernandez, I.; Hill, F.; Howe, R.; Jain, K.; Kholikov, S.; Leibacher, J.; Toner, C.; Tripathy, S.
[1]*National Solar Observatory*

The Global Oscillation Network Group (GONG) and the Solar Oscillations Investigation (SOI) using the Michelson Doppler Imager (MDI) instrument aboard the SOHO spacecraft provide combined data sets that now cover almost one solar cycle and allow us to probe the solar convection zone in unprecedented detail. Here we present the latest combined results from both projects, showing the evolution of the migrating zonal flows near the surface and throughout the convection zone, as well as subsurface flows associated with active regions and farside imaging.

TOPICS
01 Solar Interior: From Exploration to Experimentation

SUBSURFACE FLOWS ASSOCIATED WITH ACTIVE REGIONS DERIVED FROM GONG AND MDI DATA

Komm, Rudolf; Howe, R.; Hill, F.
[1]*National Solar Observatory*

Local helioseismology techniques make it possible to study the subsurface flows associated with active regions. We measure the horizontal flow components to a depth of about 16 Mm with the ring-diagram technique analyzing Doppler images from the Global Oscillation Network Group (GONG) and the MDI instrument on board the Solar and Heliospheric Observatory (SOHO). Active regions show mainly convergent horizontal flows (implying downflows) at depths less than about 10 Mm, while at greater depths strong active regions show divergent flows (implying upflows). Subsurface flows associated with active regions also show high values of vorticity and recent results suggest that the `twistedness' of subsurface flows is related to the flare production of these active regions. We will discuss some of the latest results.

TOPICS
01 Solar Interior: From Exploration to Experimentation

HELIOSEISMIC MEASUREMENTS OF SOLAR RADIUS CHANGES FROM SOHO/MDI

Lefebvre, S.[1]*; kosovichev, A. G.*[2]
[1]*SAp/CEA, Saclay;* [2]*HEPL/Stanford University, Stanford*

We report on the changes of the Sun's subsurface stratification inferred from helioseismology data. We used SOHO/MDI (SOlar and Heliospheric Observatory/Michelson Doppler Imager) f-mode frequencies and their temporal variation for the last 9 years to compute the variation of the radius in the subsurface layers of the Sun by applying helioseismic inversions. We have found a variability of the "helioseismic'' radius in antiphase with the solar activity, with the strongest variations of the stratification being just below the surface around $0.995R_s$. Besides, the radius of the deeper layers of the Sun, between $0.975R_s$ and $0.99R_s$. changes in phase with the 11-year cycle. These results imply a non-homogeneous variation of the radius with depth and time.

TOPICS
01 Solar Interior: From Exploration to Experimentation

EXAMINING THE EFFECT OF THE NEW CHEMICAL COMPOSITION ON THE SOLAR STRUCTURE BY USING THE ADIABATIC GRADIENT

Lin, Chia-Hsien[1]; Antia, H[2]; Basu, S[3]
[1]Yale University; [2]Tata Institute of Fundamental Research; [3]Astronomy Department, Yale University

Recently, Asplund, Grevesse & Sauval (2005), using a refined model for the solar atmosphere, announced the new solar chemical composition with the heavy-element abundance (0.0122) being more than 33% lower than the previously determined value (0.0181). The chemical composition affects various solar interior microphysics and structural properties that are also interfering one another. Hence, it is often difficult to determine whether the discrepancies between the Sun and a model result from the chemical composition or from other structural properties. In this study, we use the adiabatic gradient, which is independent of the macroscopic structural properties, to examine and isolate the effects of different chemical compositions. The results of our study can provide an independent test on the new composition.

TOPICS
01 Solar Interior: From Exploration to Experimentation

MEAN FIELD EFFECTS IN FORCED SPHERICAL MHD MODELS

Livermore, Phil; Tobias, S; Hughes, D
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A common approach used in understanding the generation of the large scale solar magnetic field is mean field theory in which we try to abstract the important physical processes to simplified models. Since its conception in the 1960s, mean field MHD has been used with great success to provide many insights into the inner workings of the sun. The theory seeks to explain the growth and subsequent saturation of the mean solar field by parameterising the action of small scale turbulent fluctuations in terms of the well-known alpha-effect. The alpha effect under certain approximations can be intimately linked to the kinetic helicity of the underlying plasma. It is therefore often assumed that mean field dynamo action benefits from strongly helical motions.

We test this prediction of mean field theory by using a fully 3D spherical incompressible MHD code with forced flows of various net kinetic helicities to see whether or not an axisymmetric "mean" magnetic field can be efficiently generated. We find that the magnitude of the mean field component of the subsequent linear and nonlinear states does not have any definite correlation to the net helicity of the flow. In particular, we find that in some cases flows of zero net kinetic helicity can act as better mean field dynamos than flows of near maximal helicity. Studies of observational proxies of the solar kinetic helicity may therefore not clarify the large scale dynamo mechanism.

TOPICS
01 Solar Interior: From Exploration to Experimentation

HELIOSEISMIC TRAVEL TIMES FROM THE MDI STRUCTURE PROGRAMME

Roth, Markus[1]; Beck, J. G.[2]; Gizon, L.[1]
[1]Max-Planck Institut für Sonnensystemforschung; [2]W.W. Hansen Experimental Physics Laboratory, Stanford University

We present travel-time measurements obtained from the MDI Structure Programme data for the years 1996-2003. We study the variations of the travel times with travel distance, heliographic latitude, and time.

TOPICS
01 Solar Interior: From Exploration to Experimentation

NEW FULL-FARSIDE ANALYSIS WITH 10-YEARS OF MDI OBSERVATIONS

Scherrer, Philip[1]; Oslund, K.[2]; Lindsey, C.[3]; Braun, D.[3]; Gonzalez-Hernandes, I.[4]
[1]Stanford University; [2]CalTech; [3]CORA, NWRA; [4]NSO

The combined 2-by-2 skip with 1-by-3 skip method for computing solar farside images (Braun & Lindsey, 2001 ApJL 560, 189) has been refined and used to compute farside images for the full MDI dataset. The refinements consist of re-ordering some final steps in processing with an improved trend removal. Also, new viewing tools have been developed to allow easy access via a web interface. The data is accessible both as images at http://soi.stanford.edu/data/full_farside and as FITS format files to enable statistical analyses.

TOPICS
01 Solar Interior: From Exploration to Experimentation

TEN YEARS OF MDI MEDIUM-L MODE FREQUENCIES

Schou, Jesper
Stanford University

With almost a solar cycle of MDI Medium-l data available it is now possible to determine how the frequencies and splittings vary over the solar cycle. These frequencies and splittings can then be used to constrain the variations in solar structure and rotation with unprecedented accuracy. In this poster I will discuss the Medium-l program and the fitting of mode frequencies, review some of the results obtained so far and discuss what we have learned.

TOPICS
01 Solar Interior: From Exploration to Experimentation

DYNAMICS OF THE SOLAR RADIATIVE ZONE: PRESENT AND FUTURE

TURCK-CHIEZE, Sylvaine
CEA

SoHO has been a wonderful opportunity to demonstrate that one can probe the solar interior down to the core in a very informative way (Turck-Chieze et al. , ApJ 2001; Couvidat et al., ApJ 2003) using the low degree, low order acoustic modes which are practically not sensitive to the external solar cycle activity. In this short review, I would like to summarize the results we get on the radiative region of the Sun and the questions which have found answers: core sound speed, microscopic diffusion, pp cross section, precise predicted neutrino fluxes, screening and relativistic effects, proper rotation profile down to the core limit. These successes have stimulated interesting conclusions on the solar neutrino puzzle and new works beyond the standard models (Talon & Charbonnel, Science 2005; Eggenberger, Meynet & Maeder, A&A 2005) on the angular momentum transport by internal waves or (and) by magnetic field. Both works encourage complementary measurements. The helioseismic constraints on the radiative zone have also provoked new challenges coming from the important reestimate of the solar metallicity composition which has not detroyed the coherence between the two solar probes of the Sun (Turck-Chièze et al, ApJ 2004). They have effectively stimulated new efforts to perform laboratory opacity experiments (Turck-Chieze et al. 2005) on high energy lasers and to investigate the role of the magnetic field on microscopic and macroscopic processes. In the secund part of this short review, I shall summarize the new open questions on the internal rotation, magnetic field and meridional circulation in the solar radiative zone. Fundamental ingredients are still needed from the observations on the solar core dynamics to give some reality to the detailed 3D numerical simulations. Only the detection of gravity modes will allow to determine the rotation profile in the core. These modes will also contribute to put limits and orders of magnitude of the corresponding magnetic field and may be also on its configuration (s). A summary of what GOLF/SoHO has suggested to be potentially accessible will be recalled (Turck-Chieze et al., ApJ 2004a; Turck-Chièze et al., SoHO 14; Garcia et al., ApJ 2006). Then I shall concentrate on the better understanding properties of the gravity modes (Dintrans et al., A&A 2004, Rogers et Glatzmaier, ApJ 2005). It is clear nowadays that the mixed modes have a shorter lifetime than thought previously and that we are not far to detect the first gravity modes without ambiguity. We know how to improve the detection of these modes in the near future and we are presently building a prototype GOLFNG which will observe in Tenerife in 2006 (Turck-Chièze et al, Adv. Space Res, 2005, see also the other contribution of Turck-Chièze and the GOLFNG team, these proceedings)). I shall discuss here only the scientific motivations for pursuing this research through the space project DynaMICS in order to put constraints on the magnetic field in the solar radiative zone (see also Dikpati, ApJ 2005). The new orientation today is to follow the time evolution of the solar radiative zone. It will be related to the waited progress on the solar terrestrial relationship for the next decades.

TOPICS
01 Solar Interior: From Exploration to Experimentation

RELATIONSHIP BETWEEN THE HORIZONTAL FLOW VELOCITY WITH CELL SIZE AND CELL LIFETIME

udayashankar, Paniveni
Indian Institute of Astrophysics

A study of 90 supergranular cells obtained from SoHO dopplergrams was undertaken in order to investigate a possible relation between the sizes and peak horizontal velocities of the cells. For the sample obtained, the two parameters are found to be correlated with a relation: horizontal velocity $\propto$ (size)$^{1/3}$. A study of 50 supergranular cells obtained from SOHO Dopplergrams was undertaken in order to investigate the relationship between the lifetime (T) and the horizontal flow velocity (v_h) of the cells. For this sample we find that the two parameters are correlated with a relation $v_h\propto T^{0.5}$ and T is identified with the eddy turn-over time. These investigations are in agreement with the turbulent convective model of the solar atmosphere where the velocity spectrum of supergranular field given by $v_h \propto L^{1/3}$ can be identified with the Kolmogorov spectrum for the eddy size L.

TOPICS
01 Solar Interior: From Exploration to Experimentation

THE INTERPLAY BETWEEN COMPLEX PATTERN FORMATION AND GLOBAL DYNAMICS OF THE PHOTOSPHERE

Vecchio, Antonio[1]; Carbone, Vincenzo[2]; Lepreti, Fabio[3]; Sorriso-Valvo, Luca[3]; Primavera, Leonardo[3]; Veltri, Pierluigi[3]; Straus, Thomas[4]
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The interior of the Sun behaves like a resonant cavity supporting the excitation of mechanical oscillations at discrete frequencies on the whole sun. In presence of the gravitational field and density stratification two main kind of modes can be excited: acoustic p-modes and gravitational g-modes. Photospheric periodic motions, known as "5-min'' oscillations, have been observed since 1962 (Leighton et al. 1962). These oscillations have a period of about 3-12 min and are usually identified as p-modes. The Fourier detection tecniques currently used reveal the presence of a wide number of discrete oscillations in the range of p-modes frequencies, but can not resolve the continuum which is present at lower frequencies (g-modes). Beside that, in the convection region another phenomenon is at work: the turbulent convection. What is the effect of the convection layer on solar global oscillation? Are linear coupling at work? We present the results of an application of a new technique to decompose the velocity field, measured by MDI, providing a basis that optimally represents a flow in the energy norm. This is called Proper Orthonormal Decomposition (POD) and it is also known as the Karhunen-Loève expansion.The POD is the best up-to-date technique to capture the energetics of the phenomena, giving information on the dynamic of the coherent structures, and providing an orthogonal empirical basis. This tecnique was introduced some times ago in the context of turbulence by Lumley (Lumley 1967), and is a powerful technique to extract basis functions that represent ensemble averaged structures, such as coherent structures in turbulent flows. The structures which are usually observed on the photosphere, e.g granulation pattern, can be seen as a kind of coherent structure within a stochastic field. The velocity field at different times is used as an ensemble of different contribution to gain some insight the complex spatio-temporal nature of turbulent convection.

TOPICS
01 Solar Interior: From Exploration to Experimentation

SOLAR TACHOCLINE AS SEEN FROM SOHO MDI 1996-2006

Vorontsov, Sergei
Queen Mary, University of London

Results of current helioseismic measurements of the solar tachocline, targeted at resolving its seismic stratification, rotation as a function of depth and latitude, and variations with solar activity, are presented and discussed. The helioseismic inversions are performed with solar p-mode frequencies and frequency splittings measured in ten years of almost continuous observations with SOHO MDI. Recent efforts targeted at reducing systematic errors of the standard frequency measurements, which will allow to improve further the accuracy and resolution of the helioseismic measurements of the tachocline with using the raw data already available, are briefly outlined.

TOPICS
01 Solar Interior: From Exploration to Experimentation

THE SOLAR ABUNDANCE OF NEON AND THE STANDARD SOLAR MODEL

Young, Peter
CCLRC Rutherford Appleton Laboratory

Solar abundances of C, N and O have been revised in recent years (see Asplund et al. 2005, ASP Conf. Series 336, 25, and references therein) resulting in the Standard Solar Model (SSM) for the Sun's interior to now disagree with helioseismological observations. To reconcile the two, one suggestion has been to revise the solar abundance of neon upwards by around 0.44 dex (Bahcall et al., 2005, ApJ, 631, 1281). Neon does not give rise to any photospheric absorption lines and so its abundance can not be determined in the same manner as other elements. Instead abundance measurements of solar energetic particles (SEPs) have been used to measure the Ne/O ratio. The abundance of neon thus automatically fell when the photospheric abundance of oxygen was revised. Adjusting it back to its original value would resolve the discrepancy between the SSM and observations. Support for this revision has been provided by Drake & Testa (2005, Nature, 436, 525) from X-ray observations of a sample of active cool stars.

Analysis of SOHO/CDS spectra allows the Ne/O ratio to be determined in the transition region (100-300 MK) of the quiet Sun. The lack of a FIP effect in the quiet Sun transition region (Young, 2005, A&A, 439, 361) means that this is a proxy of the photospheric abundance ratio. Twenty-four data-sets over a 28 month period were analysed yielding an abundance ratio A(Ne)/A(O) of 0.17 +/- 0.05 with little variation in time. This value is in excellent agreement with the photospheric ratio of 0.15 +/- 0.03 of Asplund et al. (2005). Thus there is no evidence from the CDS spectra for a revised neon abundance and so the discrepancy between the SSM and helioseismological observations remains.

TOPICS
01 Solar Interior: From Exploration to Experimentation

ON THE CHOICE OF PHASE-SPEED FILTERS FOR HELIOSEISMIC TRAVEL-TIME MEASUREMENTS

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As time-distance helioseismology techniques are being developed further in pursuit of increased sensitivity to local structure and dynamics of the Sun, it is necessary to gain better knowledge and understanding of the systematic errors and inter-dependencies in the methods and measurements. Time-distance helisoseismology consists of measuring travel times of acoustic waves, which times are then inverted using sensitivity kernels (built from the forward model) to infer the local structure and dynamics of solar interior. Travel times of acoustic waves are calculated from Dopplergrams of solar observations using temporal cross-correlations of the oscillation signals from separated points on the solar surface. Due to the fact that acoustic waves with the same horizontal phase speed travel the same horizontal distance, travel times for acoustic waves propagating between two surface locations are measured from the waves with the same phase speed via filtering. Such phase speed filtering not only improves the signal-to-noise ratio in travel time measurements, but also allows the measurement of travel times at short distances. In this work we investigate the travel time measurements sensitivity to the choice of phase-speed filter parameters. Various choices of phase-speed filter may be found in the literature. Whilst new methods for building travel-time sensitivity kernels take into account the filtering procedure used for travel-times extraction, here we statistically/numerically compare travel times measured by different methods and extracted from SOHO/MDI Dopplergrams using varying filter parameters.

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01 Solar Interior: From Exploration to Experimentation

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2 Magnetic Variability: From the Tachocline to the Heliosphere

TEMPORAL VARIATION OF THE SOLAR ROTATION RATE DURING THE LAST DECADE

Basu, Sarbani[1]; Antia, H.M.[2]
[1]Yale University; [2]Tata Institute of Fundamental Research

With over a decade of helioseismic data now available, we study the variation of the solar rotation rate as a function of time. In addition to the the well known latitudinal shift in the zonal flow pattern, we also find that at low latitudes the pattern shifts upwards with time. This pattern can be compared with predictions of solar dynamo theories. We also examine possible periodic variations of the rotation rate in the region of the tachocline.

TOPICS
02 Magnetic Variability: From the Tachocline to the Heliosphere

ASPHERICITY AND TIME VARIATION OF THE STRUCTURE OF THE NEAR-SURFACE LAYERS OF THE SUN

Basu, Sarbani[1]; Antia, H.M.[2]; Bogart, R.S.[3]
[1]Yale University; [2]Tata Institute of Fundamental Research; [3]Stanford University

We present results on the structure of the near-surface layers of the Sun obtained by inverting frequencies of high-degree solar modes from "ring diagrams''. We find that there is a substantial latitudinal variation of both sound speed and the adiabatic index γ1 in the outer 2% of the Sun. We find that both the sound-speed and γ1 profiles change with changes in the level of solar activity.

TOPICS
02 Magnetic Variability: From the Tachocline to the Heliosphere

HIGH RESOLUTION OBSERVATIONS OF EMERGING ACTIVE REGIONS CARRIED OUT AT THE THEMIS TELESCOPE

Battiato, Viviana[1]; Billotta, S.[2]; Contarino, L.[3]; Guglielmino, S.[3]; Romano, P.[2]; Spadaro, D.[2]; Zuccarello, F.[3]
[1]INAF; [2]INAF - Catania Astrophysical Observatory; [3]University of Catania - Dipartimento di Fisica e Astronomia

Using data acquired during two observational campaigns at THEMIS telescope in IPM mode, coordinated with other instruments (IOACT, BBSO, TRACE, EIT/SOHO, MDI/SOHO), the first evolutionary phases of some active regions have been analysed, in order to study the morphology and dynamics of magnetic structures (pores, spots, AFS) during their emergence. The results obtained have provided indications on the atmospheric layers where the first manifestations of the emerging AR are evidenced, on the upward velocity of AFS, on asymmetries in downward motions in the AFS legs. These results have been interpreted in the framework of rising flux tube models.

TOPICS
02 Magnetic Variability: From the Tachocline to the Heliosphere

ON LINEAR AND NONLINEAR ANALYSIS OF JET AND CURRENT SHEET INTERACTIONS IN THE SOLAR SYSTEM: 2D HYBRID COMPACT SHOCK CAPTURING SIMULATIONS

Bettarini, Lapo[1]; Landi, S.[1]; Londrillo, P.[2]; Velli, M.[1]
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In several astrophysical and solar environments the interactions between a stream and a current sheet is the starting point to understand the dynamics and evolution of complex structures such as, for example in the heliospheric region, the solar wind on the equatorial plane both close to the Sun and far from it, reconnection jets in the solar flares, solar plumes, the interaction between the solar wind and the planetary magnetospheres. A general model used to describe these structures consists in a sheared flow in the presence of strong magnetic field gradients. We analyze the linear instability and the successive nonlinear evolution of such structures by using a 2D high order upwind "weno+compact" numerical scheme which solves the compressive MHD equations and combines the shock capturing property with a pseudospectral analysis method, allowing to reach those high values of sonic and alfvénic Mach number which necessarily characterize such systems. The results are applied to the ``slow" solar wind evolution in correspondence of the heliospheric current sheet within the first solar radii and to the dynamics of the post-termination shock jet on the equatorial plane found in 3D global heliospheric simulations.

TOPICS
02 Magnetic Variability: From the Tachocline to the Heliosphere

NUMERICAL SIMULATIONS OF SUNSPOTS

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On the visible surface of the sun, magnetic flux is pushed to the boundaries of granules and supergranules where they (possibly) grow in field strength to becomes pores. These pores may grow into sunspots, which can have lifetimes of up to several weeks. High-resolution observations have shown that sunspots possess intricate magnetic structures.

The origin, structure and evolution of sunspots are investigated using a numerical model. The compressible MHD equations are solved with physical parameter values that approximate the top layer of the solar convection zone. A three dimensional (3D) numerical code is used to solve the set of equations in cylindrical geometry, with the numerical domain in the form of a wedge.

The linear evolution of the 3D solution will be compared with an axisymmetric numerical solution, before nonlinear development in 3D will be discussed. The model and this work is an extension of axisymmetric results obtained earlier [1,2] and it elucidates some of the open issues associated with research into sunspots.

[1] N.E. Hurlburt and A.M. Rucklidge, 2000, MNRAS, 314, 793-806.
[2] G.J.J. Botha, A.M. Rucklidge and N.E. Hurlburt, 2006, MNRAS, submitted.

TOPICS
02 Magnetic Variability: From the Tachocline to the Heliosphere

ORIGIN AND DYNAMICS OF THE SOLAR INTERNAL MAGNETIC FIELD

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CEA-Saclay

We present recent advances made in modelling and understanding the complex magnetic phenomena occuring within the Sun. Based on multi-D MHD models of the Sun's radiative and convective zones we discuss in details the physical processes thought to be at the origin of the solar magnetic activity and cycles, its differential rotation and meridional circulation and its deep internal dynamics. In particular we show that the interactions between rotation, shear and magnetic field lead to interesting new perspectives regarding both the organization of the magnetic field in the solar interior, and the dynamical structure of the solar tachocline.

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SOLAR PHOTOSPHERIC MAGNETIC ELEMENTS DIMENSION AND ASSOCIATED RADIANCE

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The position of the photospheric magnetic elements or facular regions in the solar disc is used to study the angular distribution of the emitted radiation. We perform a combined analysis of the longitudinal magnetic field along the line of sight obtained with the Ni 676.8 nm line, and the emitted radiation in the continuum around the same line, measured by the MDI instrument aboard SOHO with two spatial resolutions, 4 arc seconds and 1.2 arc seconds (2 and 0.6 arc second pixels, respectively). Several sizes of magnetic structures have been studied aiming to obtain by extrapolation the characteristics of the smallest structures observable with MDI. The results allow us to discriminate between noise effects and foreshortening effects when obtaining the centre-to-limb distribution of the contrast between the radiating source and their surrounding. A comparison with recent theoretical numerical simulations of the photosphere is presented.

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THE TRANSITION REGION ABOVE SUNSPOTS

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We present results from spectroscopic observations of sunspots obtained in the vacuum ultraviolet wavelength range by SUMER on SOHO. The solar atmosphere above sunspots is very special and entirely different compared to other parts of the solar surface. The sunspots transition region, which is normally a thin layer extends very high in altitude and is filled by cold, low-density plasma. Sunspot plumes are very dynamical sites of systematic downflow into a bottom layer, which is coherently oscillating with a 3-minute period.

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SIMULATION OF ACTIVE REGION CORONAL LOOP EUV EMISSION

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The work concerns with study and simulation of spectral line emission of thin coronal loops observed in active regions by SOHO/EIT and TRACE. The model considers three–dimensional magnetic field structure, as well as flux–tube associated density and temperature distributions. The location and shape of magnetic loops in active region have been obtained from potential and/or linear force–free extrapolations of magnetic field from SOHO/MDI active region magnetograms. The emissivity in EUV spectral lines is then computed for tested density and temperature models and the outcome is confronted with EUV observations from SOHO/EIT and TRACE.

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REVIEW OF THE LONG-TERM PERFORMANCE OF THE PMO6 RADIOMETERS ON VIRGO/SOHO

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VIRGO on SOHO is now continuously operating for 10 years and it seems adequate to review the operational algorithms adopted long time ago. We report on the performance of the PMO6-type radiometers and focus on the problems which had to be tackled in the course of the years. The failure of the shutter mechanism forced a change of the mode of operation. During the process of re-characterization of the radiometers for the new mode of operation we gained insight into some important, but normally hidden, aspects of solar radiometry with room-temperature radiometers. Ten years of VIRGO radiometry has also taught us how to deal with instrumental "degradation" and by comparison of the two types of radiometers within VIRGO we have learned about the importance of non-exposure dependent changes. The scientific results of the VIRGO radiometry mainly emanate from the stability of its total solar irradiance (TSI) record combined with the contiguous coverage over nearly a full solar cycle by an individual TSI experiment.

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SEARCHING FOR COMMON MID-TERM VARIATIONS IN THE DIFFERENT ASPECTS OF SOLAR ACTIVITY

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We analyze the statistical properties of the following kinds of data series of solar activity phenomena: magnetic synoptic charts, solar flare index, coronal index, solar radio flux, interplanetary magnetic field, and proton speed in the solar wind to find common mid-term periods during Solar Cycles 21--23. Our approach differ mainly from the previous works that we investigate not only the area of the active regions, but the behaviour of magnetic polarity. In this way we hopefully can get additional information whether this periodicity arise directly from the impact of the variation of the tachocline thickness or it is in consequence of the interaction between the emerging flux tubes and the flow in the convective zone. Moreover, we also analyse on a homogenous way several other indicators of the solar activity phenomena for the same epoch.

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TOTAL SOLAR IRRADIANCE VARIABILITY: WHAT HAVE WE LEARNED FROM SOHO ABOUT SOLAR CYCLE 23?

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Solar cycle 23 is almost completely covered by measurements of total solar irradiance (TSI) by VIRGO/SOHO. The continuous measurements and the very quiet thermal environment of SOHO allowed to improve our understanding of the long-term behaviour of room-temperature radiometers in space. This not only improves the quality of the VIRGO record itself, but allows also to improve results from other space missions, as demonstrated by the PMOD composite of TSI which covers the last three solar cycles. The 10-year VIRGO TSI record will be presented, discussed and compared with other contemporaneous TSI time-series. Moreover, the differences and similarities in terms of TSI variability observed during this cycle and the two previous ones are discussed.

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SOLAR CYCLE VARIABILITY OF TOTAL SOLAR IRRADIANCE AND P-MODE FREQUENCIES

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During the 11-year solar cycle the total solar irradiance (TSI) varies by about 0.1 per from activity minimum to maximum, being larger during periods of high activity. The resonant p-mode frequencies change in a very similar manner. To effect a comparison of the TSI with these frequencies we have made use of mean shifts made from averages over p modes with low angular degree and intermediate tesseral order (l = 0...3, n = 21...24). These have been extracted from the analysis of data collected by the VIRGO/SPM and VIRGO/LOI instruments on board SOHO and the ground-based Birmingham Solar-Oscillations Network (BiSON). The mean shift of these modes is of order 0.5 μHz -- a fractional shift of 0.02 per cent -- from minimum to maximum. We have analyzed each data set in contiguous segments of length 108 days. All data covers the period through November 2005, the TSI composite starts 1978 November 18, the BiSON data 1991 February 2and the SPM and LOI sets 1996 February 22 and 1996 May 29 respectively, with the 108-d period beginning 1998 June 25 ignored due to instrument down-time during the `SOHO vacation'. Each set has been linearly regressed against TSI, corrected for the short-term influence of active regions by sunspots and faculae, which represents best the variability of the global quantity needed for adequate comparison with low-degree p modes. The BiSON data allow one to compare the descending phase of cycle 22, and together with the SPM and LOI data the almost complete cycle 23. We find that all three sets of low-l p-mode shifts are correlated strongly with the changing irradiance. During the SOHO period the degree-averaged slopes of the combined SPM and LOI data are slightly higher than the corresponding BiSON values, which may not be significant in view of the differences between the SPM and LOI data sets, with the latter being higher at the 2-sigma level.

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LARGE SCALE TOPOLOGY AND DYNAMICS OF SOLAR MAGNETIC FIELD.

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The new results are presented related to the latitudinal topology composed by four zonal structure with 22 -year period and running poleward waves with quasi 2-year period as well as a longitudinal structure and rotation of solar magnetic field over the last three cycles of solar activity.

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RELATIONSHIPS BETWEEN THE PHOTOSPHERIC MAGNETIC FIELD, SOLAR WIND AND GEOMAGNETIC CHARACTERISTICS. HAS BEEN BEEN PERFORM TO STUDY THE RELATIONSHIPS BETWEEN THEM DURING 21, 22 AND 23 SOLAR ACTIVITY CYCLES AND TO MAKE A PREDICTION FOR SPACE WEAT

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[1]Arcetri Astrophysical Observatory

Comparison between the temporal behavior of the photospheric and interplanetary magnetic fields, solar wind and geomagnetic characteristics has been been perform to study the relationships between them during 21, 22 and 23 solar activity cycles and to make a prediction for space weather on a long term scale.

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ROTATION OF THE EXTENDED SOLAR CORONA FROM SOHO/UVCS OBSERVATIONS

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The UVCS instrument aboard SOHO provides unprecedented high spatial resolution and almost uninterrupted observations of the solar corona in UV spectral region which covers nearly a complete activity cycle. The daily observations from April 1996 to the present have been analyzed to reconstruct long time series of the intensity emission from spectral line such as the OVI 1032 and HI Lyα at different latitudes in the coronal region from 1.5 to 3.0 Solar Radii. Some features persist for several solar rotations and thus it is possible to analyze the UV emission as a time-series modulated at the period of the solar rotation. The Lomb-Scargle periodogram is used to extract the most significant frequency components from time-series obtained with the UVCS observations. The method allows to determine the rotation period for unevenly sampled data and the results have been validated with the more traditional autocorrelation method. At the solar minimum we find evidence of differential rotation in the outer corona which differs from that of the photosphere. The variation of the coronal rotation rate with latitude shows that the extended corona is more influenced than the inner corona by the magnetic dipole and quadrupole of the Sun. We study the radial variation of the rotation period and we find that the degrees of differential rotation decreases with altitude. We study also the observations at the solar maximum, when an accurate determination of the rotation rate is more difficult, due to the complexity and rapid evolution of the corona, we find that the extended corona rotation is little affected by the slower rotation of the inner corona at the solar maximum.

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PROMINENCE PARAMETERS DERIVED FROM HYDROGEN LYMAN-A SPECTRAL PROFILES MEASURED BY SOHO/SUMER

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We present SOHO/SUMER observations of a solar prominence in the hydrogen Lyman-ɑ line and compare the line intensities with synthetic ones obtained using our 2D prominence modelling. The observations contain the raster image of a solar prominence in Lyman-ɑ and in Si III lines (observed on 18 April 2005). The raster consists of 80x50 pixels and in each pixel we have the full profile of the two lines. In order to derive the prominence parameters we used our fine structure models of vertical threads in magnetohydrostatic (MHS) equilibrium. Such thread models have been described by Heinzel & Anzer (2001) and Heinzel, Anzer & Gunár (2005). Starting with a grid of 18 models constructed in the latter paper we found a model having the Lyman-α profile similar to a typical profile chosen from the raster. By varying the input model parameters (central temperature, boundary pressure, magnetic field, central column mass and turbulent velocity) we obtained synthetic Lyman-ɑ profiles which are in good agreement with the observed ones. In this way we are able to determine the structure of the magnetic dip and thermodynamical parameters in the observed prominence. Finally, we check our results against the diagnostical constraints set on the prominence-corona transition region emission of Si III line.

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A ROUND-SHAPE FILAMENT AND THE EFFECT OF THE MAGNETIC FIELD ORIENTATION ON LYMAN-LINE PROFILES

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We present the MEDOC coordinated campaign (SOHO and ground-based instruments) observations of a round-shape filament observed from October 15 to 17, 1999. The observations contain the Lyman series obtained mainly by SUMER with complementary observations made with the MSDP on VTT and with the Big Bear Hα telescope. The round-shape filament shows different Lyman-line profiles observed as moves towards the limb during this period of observations. To interpret such differences we used 2D thread models developed by Heinzel and Anzer (2001). By detailed modelling of the observed spectra we show that these differences in Lyman-line profiles can be understood by different orientation of the magnetic field with respect to the line-of-sight. Our 2D thread models are based on two-dimensional a magnetohydrostatic equilibrium which determines, together with the temperature distribution, the structure of the prominence-corona transition region (PCTR). This then leads to different shapes of Lyman-line profiles when observed along and across the magnetic field lines.

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MOVING MAGNETIC FEATURES OBSERVED IN PHOTOSPHERE, CHROMOSPHERE, AND CORONA

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We study TRACE observations in 1600Å to find Moving Magnetic Features, using the method developed by Hagenaar & Shine (2005). The signal in 1600 Å roughly corresponds to the unsigned magnetic flux density, and is directly compared with a Full Disk SoHO/ MDI magnetogram. After detecting MMF's in the TRACE 1600Å we study their presence in high resolution (diffraction limited) filtergrams made with the Dunn Solar Telescope on Sacramento Peak, New Mexico, in CaK, G-band, Hα; together with vector magnetograms. Combined with TRACE data in 171Å, these data shed some light on MMF's, not only in the photosphere, but also in the chromosphere and the corona.

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WHAT WE HAVE LEARNED ABOUT PROMINENCES AND FILAMENTS FROM SOHO/SUMER AND CDS SPECTRAL OBSERVATIONS

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We summarise the results of our prominence and filament studies based on extensive spectral observations with SOHO/SUMER and CDS instruments. During the past decade we have gathered several sets of UV and EUV spectral data, containing various emission lines of different species. Our main objective was to better understand the formation of hydrogen Lyman lines and continuum (using the results of complex non-LTE transfer simulations), but we have analysed also UV and EUV lines formed under transition-region and coronal conditions. Some highlights of our studies are: reproduction of Lyman-line profiles with partial redistribution, understanding of the role of prominence-corona interface in the formation of Lyman-line cores, establishing the effect of the magnetic-field orientation on the shape of Lyman lines, discovery of EUV filament extensions (invisible in the Hα line) and their explanation, reconstruction of a 3D topology of the filament using EUV coronal lines, temperature diagnostics based on measurements of the hydrogen Lyman continuum, proper explanation of a prominence darkening detected in coronal lines.

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DARKENING OF CORONAL LINES BY LIMB PROMINENCES OBSERVED BY SOHO/SUMER

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We report on SOHO/SUMER observations of limb prominences in two coronal lines FeXII 1242 A and MgX 625 A. The importance of this line pair is that while MgX line is affected both by the absorption and the volume-blocking, FeXII line can be darkened only by the latter mechanism. By prominence absorption we mean here the hydrogen ground-state photoionisation (Lyman continuum) by MgX coronal radiation, while the volume-blocking accounts for the lack of coronal emission within the volume occupied by the prominence. We use several examples of different prominences and show how these two mechanisms work and how they can be separated by using such line pair for the diagnostics. This work generalises previous results of Kucera et al. (1998) on the prominence absorption.

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THE ORIGIN OF CURRENT HELICITY IN ACTIVE REGIONS

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Following an earlier proposal by Choudhuri (2003) for the origin of twist in the magnetic fields of solar active regions, we model the penetration of a wrapped up background poloidal field into a toroidal magnetic flux tube rising through the solar convective zone. The rise of the straight, cylindrical flux tube is followed by numerically solving the induction equation in a comoving Lagrangian frame, while an external poloidal magnetic field is assumed to be radially advected onto the tube with a speed corresponding to the rise velocity. One prediction of our model is the existence of a ring of reverse current helicity on the periphery of active regions. On the other hand, the amplitude of the resulting twist depends sensitively on the assumed structure (diffuse vs. concentrated/intermittent) of the active region magnetic field right before its emergence, and on the assumed vertical profile of the poloidal field. Nevertheless, in the model with the most plausible choice of assumptions a mean twist comparable to the observations can result rather naturally. Our results indicate that the contribution of this mechanism to the twist can be quite significant, and under favourable circumstances it can potentially account for most of the current helicity observed in active regions.

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MULTI-WAVELENGTH OBSERVATIONS WITH HIGH RESOLUTION OF A M5.4 FLARE FROM GROUND AND SPACE.

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We present observations of all phases of a M5.4 flare and the associated CME. Multi-wavelength observations were performed in a coordinated campaign to cover the whole solar atmosphere from the photosphere to the corona and interplanetary space. Observations were made with the German VTT, (WL, H-alpha images, photospheric spectral lines near the flare), SOHO/CDS (six spectral lines), SOHO/EIT, and TRACE. Supplementary data were collected from astronomical databases, namely SOHO/MDI (white light and magnetograms), SOHO/LASCO, RHESSI X-ray data, full Stokes magnetograms from Mitaka, Big Bear and Haleakala observatories, GOES X-ray data and radio-observations from Trieste, Zuerich, Irkutsk and Potsdam. The temporal evolution of the event in particular channels and spectra is presented in the form of movies and some results are discussed. Especially the dynamics of a filament eruption observed in both H-alpha and TRACE (19.5 nm) is documented. In addition intensity and velocity oscillations observed in SOHO/CDS spectra and the coupling and timing of different hot layers revealed in RHESSI, SOHO/CDS, SOHO/EIT and TRACE data with the CME observed with SOHO/LASCO are discussed.

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ANALYSIS OF A RELATION BETWEEN SUBPHOTOSPHERIC PLASMA FLOWS AND PHOTOSPHERIC CURRENT KERNELS

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Recent papers showed that new emerging flux in active region carries electric currents of subphotospheric origin. The question of how these currents are produced is still open. Very recently the subphotospheric plasma flows below the sunspots and active regions were revealed by the Time-Distance method of local helioseismology from SOHO/MDI data. In this paper we study positions of current kernels obtained from vector magnetograms together with maps of z-component of kinetic helicity at several depths below the photosphere. The MFSC vector magnetograms obtained from internet archive were used together with 3-D velocity fields obtained by Time-Distance method and provided by Stanford Solar Group.

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ON THE ORIGIN OF "UNIPOLAR" MAGNETIC FLUX EMERGENCE: THE EMERGENCE YOU SEE IS NOT THE TRUE EMERGENCE

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Automated tracking of magnetograms provides the ability to detect magnetic features in an unbiased manner. Such feature tracking shows many instances of apparent unipolar flux emergence. Flux conservation dictates that this cannot be a real phenomenon and thus must be due to processes below the detection limit of routine measurements. We use large numbers of these apparent unipolar events to distinguish between two models of small-scale magnetic flux formation. In "small flux coalescence" magnetic features below the resolution limit converge to produce a detectable signature, and in "asymmetric emergence" the cross-section of one end of the flux tube is too large to be detected. We find that coalescence due to sub-resolution processes provides a better explanation for the apparent unipolar emergences.

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DYNAMICS OF THE TACHOCLINE: TURBULENCE, SHEAR, ROTATION AND STRATIFICATION.

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Turbulence is one of the most important transport process taking place in the Sun. This is particularly true since the molecular values of transport coefficients are often too small to explain observations. For instance, the uniform rotation in the radiative interior requires an efficient transport of angular momentum towards the convection zone, which is enhanced over molecular value. Furthermore, the surface depletion of light element, such as lithium, implies an efficient transport of this element from the convection zone towards the radiative interior where it can be destroyed by nuclear reaction. A key point in understanding these phenomena is the dynamics of the tachocline, a thin layer between the radiative interior and the convective zone, where the transport in the two regions is linked. Despite their importance, turbulent transport coefficients relevant to the solar interior are poorly understood, and are thus often crudely parameterized and then fine-tuned to be consistent with observations. In this contribution, we present a self-consistent theory of turbulent transport in the solar tachocline by incorporating a number of crucial physical effects, which are pertinent to understanding the dynamics of the solar tachocline. Turbulence in the tachocline is assumed to be driven by plumes penetrating from the convection zone. We first show that (stable) radial differential rotation regulates turbulence by shearing (via shear stabilization), leading to anisotropic turbulence, even in the absence of magnetic fields and stratification. Specifically, turbulence amplitude and particle transport in the vertical (radial) direction are more severely reduced compared with those in the horizontal direction. We then study the effects of Coriolis force by including the average rotation of the Sun. In the case where the shearing rate A by radial differential rotation is comparable to the average rotation rate Ω, which is relevant to the present Sun, we show that the reduction in the transport (via shear stabilization) is the same, both for the angular momentum and the chemical species in both vertical (radial) and horizontal directions, being proportional to A^2, in contrast to the non-rotating case, mentioned above. However, turbulence amplitude is less affected by Coriolis force. That is, as in the case without rotation, the horizontal turbulence is less reduced by the shear than the vertical one although the anisotropy is much less pronounced in the rotating case, the relative intensity being of order ln A (as compared to A^{1/3} in the non-rotating case). In the extreme limit of a very rapidly rotating star (Ω >> A), we find a significant effect of rotation on turbulent transport, depending on the quantities and directions. Specifically, while the turbulence amplitude and transport of angular momentum are not reduced much by the rotation, the transport of chemical species is reduced in an anisotropic way: compared to the case without rotation, the transport in the direction of the shear flow is further reduced by a factor of (Ω/A)^2 whereas the transport in the vertical and the other horizontal direction is reduced only by a factor Ω/A. We will discuss the effects of stratification and some of the important implications for angular momentum transport and mixing of lithium as well as a long-term dynamics of the solar tachocline (such as its thinness).

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DOES THE UMBRAL BRIGHTNESS REALLY CHANGE WITH SOLAR CYCLE?

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Albregtsen and Maltby (1978, Nature, 274, 41) reported a variation in umbral core brightness with solar cycle. From the analysis of 20 sunspots which cover solar cycle 20 and 21, they found that the umbral core intensity increases from early to the late phase of the cycle. Here we revisit this topic by analyzing a large number of sunspots observed by SoHO/MDI instrument for the period between 1996 June to 2004 March. The data set covers a sizable part of solar cycle 23. Data for more than 200 sunspots, with umbral radius greater than 5 arc-secs are included in the analysis. We utilized full disk continuum images observed with the above instrument for this purpose. The advantage of this data set is its homogeneity, with no seeing fluctuations. A careful stray light correction is carried out before the umbral core intensities are obtained. The influence of the measured "continuum" intensity by the Zeeman-split spectral line is also taken into account. In this presentation we will discuss the results obtained form the analysis and compare our results with earlier findings.

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SOUND WAVE TRAVEL TIMES IN PLAGE AREAS - THE EFFECT OF ABNORMAL GRANULATION

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We consider the effect that abnormal granulation observed in active regions should have on the propagation of acoustic waves. Any such effect is found to be limited to a shallow surface layer where sound waves propagate nearly vertically. The magnetically suppressed turbulence implies higher sound speeds, leading to shorter travel times. This time shift is independent of the travel distance, while it shows a characteristic dependence on the assumed plage field strength. As a consequence of the variation of the acoustic cutoff with height, the time shift is expected to be significantly higher for higher frequency waves within the observed regime of 3--5 mHz. The lower group velocity near the upper reflection point further leads to an increased envelope time shift, as compared to the phase shift. These characteristics of the time shifts are in accordance with observations. The calculated overall amplitude of the time shift is about ten seconds, comparable to, but still significantly less than suggested by measurements.

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STABILITY OF MAGNETIC FIELD BELTS IN THE SOLAR TACHOCLINE

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The stability of toroidal magnetic fields in the differentially rotating solar tachocline is studied by means of global 3D MHD simulations. The tachocline is the location where the hydrodynamic Rayleigh instability and the magnetic Tayler instability interact. Nonaxisymmetric magnetic modes with m>0 are linear-unstable under the weak influence of the underlying rotation law. We found stability limits for toroidal fields of only i) 100 Gauss for an incompressible and stably stratified sphere in radiative equilibrium and ii) of 1000 Gauss in the outer (supergranulation) layer of the solar convection zone. We conclude that the tachocline is NOT a suitable site for the storage of too strong magnetic fields. On the other hand, all our results lead to a nonturbulent but magnetic solar tachocline where the magnetic field geometry is strongly influenced by the meridional circulation of about 10 m/s which is generated by the above-located convection zone and which slightly penetrates the tachocline. Since these results are based on an extrapolation of our numerical computations to lower solar diffusivities, high-resolution calculations at higher magnetic Reynolds numbers and for lower magnetic Prandtl number are now in progress.

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MAGNETIC VARIABILITY OF THE STREAMER BELT

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In order to study the temporal variation of the streamer belt with the magnetic field of the Sun, we have implemented a new approach based on forward modelling. The 3-D electron density is constructed from the neutral sheet computed using the Potential Field Source Surface (PFSS) mode, compressed using the octree formalism, and synthetic images of the solar corona are calculated by ray-tracing incorporating the Thomson scattering. The resulting images are compared to the LASCO-C2 observations, both qualitatively and quantitatively, preferably using the synoptic maps which display the global behaviour of the streamer belt over successive Carrington rotations. The local electron density in the streamer belt has been determined for 54 Carrington rotations (CR 1910 to CR 1970, i.e., from 06/1996 to 12/2000) and increases by no more than a factor 1.5, compared to a factor of at least 3 for the global density obtained from direct inversion of the calibrated LASCO-C2 pB images. We show that this difference of a factor ~2 between the local and global densities result from two combined effects, i) the increase of the length of the neutral line as the warping of the neutral sheet grows with the progression of the solar cycle, and ii) the emergence of magnetic structures with are not accounted for by the PFSS (Saez et al. 2005).

TOPICS
02 Magnetic Variability: From the Tachocline to the Heliosphere

IMPORTANCE OF ABSORPTION AND VOLUME BLOCKING FOR LINE INTENSITY DEPRESSION IN EUV FILAMENTS

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Absorption by hydrogen and helium resonance continua and a volume blocking can contribute together to an intensity depression of EUV filaments. For estimation of the relative contribution of those two processes to intensity depression it is necessary to know the optical thickness at the resonance continuum of hydrogen. This can be estimated from the non-LTE diagnostics of the hydrogen Lyman lines using e.g. one-dimensional slab model of the filament. In our previous work we reported modelling of hydrogen Lyman lines (Lβ, Lδ, Lε, L6 and L7) of the EUV filament observed by SoHO/SUMER on 15 October 1999. This EUV filament was rather inhomogeneous and composed of several threads. For part of the EUV filament visible also in the Hα line (the Hα filament) we obtained large (several hundreds) optical thickness tau_{912} at head of the hydrogen Lyman continuum. This result was expected since the Hα filament is always optically thick also in the Hα line. In the EUV extension there were some areas where modelling gave very low (<<1) optical thickness tau_{912}. Therefore, the volume blocking must play a crucial role in these areas, because also they were observed by SoHO/CDS as parts of a dark feature of the EUV filament as well. But there were also areas of optical thickness tau_{912}~5. In these parts of the EUV extension also absorption should play an important role. In this work we are modelling hydrogen Lyman lines (Lε to L11) of a more compact and better pronounced EUV filament observed by SoHO on 5 May 2000. We are using the same non-LTE model and fitting technique as for the previous case. Finally, we compare results obtained from modelling of both EUV filaments, in order to establish their common properties.

TOPICS
02 Magnetic Variability: From the Tachocline to the Heliosphere

NUMERICAL SIMULATIONS OF SLOW STANDING WAVES IN A CURVED SOLAR CORONAL LOOP

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[1]UMCS; [2]Institute of Physics UMCS

We consider slow standing waves that are impulsively excited in a curved solar coronal loop. A numerical model we implement includes the effect of nonlinearity in a frame of two-dimensional ideal magnetohydrodynamics. We discuss a role of curved magnetic field lines on excitation and attenuation of slow standing waves.

TOPICS
02 Magnetic Variability: From the Tachocline to the Heliosphere

THE FOCAL PLANE PACKAGE OF THE SOLAR OPTICAL TELESCOPE ON SOLAR-B

Tarbell, Ted
Lockheed Martin Solar & Astrophysics Lab

The Solar-B satellite will be launched into a full-sun low-earth orbit in the fall of 2006 from Japan's Uchinoura Space center. It includes the 50-cm diameter Solar Optical Telescope with its Focal Plane Package (FPP), for near-UV and visible observations of the photosphere and chromosphere at very high (diffraction limited) angular resolution. The FPP has a Spectro-Polarimeter (SP) for precision measurements of photospheric vector magnetic fields over a 160 x 320 arcsecond field of view; a Narrowband Filter Imager (NFI) with a tunable birefringent filter for magnetic, Doppler, and intensity maps over the same field of view; and a Broadband Filter Imager (BFI) for highest resolution images in six wavelengths (G band, Ca II H, continua, etc.) over two-thirds of that field of view. A polarization modulator in the telescope allows measurement of Stokes parameters at all wavelengths in the SP and NFI. The NFI wavelengths include both photospheric and chromospheric lines (Fe I, Mg b, Na D, H-alpha). All images are stabilized by a tip-tilt mirror and correlation tracker. This poster will include pictures and description of the instrument, results from calibration and sun testing, portions of the draft science plan, and some preliminary JOP's. Solar-B is an international cooperative mission between JAXA/ISAS of Japan, NASA of the United States, and PPARC of the United Kingdom. The Solar Optical Telescope has been developed by the National Astronomical Observatory of Japan, Mitsubishi Electric Company, and JAXA/ISAS. The FPP has been developed by the Lockheed Martin Advanced Technology Center, High Altitude Observatory, and NASA.

TOPICS
02 Magnetic Variability: From the Tachocline to the Heliosphere

THE DYNAMIC NATURE OF THE LOWER TRANSITION REGION AS REVEALED BY SPECTROSCOPY OF THE HYDROGEN LYMAN ALPHA LINE.

Teriaca, Luca; Schuehle, U.; Solanki, S.K.; Curdt, W.; Marsch, E.
[1]*Max Planck Institut fuer Sonnensystemforschung*

Past spectroscopic observations of the Lyman alpha line have been often characterised by a compromise between spatial and spectral resolution and, even more often, by the lack of adequate temporal resolution and coverage. However, they have shown the extreme variability of the Lyman profiles in different solar features.

Taking advantage of the spectral capabilities of the stigmatic SUMER spectrograph aboard SOHO, we have acquired several temporal sequences comprising both the H I Lyman alpha and the optically thin Si III 120.6 nm line (T ~ 20,000 K) on both Sun centre and the north limb. The temporal evolution of the integrated radiances looks very similar at the 1.5" SUMER spatial resolution, showing the integrated Lyman alpha radiance to be a good diagnostic of the dynamics of the lower transition region. At disk centre we obtain a clear signature of the internetwork 3 min oscillations, while larger periods seems to be present in the network. At the north limb, the variability is dominated by spicules and macrospicules. Several of them show a quick (~ 100 s) raise up to around 30" to 40" followed by a slower fall back (200 to 300 s). An indication of a periodicity of about 10 min is also present.

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02 Magnetic Variability: From the Tachocline to the Heliosphere

THE DYNAMICS AND STRUCTURE OF THE SOLAR ATMOSPHERE AS OBTAINED FROM COMBINED SUMER/SOHO AND TIP2/VTT OBSERVATIONS

Teriaca, Luca; Lagg, A.; Aznar Cuadrado, R.; Sasso, C.; Solanki, S.K.
[1]*Max Planck Institut fuer Sonnensystemforschung*

We present combined observations of Active regions and quiet Sun areas. The SUMER spectrograph aboard SOHO provided high spatial, spectral and temporal resolution spectra of several lines formed at transition region temperatures ($4.2<\log(T/K)<5.6$) while the TIP2 spectropolarimeter on the VTT telescope was acquiring spectra of the chromospheric He I 10830 line and the photospheric Si I 10827 line in the four Stokes parameters. These data allow us to study the relationship between the structures and flows observed in transition region with the full magnetic vector at the chromospheric and photospheric levels as obtained from the inversion of the spectropolarimetric data.

TOPICS
02 Magnetic Variability: From the Tachocline to the Heliosphere

SOLAR CYCLE CONTRAST CHANGES AS SEEN IN EUV TRANSITION REGION LINES

Thompson, William
NASA/GSFC, L-3 Communications

Synoptic CDS measurements are used to explore the evolution of the network contrast in the transition region lines of He I at 58.4 nm and O V at 63.0~nm from 1996 to the present. Intensity histograms are fitted as log-normal distributions, and the evolution of the contrast parameter is traced as a function of time and latitude. The implications for the sources of solar EUV irradiance variations are explored.

TOPICS
02 Magnetic Variability: From the Tachocline to the Heliosphere

MAGNETOHYDRODYNAMIC SIMULATION OF SOLAR SURFACE CONVECTION WITH REALISTIC PHYSICS

Ustyugov, Sergey
Keldysh Institute of Applied Mathematics

Three-dimensional magnetohydrodynamical large eddy simulation of solar surface convection using realistic model physics is conducted. The effects of magnetic fields on thermal structure of convective motions into radiative layers ,the range of convection cell sizes and penetration depths of convection is investigated. We take of a some portion of the solar photosphere and the upper layers of the convection zone, a region extending 30 x 30 Mm horizontally from 0 Mm down to 18 Mm below the visible surface . Equations of the fully compressible radiation magnetohydrodynamics with dynamical viscosity and gravity are solved. In simulation we apply : 1)realistic initial model of Sun and equation of state and opacities of stellar matter, 2) high order conservative TVD scheme for solution magnetohydrodynamics, 3) diffusion approximation for solution radiative transfer, 4) calculation dynamical viscosity from subgrid scale modelling. Simulations are conducted on horizontal uniform grid of 320 x 320 and with 144 nonuniformly spaced vertical grid points on the 128 processors of supercomputer with distributed memory multiprocessors.

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STATISTICAL ANALYSIS OF MAGNETIC FIELD TILTS IN THE CYCLE 23 WITH THE AUTOMATED SUNSPOT GROUP CLASSIFICATION USING SFCS

Zharkov, Sergei[1]; Zharkova, V.V.[2]; Bianda, M.[3]; Cortesi, S.[3]
[1]University of Sheffield; [2]Bradford University; [3]IRSOL, Locarno Observatory

We investigate statistical variations of magnetic field tilt in sunspot groups and their relation to the total magnetic field contained in sunspots during different phases of the solar cycle 23 using the automated sunspot group classification from the Solar Feature Catalogues (http://solar.inf.brad.ac.uk) for 1996-2005. The classification results are compared with the similar research for the cycle 22 and the specifics on the cycle 23 is discussed. The results are also tested against the existing solar dynamo models and their applicability for the solar activity forecast.

TOPICS
02 Magnetic Variability: From the Tachocline to the Heliosphere

SUNSPOT AND PLAGE LATITUDINAL DISTRIBUTIONS AND THEIR CORRELATION WITH PERIODICITY OF THE GLOBAL MAGNETIC FIELD IN THE CYCLE 23

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[1]Sheffield University; [2]University of Florence; [3]University of Bradford

We investigate latitudinal activity of sunspots and plages in the cycle 23 extracted from the Solar Feature Catalogues (http://solar.inf.brad.ac.uk) and compare them with large scale magnetic field variations extracted from the MDI and WSO magnetograms. The area and magnetic field variations in time and cumulitative variations in the butterfly diagrams for sunspots and plages are compared with the zone structure and periodicity of the global magnetic field detected by different instruments for the cycles 23 (WSO and MDI) and 22 (WSO). The results are discussed in applications to theoretical dynamo models and to the solar activity forecast.

TOPICS
02 Magnetic Variability: From the Tachocline to the Heliosphere

LARGE-SCALE STRUCTURE OF THE SOLAR CORONA OBSERVED BY SOHO

Zhukov, Andrei[1]; Saez, F.[2]; Lamy, P.[2]; Llebaria, A.[2]; Koutchmy, S.[3]; Stenborg, G.[4]; Lawrence, G.[1]
[1]Royal Observatory of Belgium; [2]Laboratoire d'Astrophysique de Marseille; [3]Institut d'Astrophysique de Paris; [4]NASA Goddard Space Flight Center and Catholic University of America

Observations by SOHO/LASCO and SOHO/EIT can be used to obtain information on the three-dimensional structure of the quasi-stationary solar corona. We investigate the structure of the streamer belt using a model that allows us to simulate its quasi-stationary configuration. Starting from the National Solar Observatory photospheric magnetograms, the position of the neutral line at the source surface (2.5 solar radii) is determined. A plasma sheet is centered around the current sheet represented as the radial extension of the neutral line. We then compare the synoptic maps of the streamer belt obtained with the SOHO/LASCO C2 coronagraph and the simulated synoptic maps constructed from our model of the warped plasma sheet. We confirm earlier findings that the streamers are associated with folds in the plasma sheet. During the years of solar cycle minimum, the large-scale configuration of the plasma sheet can be determined by the potential field source surface model (PFSS). Some features, however, cannot be explained in this framework and require the introduction of additional folds of the neutral line. These additional folds are well visible in photospheric magnetograms and in the configuration of filaments. During the epoch of high solar activity the PFSS model can describe only a part of the streamer belt. High-latitude streamers associated with the polar crown filaments can form separate streamer belts and are not represented in the PFSS model. Our results suggest that the PFSS model is not fully adequate for the description of the structure of the streamer belt, even during the years of low activity.

TOPICS
02 Magnetic Variability: From the Tachocline to the Heliosphere

SOHO 17: List of Posters

3 Atmospheric Heating and Solar Wind Origin: MHD vs. Plasma Physics

CORONAL SEISMOLOGY USING PERIODS AND DAMPING RATES OF OSCILLATING LOOPS

Arregui, Inigo[1]; Andries, J.[2]; Goossens, M.[2]; Van Doorsselaere, T.[2]; Poedts, S.[2]
[1]Universitat de les Illes Balears; [2]Centre for Plasma Astrophysics, K.U. Leuven

We report on how the combination of observational values of the period and the damping rate of transverse loop oscillations and theoretical and numerical results for resonantly damped quasi-mode kink oscillations in non-uniform flux tubes can be used to extract information on physical parameters in oscillating coronal loops. Observationally estimated periods and damping rates of coronal loops are used together with parametric studies of the period and damping of quasi-mode kink oscillations to calculate equilibrium models that have the same period and damping rate as observed through the assumed damping mechanism. When only the damping rate is used, we only obtain an infinite number of equilibria given by some restricted values that are however linked one to another. The use of both the observed periods and damping rates allows us to obtain a restriction on the internal Alfv\'en velocity, the density contrast and the radial inhomogeneity length-scale. Remarkably, the consideration of radially inhomogeneous flux tube models extends considerably the range of possible equilibrium models when compared with previous seismic determinations using uniform models. The present method not only allows the estimation of unknown physical parameters of coronal loops, but is also a test of the assumed physical damping mechanism.

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03 Atmospheric Heating and Solar Wind Origin: MHD vs. Plasma Physics

TOMOGRAPHIC RECONSTRUCTION OF POLAR PLUMES WITH EIT/SOHO

Auchère, Frédéric[1]; Barbey, N.[2]; Rodet, T.[3]; Vial, J.-C.[1]; Bocchialini, K.[1]
[1]Institut d'Astrophysique Spatiale; [2]Institut d'Astrophysique Spatiale/Laboratoire des signaux et systèmes; [3]Laboratoire des signaux et systèmes

We present a three-dimensional reconstruction of the polar plumes observed by EIT/SOHO. Using rotational tomography, the local emissivity is obtained in the three coronal passbands of EIT (17.1, 19.5 and 28.4 nm), which permits the derivation of the temperature structure. Future reconstructions will be better constrained by more realistic assumptions on the geometry and on the temporal evolution. In combination with the forward modeling of the EUV emission, this work paves the road for the data analysis of the STEREO mission to be launched in july 2006.

TOPICS
03 Atmospheric Heating and Solar Wind Origin: MHD vs. Plasma Physics

SPATIAL DAMPING OF MAGNETOACOUSTIC WAVES IN A PROMINENCE MEDIUM

Ballester, Jose Luis
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Using an energy equation with optically thin radiative losses, thermal conduction and heating, we have studied the spatial damping of magnetoacoustic waves in a prominence medium. The results point out that at long and intermediate periods, the spatial damping of magnetoacoustic waves is dominated by radiation, while at short periods thermal conduction dominates. Then, for the interval of periods detected in prominence oscillations, radiation is responsible for the spatial damping of magnetoacoustic waves and, while the fast wave displays a very long damping length, the slow wave shows that for typical periods of prominence oscillations between 5 and 15 minutes, the damping length is order $10^4 - 10^5 km$.

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03 Atmospheric Heating and Solar Wind Origin: MHD vs. Plasma Physics

OFF-LIMB CORONAL LOOP DYNAMICS AS SEEN FROM CDS, EIT AND TRACE

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Observations have revealed the existence of weak transient disturbances in extended coronal loop systems. These propagating disturbances (PDs) originate from small scale brightenings at the footpoints of the loops and propagate upward along the loops. In all cases observed, the projected propagation speed is close to, but below the expected sound speed in the loops. This suggest that the PDs could be interpreted as slow mode MHD waves. Interpreting the oscillation in terms of different wave modes and/or plasma motions always depend on the line of sight as we observe in the limb or on the center of the disk. The JOP 165 campaign will address some of these questions. MDI and TRACE photospheric and UV imaging of TRACE and SPIRIT have been acquired simultaneously with high temporal and spatial coverage along with the spectroscopic data from CDS. EIT was operated in the shutterless mode to achieve high Cadence. Some of the off-limb active region dynamics and oscillations observed during this JOP campaign will be focussed in this presentation. Plasma condensations and temporal variations in active region loops will be also addressed.

TOPICS
03 Atmospheric Heating and Solar Wind Origin: MHD vs. Plasma Physics

CORONAL EVOLUTION DURING A SOLAR CYCLE WITH SYNOPTIC MAPS FROM SOHO/UVCS OBSERVATIONS

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The UVCS instrument aboard SOHO provides, for the first time, long time series of data for the UV corona from 1.5 to 3.0 Solar Radii. The UVCS observations, performed nearly daily from April 1996 to the present, cover almost an entire solar cycle, thus these data allow the reconstruction of synoptic maps which represent a powerful means of obtaining information on the short and long term coronal evolution. In this work we describe the techniques for reconstructing the synoptic maps of the spectral line parameters derived by fitting the UVCS data. We present the intensity synoptic maps of the main spectral lines observed by UVCS (H I Lyman α, O VI doublet and Si XII), the temperature maps of H I atoms and O VI ions, the maps of O VI doublet ratio and the inferred O/H abundance map at different heliocentric heights. The maps show the evolution over the solar cycle of the physical properties of the corona (such as densities, temperatures and outflow velocities) and allow the study of the variation of large scale structures, such as high and low latitude coronal holes and quiescent and active streamers.

TOPICS
03 Atmospheric Heating and Solar Wind Origin: MHD vs. Plasma Physics

A DYNAMICAL MODEL OF MAGNETIC RECONNECTIONS

Berrilli, Francesco[1]; Viticchie`, B.[1]; Del Moro, D.[2]; Giordano, S.[1]; Egidi, A.[1]
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Magnetic reconnections play a central role in solar corona heating processes. However, significant energy contributors like large flares are too rare to account for the energy required to maintain a hot corona. Since the number of flares is inversely proportional to their energy, a natural solution (Parker, 1972) is to consider the contribution of a large number of small flares (i.e., microflares and nanoflares). Under this hypothesis, the coronal heating is essentially a statistical problem (Georgoulis, 2003). Particularly, assuming that the energy probability distribution function (PDF) of small-scale magnetic events is described by a power law, in order to be statistically significant the exponent must be greater than 2. A second statistical property of solar flares is the frequency distribution function of waiting times (WTD), i.e. the distribution of times between magnetic events. Time statistics can give information on how to model flare statistics or to probe the character of the external drive (Boffetta et al.,1999). Recently, Hughes et al. (2003) investigated the emergence of a power law distribution of flare energies associated with a scale free network of magnetic loops. The authors studied the reconnections of multiple interacting magnetic loops randomly driven at their footpoints, mimicking a turbulent motion. Nevertheless, as reported by the authors, the model neglected important features of the photosphere such as spatiotemporal correlations. We present a photospheric dynamic model of coronal magnetic field in which magnetic loop footpoints are controlled by horizontal flows computed through a N-body simulation. The N-body advective-interaction model, based on the approach proposed by Rast (2003), reproduces large spatial organization scales (e.g. meso and super-granulation) from interaction of granular-scale advection flows. Magnetic reconnections, modeled according the multiple magnetic loops scheme (Hughes, 2003), are due to magnetic field reconfigurations triggered by magnetic footpoints passive advection through space-temporal correlated photospheric flows. Probability distribution functions and waiting time statistics for simulated reconnections are discussed in the framework of coronal heating problem.

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03 Atmospheric Heating and Solar Wind Origin: MHD vs. Plasma Physics

NON-LOCAL PHENOMENA IN NUMERICAL HYDRODYNAMICS: APPLICATION TO THE SOLAR ATMOSPHERE

Bradshaw, Stephen; Cargill, P J
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The relevance of non-local phenomena to the plasma physics of the solar atmosphere has long been appreciated and a number of early attempts have been made to incorporate the associated effects into numerical models. Non-local phenomena arise in the presence of steep physical gradients, such as are characteristic of the solar transition region, where high-energy electrons may stream collisionlessly from the hottest regions of the atmosphere and travel a great distance before reaching substantially cooler and denser regions (e.g. Shoub, E.C., 1983, ApJ, 266, 339; Owocki, S.P., and Canfield, R.C., 1986, ApJ, 300, 420). The high-velocity tail to the distribution function that arises under these circumstances represents a substantial departure from the commonly assumed Maxwellian distribution. In the solar case a high-velocity tail to the distribution function has two important consequences. The first consequence is a necessary modification of the heat flux from the corona to the underlying atmospheric layers. Traditionally calculated by assuming a small departure from a Maxwellian distribution due only to local effects (e.g. Spitzer, L., and Harm, R., 1953, Phys. Rev., 89, 977); this treatment is invalid when the contribution to the heat flux from particles with many times the local thermal velocity becomes significant. Luciani et al., (1983, Phys. Rev. Lett., 51, 1664) derived an integral expression to calculate non-local contributions to the heat flux suitable for incorporation into a hydrodynamic code and Karpen, J.T., and DeVore, C.R., (1987, ApJ, 320, 904) implemented their method to study non-local thermal transport in solar flares. The second consequence concerns the ionisation balance of the plasma. Collisional ionisation is a more energetic process than collisional excitation and so most of the ionisation energy comes from higher velocity electrons; a substantial enhancement in the population of high-velocity tail electrons over a Maxwellian will naturally alter the rate of ionisation and the ionisation balance. This will have an attendant effect upon the formation and intensity of emission lines, with quantitative significance for spectroscopic diagnostics and the total radiative energy loss. MacNeice et al., (1991, ApJ, 369, 544) accounted for non-local effects in calculations of the ionisation balance of O, Ne and Si for quiet Sun models. In recent years, as observatories such as SoHO have revealed an enormous amount about the structure of the solar atmosphere, the subject of non-local effects began to be revisited when the difficulty of reconciling theoretical predictions with observational measurements became clear. Part of the reason for this difficulty may undoubtedly be ascribed to a lack of sophistication of our physical models in comparison to the complexities that SoHO and others have revealed. In the current work a new version of the HYDRAD code (Bradshaw, S.J., and Mason, H.E., 2003, A&A, 401, 699) is presented; developments of the physical model upon which HYDRAD is based include a two-fluid description and the ability to calculate the distribution function (for all species) in each grid cell, including non-local effects, from which quantities such as the heat flux and collisional rates can be calculated in a self-consistent way by feeding them back into the hydrodynamics equations. These improvements to HYDRAD allow for a considerably more realistic treatment of the transport of energy through the solar atmosphere than has previously been possible. Results from preliminary investigations will be discussed.

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03 Atmospheric Heating and Solar Wind Origin: MHD vs. Plasma Physics

SIMULATIONS OF MHD TURBULENCE IN THE SOLAR CORONA BY COUPLED SHELL-MODELS

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So as to get statistical results on MHD turbulence that cannot be obtained by direct numerical simulations (which have small Reynolds numbers and give too short time series), we propose a model consisting in simplified models of the non-linear terms of MHD (shell-models, e.g. Giuliani & Carbone 1998) coupled by Alfvén waves propagating along a dominant magnetic field B_0. In the case of a magnetic loop in the solar corona, the energy is introduced at the loop foot-points by the motions of the photosphere, and we analyze the fields and the heating that are obtained (turbulent spectra, cross-scale energy flux, intermittency, properties of dissipation and dependence on parameters, distributions of events, correlations...). A more realistic loop can be obtained thanks to a stratification along B_0 (with a given profile of Alfvén velocity). Furthermore, the stratification makes it also possible to simulate other regions of space where plasmas can be modelled by MHD, such as the magnetically open regions of the corona, in which turbulence is produced by the interactions between the Alfvén waves propagating upwards and the ones which are reflected downwards (see submission by Andrea Verdini).

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TIME DAMPING OF LINEAR NON-ADIABATIC MAGNETACOUSTIC WAVES IN A SLAB-LIKE QUIESCENT PROMINENCE.

Carbonell, Marc
Universitat de Illes Balears

We study the time damping of linear non-adiabatic magnetoacoustic waves in a homogeneous, isothermal and bounded magnetic slab of plasma with physical properties akin to those of quiescent solar prominences. Because of the chosen configuration, our results are related to short or intermediate period prominence oscillations and show that the damping times of fast modes are very long compared to those of slow modes. In an attempt to mimic optically thick prominences, different prominence regimes have been considered by reducing radiative losses. Then, when the temperature and/or density of the prominence are modified, the damping time varies in a complex way which also depends on the prominence regime considered. In all the prominence regimes, a minimum of the damping time can be obtained for a certain value of temperature and density. Finally, the consideration of different heating mechanisms, the case of no heating included, can modify the damping times in a substantial way while the periods are only slightly affected.

TOPICS
03 Atmospheric Heating and Solar Wind Origin: MHD vs. Plasma Physics

THE DETECTION OF SMALL-SCALE CORONAL MASS MOTIONS AS A WAY TO "SOLVE" THE CORONAL HEATING PROBLEM

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In a corona heated by small-scale magnetic reconnection, one would expect an important potential diagnostic to be the detection of small-scale plasma jets. It is likely that these cannot be detected individually, but that with a large enough pixel size and long integration times, systematic line broadening may be observable. We show that in fact making such a detection may be rather difficult, especially when the corona has a small filling factor. Problems include low jet emission measures, rapid thermalisation and cooling, and a tendency to fly instrumentation that does not look at the most interesting temperature ranges.

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03 Atmospheric Heating and Solar Wind Origin: MHD vs. Plasma Physics

LINEAR MHD WAVES IN TWISTED FLUX TUBES: APPLICATIONS TO CORONAL LOOP OSCILLATIONS.

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The propagation of MHD waves in structured magnetic flux tubes embedded within a solar coronal environment is studied. The motivation of this analysis comes from the observations of damped loop oscillations showing a remarkable feature of coronal loops that possibly only part of the loop is homogeneous in the radial direction. The general dispersion relation of magneto-acoustic wave propagation is derived for a magnetic configuration consisting of a straight core, surrounded by a twisted annulus and embedded in a straight ambient external field. Modes of oscillations are examined from the general dispersion relation. It is shown that there are purely surface (i.e. evanescent) and hybrid (spatially oscillatory in the twisted annulus, otherwise evanescent) modes. Specific attention is made to the coronal case, considering the effect of twist, annulus thickness and different density and magnetic field strengths on the periods of oscillation. A continuum band of frequencies, for the sausage hybrid modes, is found to exist due to the twisted feature of the tube. Observational predictions and applicability will be discussed with specific attention to the capabilities of SDO and Solar-B.

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03 Atmospheric Heating and Solar Wind Origin: MHD vs. Plasma Physics

3D NUMERICAL SIMULATIONS OF CORONAL HEATING AT SEPARATORS AND SEPARATRICES

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[1]University of St Andrews; [2]Niels Bohr Institute

We present the results of numerical simulations of 3D magnetic reconnection driven by photospheric footpoint motions. The model consists of two positive and two negative sources, which are placed on opposite boundaries of the cubic domain. Two different types of photospheric motions are then considered, namely rotating and twisting of the sources. These different footpoint motions result in a difference in the evolution of the magnetic skeleton and the location and efficiency of the energy build up. Both the dynamical evolution and the corresponding potential evolution of each system is investigated and a comparison is made with a recent analytical study into the formation of strong currents along coronal loops (Priest, Loncope and Heyvaerts, 2005). These authors investigate energy storage and heating occurring at separatrices and separators and suggest that coronal heating is of comparable importance at both of these locations. Finally, the results of the numerical models are put into the perspective of solar atmospheric observations.

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03 Atmospheric Heating and Solar Wind Origin: MHD vs. Plasma Physics

SOHO/CDS OBSERVATIONS OF QUIESCENT ACTIVE REGION LOOPS.

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[1]University College London; [2]UNiversity of Cambridge; [3]CfA, Harvard-Smithsonian

The CDS spectral capabilities, together with high-resolution TRACE imaging, allow for the first time an understanding of the overall structure in active region loops and their temporal variations. The physical characteristics of the quiescent 1 MK loops, whose legs are best seen with CDS, are discussed and related to the underlying photospheric magnetic field. We show how different diagnostic techniques can produce different results in terms of physical parameters (e.g. elemental abundances) and we present simultaneous TRACE multi-filter and CDS observations. The limitations of current and future instruments in providing good observational datasets for testing coronal heating theories is briefly summarised.

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SOHO OBSERVATIONS OF POLAR CORONAL JETS OVER THE LAST SOLAR CYCLE

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The polar coronal jets were first observed by SOHO instruments (EIT, LASCO, UVCS) during the last solar minimum, in 1996. They were small, fast coronal eruptions originating from the flaring UV bright points within large polar coronal holes. Data analysis and modeling provided estimates of jet plasma conditions, dynamics, evolution of the electron temperature and heating rate. At solar maximum the polar holes disappeared together with the polar jets. However, as the Sun's activity was decreasing, the polar holes again became permanent structures. A special SOHO Joint Observing Program (JOP 155) was designed with the aim to study the origin and dynamics of the jets throughout the solar cycle. It involves several SOHO instruments (EIT, CDS, UVCS, LASCO) and TRACE. The coordinated observations have been carried out since April 2002. They enabled to identify counterparts of the 1996-1998 solar minimum jets. We will present SOHO observations of the polar coronal jets ranging from the last solar minimum at 1996 until present. We will discuss major results of data analysis and their implication for the jet models.

TOPICS
03 Atmospheric Heating and Solar Wind Origin: MHD vs. Plasma Physics

X-RAY DIAGNOSTICS OF THE NON-THERMAL ELECTRON DISTRIBUTION

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The observed X-ray spectra of the impulsive phase of the solar flare very often can not be explained by using the assumption of the electron Maxwell distribution. The unusual spectral line ratios indicate the presence of the non-thermal electron distribution. The diagnostics of the shape of the electron distribution function from X-ray spectra observed by RESIK is presented. The satellite lines and the allowed lines belonging to ions in different degree of ionization have been used for diagnostics. The diagnostics has been applied on the RESIK X-ray spectra of the impulsive phase of the solar flares.

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03 Atmospheric Heating and Solar Wind Origin: MHD vs. Plasma Physics

THE MODIFICATION OF CHIANTI FOR COMPUTATION OF SYNTHETIC EMISSION SPECTRA FOR THE ELECTRON NON-THERMAL DISTRIBUTIONS

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CHIANTI contains atomic data for the majority of the astronomically interesting ions and has a very good software support. The modification of CHIANTI software and broadening of its database has been done to be able to compute the synthetic emission spectra for the electron non-thermal distributions and diagnose the shape of the electron distribution function. Because the CHIANTI database contains only the collision strengths averaged over the Maxwellian distribution, the functional form of the approximation has been used to evaluate the approximation for Omega from CHIANTI by inverse technique. Computed approximations of Omega-s have been compared with known data from TIPbase. The modification of CHIANTI codes which uses derived approximations of Omega allows quick computation of the line intensities and synthetic spectra for two different groups of non-thermal distributions: the power and kappa electron distributions. New code in CHIANTI allows to model the influence of the shape of the electron distribution function on the line spectrum, to find the lines whose intensities are sensitive to the shape of the electron distribution function and searching for the lines which are suitable for the diagnostics of the non-thermal distributions.

TOPICS
03 Atmospheric Heating and Solar Wind Origin: MHD vs. Plasma Physics

FLUX EMERGENCE AND ITS IMPACT ON CORONAL HEATING.

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The emergence of magnetic flux from the convective zone into the coronal allows for significant interactions between the two independent flux system. The emerging flux drives its way into an already existing magnetic field. This stresses the two system and strong magnetic tension may buildup over the interface between the two flux systems. When this is the case, then magnetic reconnection eventually starts to liberate the free magnetic energy. This results in plasma heating localised to the regions connected to the reconnecting field lines, changes in the initial field line connectivity and particle acceleration. These processes give rise to the flaring of activity seen in observations of emerging flux events. To investigate the emergence process and its potential to act as an agent for impulsive coronal heating, we have conducted a series of numerical 3D MHD experiments. These investigate the effect of the interaction between an emerging magnetic flux tube and a simple plan-parallel coronal magnetic field. To get better estimates of the coronal plasma diagnostics, experiments including anisotropic heat conduction in the energy equation are being conducted. The general results show that the location and efficiency of the reconnection process depends significantly on the relative orientation between the two interacting flux systems. In the antiparallel cases reconnection takes place along a current sheet that stretches over the summit point of the interface. In the near parallel cases reconnection occurs much lower in the atmosphere and is much less effective.

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03 Atmospheric Heating and Solar Wind Origin: MHD vs. Plasma Physics

COMPARISONS OF HI LY-ALPHA LINE WIDTHS IN STREAMERS AND CORONAL HOLES MEASURED WITH UVCS/SOHO AND UVCS/SPARTAN-201 IN NOVEMBER 1998

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The Spartan-201 satellite was comprised of two scientific instruments, the White Light Coronagraph, provided by the High Altitude Observatory and NASA, and the Ultraviolet Coronal Spectrometer, provided by the Smithsonian Astrophysical Observatory. UVCS/Spartan is a "forerunner" to the Ultraviolet Coronagraph Spectrometer on SOHO. Coordinated and coregistered observations of streamers and coronal holes were carried out with UVCS/Spartan and UVCS/SOHO during Spartan's final mission in November 1998. We will present detailed comparisons of HI Ly-alpha line shapes measured with the two instruments. Spartan was carried into orbit by the Space Shuttle five times in the period from April 1993 to November 1998. For each mission, Spartan was deployed in order to carry out in an autonomously fashion approximately 40 hours of coronal observations, and then retrieved by the Shuttle and returned to Earth. UVCS/Spartan and UVCS/SOHO have similar solar disk light supression geometries but different spectrometer designs. The optical parameters of UVCS/Spartan and UVCS/SOHO are based on radiometric and spectrometric calibrations carried out in our laboratory before the missions, and in the case of Spartan, after the mission as well. This work was supported by NASA grant number NNG05GG38G to the Smithsonian Astrophysical Observatory.

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SOLAR CORONA SEEN BY UVCS IN MINIMUM AND MAXIMUM OF SOLAR ACTIVITY

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The new results are presented related to the analysis of solar corona brightness seen by UVCS in 1996 and in 2000. Comparison with LASCO immages and coronal field structure has been performed.

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OBSERVATIONS OF SOLAR WIND NI AND FE

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Using data from SOHO/CELIAS/MTOF we have derived the Ni/Fe solar wind abundance ratio, both in typical interstream and in coronal hole-associated solar wind. We compare our value with the meteoritic ratio, which can be taken as a reliable reference for the solar system and for the outer convective zone, since neither element is volatile and no meteoritic fractionation is expected. Similarly, meteoritic and terrestrial isotopic nickel abundances agree and they can be adopted as a reliable reference for the solar isotopic composition. Indeed, a preliminary inspection of the raw MTOF data reveals that the solar wind elemental Ni/Fe ratio and the isotopic composition of solar wind nickel are in broad agreement with the meteoritic benchmark, giving further proof for the faithful representation of low-FIP elemental abundances and for the absence of substantial isotopic fractionation effects for medium and heavy elements in the solar wind. In this paper we will present instrument efficiency-corrected abundance values for the solar wind Fe/Ni and Ni isotope ratios.

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STATISTICS OF THE QUIET SUN INTENSITY DISTRIBUTION

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The statistics of the quiet Sun intensity distribution present an interesting challenge. Some authors find that the observed distribution is adequately represented by a two component model, which seems to fit well with the notion of a network and internetwork being physically distinct. Other authors find that a single component model fits the intensity distribution data well, which seems to suggest that the network and internetwork emission may in fact be due to the same process. This paper examines the evidence for both these points of view, using CDS EUV data and mixture modeling techniques. We find that the intensity distribution is better fit using lognormal distributions, indicating that a fragmentation process may be operating. Some comments are also made on the nature of the mechanism which may create the observed distributions.

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CHROMOSPEHRIC AND TRANSITION REGIONS FEATURES IN SOLAR LIKE STARS

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We present here the analysis of the HST/STIS spectra of two solar type stars: 61 Vir (G5 V) and xsi Boo A (G8 V). The echelle spectra of these two objects, obtained with the E140M gratings cover the complete spectral range 1140 − 1670 Å with a resolution of 6.6 km/s, and an absolute wavelength accuracy of 3 km/s . We intercompare the derived redshifts, nonthermal line widths, and other parameters of transition region lines (e.g., Si iv,Civ), to those observed for the Sun.

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03 Atmospheric Heating and Solar Wind Origin: MHD vs. Plasma Physics

PREFERENTIAL PERPENDICULAR HEATING OF CORONAL HOLE HEAVY IONS BY THE FERMI MECHANISM

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One of the most peculiar features of the fast solar wind is the preferential energization of heavy ions (those more massive than protons). Observations by UVCS/SOHO have shown that much of the preferential heating in coronal holes is in the perpendicular direction and takes place within 4 solar radii. The observed preferential acceleration naturally follows from this perpendicular heating in a radially decreasing magnetic field. We demonstrate that this perpendicular heating can result from the cyclotron resonant interaction of heavy ions with both inward and outward propagating ion cyclotron waves, yielding a form of second-order Fermi acceleration for thermal particles. This process is not available to protons, so it is inherently preferential to heavy ions. We will describe the physics of this preferential heating and discuss results from a computational model.

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IMPULSIVE HEATING AND THERMAL NONEQUILIBRIUM IN SOLAR PROMINENCES

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Prominences are among the most spectacular manifestations of both quiescent and eruptive solar activity, yet the origins of their magnetic-field and plasma structures remain poorly understood. We have made steady progress toward a comprehensive model of prominence formation and evolution with our sheared 3D arcade model for the magnetic field and our thermal nonequilibrium model for the cool, dense material suspended in the corona. According to the thermal nonequilibrium model, condensations form readily in long, low-lying magnetic flux tubes if the heating is localized near the chromosphere. Our previous studies established the effects of steady heating in flux tubes of different geometries. In some cases this process yields a dynamic cycle in which condensations repetitively form, stream along the field line, and ultimately disappear by falling onto the nearest footpoint; in others, static condensations grow as long as the heating continues. Here we will discuss the effects of impulsive heating, as indicated by many coronal-heating models, on the formation and evolution of prominence plasmas. This work was supported by NASA and ONR.

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CORONAL ABUNDANCE AND DENSITY MAPS, AND COMPARISON WITH THE MHD MODEL

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We use a 12-day continuous SOHO/UVCS observations of the solar east limb at 1.64 solar radii to construct a sub limb-synoptic map of the coronal elemental abundances and electron density based on the variation of these parameters along the 42'-long UVCS slit. The UVCS data were obtained in September 2000 at position angles of 100-110 degrees. The observed lines include O VI 1032/1037 doublets, Lyβ, Lyδ, Si XII 499, [Fe X] 1028, Fe XV 481 and [Fe XVIII] 974. Therefore the absolute abundances of Si, Fe, O, as well as an estimate of the electron density and temperature can be obtained. During the two weeks, a series of active regions passed through the east limb along with filament structures and a low-latitude coronal hole. We compare the results with those from a 3-D MHD coronal model run at the Community Coordinated Modeling Center. Implications from the variations of these plasma properties with different solar structures will be discussed.

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PROMINENCE AND COOL LOOP ENERGETICS MEASURED IN THE UV, EUV, AND HA

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We investigate the thermal and dynamic properties of moving features in a prominence jet, a $\sim 10^5$ K loop near a prominence channel, and an erupting prominence. In order to make measurements of the quickly moving features seen in prominences in the UV we use the SOHO/SUMER spectrograph to take a time series of exposures from a single pointing position, providing a measurement of spectral line properties as a function of time and position along the slit. The lines observed cover a broad range of temperatures from 80,000 - 1.6 million K. These measurements are combined with TRACE movies in transition region and coronal temperature bands and with ground based Hα data to obtain more complete information concerning prominence structure and motions. The resulting observations allow us perform DEM analysis and to calculate limits on densities, pressures, and the thermal and kinetic energies of the moving sources. This work was partly funded through NASA SEC GI RTOP 370-16-25 and NASA grants NNH04AA12I, W10,232 and NNG04ED07P

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THE LYMAN-A AND LYMAN-B LINES IN THE SOLAR CORONA

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We use the plasma parameters derived from a new global 2.5D three fluid model of the solar wind to compute the Lyman-α and Lyman-β line profiles. The emergent hydrogen radiation is calculated by solving the statistical equilibrium equations for a 10 level hydrogen atom + continuum along a one-dimensional line of sight. We do not make any assumption about the formation mechanisms of the lines. We study the effect of Doppler dimming. We find that the width of the Lyman-β line more accurately reflects the plasma temperature than that of the Lyman-α line. Thus inferred temperatures from Lyman-α observations should be considered as lower limits for the plasma temperature. Our computed Lyman-α and Lyman-β emission compares well with SUMER and UVCS observations and with calculations performed by others.

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THE IN-FLIGHT MONITORING AND VALIDATION OF THE SOHO CDS NORMAL INCIDENCE SPECTROMETER RADIOMETRIC CALIBRATION

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We have validated and monitored the radiometric calibration of the Coronal Diagnostic Spectrometer on SOHO over the first six years of observations. Radiometric calibration started pre-launch with a laboratory calibration and continued after launch by checking the calibration by comparing measurements by calibrated sounding rockets payloads and also by inter-calibration with the SUMER instrument on SOHO. As well as using branching ratios and line ratios independent of the electron temperature and density, line ratios dependent on electron temperature or density have also been used successfully to validate and monitor the calibration. The results indicate that, within the uncertainties, the radiometric calibration has been validated and maintained over the first six years of observations, apart from two specific wavelengths.

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A DYNAMICAL MODEL FOR THE SPATIO-TEMPORAL INTERMITTENCY OF THE TURBULENT ENERGY CASCADE: FIRST RESULTS AND POSSIBLE APPLICATIONS TO CORONAL LOOPS.

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High resolution observation of the solar corona show that coronal loops typically consist of several thin, fibril-like structures. The coexistence of many bright (hot) and dark (cold) fibrils represents an evidence for spatially intermittent heating. We suggest that this intermittency is produced by the turbulent dynamics of coronal loops and we propose a simple dynamical model to describe the spatio-temporal intermittent behaviour of energy dissipation rate in fully turbulent flows. After describing the main properties of the model, its future developments and possible applications to the solar corona are discussed.

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EFFECTS OF ALPHA PARTICLES ON THE ANGULAR MOMENTUM LOSS FROM THE SUN

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The classic Weber-Davis model, which treats the angular momentum loss of the Sun within the framework of MHD, is extended to incorporate alpha particles self-consistently. Closely following McKenzie et al. (1979), we exploit the fact that the ion gyro-frequency is many orders of magnitude larger than any other characteristic frequency in the ion momentum equation. This in effect requires all species flow along the magnetic field in a frame of reference corotating with the Sun. Governing equations are derived from standard transport equations in view of this alignment condition. The analysis is valid for general axisymmetrical flows where two major ion species have to be treated on an equal footing. The governing equations are then solved on a prescribed meridional magnetic field line located at a colatitude of 70° at 1 AU. Empirical ion heating is adopted to produce a fast wind solution which is largely compatible with Ulysses observations. The general analysis concludes, in agreement with the Weber-Davis model, that the magnetic field helps the coronal plasma to achieve an effective corotation out to the Alfven radius, where the poloidal Alfven Mach number M_T equals unity, provided that M_T is defined as a composite one. Model computations show that, even though the Poynting flux associated with the azimuthal components is negligible in the energy budget, the solar rotation nevertheless limits the ion differential streaming in the interplanetary space. Magnetic stresses predominate the angular momentum loss from the Sun. The proton contribution, which can be in excess of the magnetic one, is offset by the alphas that develop an azimuthal speed in the opposite sense to the solar rotation. For an alpha abundance compatible with in situ measurements, the azimuthal speeds of both protons and alphas far away from the Alfven point are dominated by the differential streaming in this fast wind.

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THE DETECTION OF OSCILLATIONS IN THE TRANSITION REGION ABOVE A MOVING MAGNETIC UNIPOLE

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Moving Magnetic Features (MMFs) are small magnetic features moving in a moat surrounding a sunspot. It has been proposed that these features result from the interaction between the sunspot and the ambient supergranular magnetic fields. Many observations have shown that MMFs can carry the magnetic flux either into or away from the associated sunspot. Here, we would like show for the first time that there are oscillations and flows propagating from the MMF to the upper atmosphere. The oscillations are likely excited inside the MMF and propagated to the atmosphere along the magnetic field tubes of the MMF. Our results are based on the data from NIS, MDI, TRACE and EIT.

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THE MAGNETIC STRUCTURE OF OBSERVED CORONAL LOOPS

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Previous studies have found that coronal loops have a nearly uniform thickness, which seems to disagree with the characteristic expansion of active region magnetic fields. This is one of the most intriguing enigmas in solar physics. We here report on the first comprehensive one-to-one comparison of observed loops with corresponding magnetic flux tubes obtained from cotemporal magnetic field extrapolation models. We use EUV images from TRACE, magnetograms from the MDI instrument on SOHO, and linear force-free field extrapolations. For each loop, we find the particular value of the force-free parameter (alpha) that best matches the observed loop axis and then construct flux tubes using different assumed cross sections at one footpoint (circle and ellipses with different orientations). We find that the flux tubes expand with height by typically twice as much as the corresponding loops. We also find that many flux tubes are much wider at one footpoint than the other, whereas the corresponding loops are far more symmetric. It is clear that the actual coronal magnetic field is more complex than the models we have considered. We suggest that the observed symmetry of loops is related to the tangling of elemental magnetic flux strands produced by photospheric convection.

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CHROMOSPHERIC OSCILLATIONS FROM MILLIMETER OBSERVATIONS

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We argue that millimeter continuum observations promise to be an important diagnostic of the chromospheric dynamics and the appropriate wavelengths to look for dynamic signatures are in the range 0.8-5.0 mm.

In this contribution we analyze the millimeter intensity spectrum, expected from the radiation-hydrodynamic simulations of the solar non-magnetic atmosphere of Carlsson & Stein, together with the interferometric observations of the quiet Sun, obtained at a wavelength of 3.5 mm with the Berkeley-Illinois-Maryland Array (resolution of 10 arcsec). Model radio emission at millimeter wavelengths is found to be extremely sensitive to dynamic processes in the chromosphere, if these are spatially and temporally resolved. The estimated millimeter brightness temperatures are time-dependent, following changes in the atmospheric parameters. As the result, clear signatures of waves with a period of 180 s (corresponding frequency of 5.5 mHz) are seen in the radio intensity as a function of time. At the same time, the interferometric observations of the internetwork regions reveal significant oscillations with amplitudes of 50-150 K in the frequency range 1.5-8 mHz.

A correspondence between the model predictions based on the RHD simulations of Carlsson and Stein and the observational data can be established under assumptions on the horizontal coherence length of the oscillations (of order of 1 arcsec). We also give estimates of the influence of the limited available spatial and temporal resolution of observations on the comparison with the model predictions.

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ASSESSING THE PROPERTIES OF THE GLOBAL MAGNETIC FIELD IN THE OUTER CORONA

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Radio propagation techniques are very useful to obtain important information about the properties of the solar coronal plasma since no spacecraft has been nearer to the Sun than a few tens of solar radii. Dual frequency radio polarization measurements yield the rotation measure, a quantity that is proportional to the integral along the line of sight of the product of the electron density and the line-of-sight component of the magnetic field. When the electron density distribution is known, Faraday rotation measures of background extragalactic sources may yield unique estimates of the coronal magnetic field in the outer corona, where no other reliable forms of magnetometry have been applied. Sound estimates of the coronal plasma density distribution in this part of space are now available through SOHO observations, allowing retrieval of a reliable model magnetic field. Previous studies have shown consistency with a model presented in Mancuso and Spangler (2000, ApJ, 539, 480). In this model, the coronal field is radial, reverses polarity at the neutral line, and has a magnitude which depends on heliocentric distance according to an inverse cube law plus an inverse square law. By modelling a more sophisticated 3D global magnetic field configuration of the corona, here we adopt a forward problem approach and calculate the expected Faraday rotation measures, distinguishing the contribution of the main multipolar components of the magnetic field along the lines of sight to background radio sources. We also take into account the important effect of the tilt of the rotation and magnetic solar axes.

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STUDY ON PLASMA OUTFLOWS AND OPEN MAGNETIC FIELD LINES IN A QUIET-SUN REGION

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It is well known that the fast solar wind mainly originates in coronal holes. Whether quiet-Sun regions also are sources of the solar wind is an unsolved question, which we study here by using ultraviolet data obtained by SUMER and EIT, and magnetic field data from MDI on SOHO. The previous finding (Hassler et al . 1999) of relatively large blue shifts at the intersections of magnetic network boundaries at middle solar latitudes is confirmed. However, these intersection sites are not found to be sources of solar wind. To show this, we made a potential-field extrapolation and traced the magnetic field from the photosphere into the corona up to 80 Mm height. For the region studied by Hassler et al., we found that most of their network intersections with local blue shifts are not related to open field lines. They mostly indicate outflow that feeds plasma into loops of the magnetic carpet. It is found that the pattern of open field lines in the cross-section plane at 40 Mm height is consistent with the pattern of dark regions in the Fe 19.5 nm EIT image. Usually, a dark region is considered as a small coronal hole and possible source of the solar wind. This idea is supported by our findings. However, since the EIT ultraviolet emission comes from a height of only 40 Mm, it might still be that this radiation was generated near the foot point of a large coronal loop. In this case the dark regions would not be connected with the solar wind.

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ON THE STRUCTURE OF THE SOLAR TRANSITION REGION

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The structure of the solar transition region (TR) in the quiet Sun has been a subject of ongoing research but is still not well understood. In particular, the detailed assocation of the coronal magnetic field with the radiance patterns in the TR, when seen in the far ultraviolet (FUV) emission, remains unclear. Our paper addresses this important subject, by means of a comparison of the coronal magnetic field, as obtained by extrapolation of the NSO/Kitt-Peak photospheric field to heights of several tens of megameters, with the radiances of many FUV lines, which are emitted by the ions of various elements at different ionization stages corresponding to different local coronal temperatures. By a correlation analysis of the emission pattern with the magnetic field (network and carpet of loops), the so-called correlation height of the emission can be determined. By its help the magnetic nature of the emission regions and the temperature structure of the TR can be better revealed and understood. In particular, regions with strong emission (multiple small closed loops) are found to be located at low heights, whereas weak emissions (on locally open, i.e. far reaching fields) appear to originate at greater heights.

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ON THE ROLE OF THE PARALLEL PROTON FIRE HOSE INSTABILITY IN THE EXPANDING SOLAR WIND

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Proton fire hose instabilities can take place in a magnetized plasma with proton temperature anisotropy; these conditions naturally develop in the expanding solar wind. We present results from hybrid expanding box simulations where propagation strictly parallel to the magnetic field is considered. We found that the parallel proton fire hose instability is able to counteract the growth of the anisotropy due to the adiabatic expansion. The saturation level of the instability is in good agreement with the linear theory, standard hybrid simulations and with constraints inferred from in situ measurements. Using the expanding hybrid simulations we correct the proton parallel and perpendicular plasma betas predicted by a kinetic numerical model for the solar wind acceleraton which includes coulomb collisions. The resulting proton properties are constrained in a range close to the observations.

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QUANTITATIVE COMPARISONS OF TURBULENCE COMPUTATIONS OF COMPRESSIBLE MAGNETHOHYDRODYNAMICS AND REDUCED MAGNETOHYDRODYNAMICS: ACCURACY OF RMHD FOR EXPECTED CORONAL PLASMA CONDITIONS.

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Direct numerical simulations of low Mach number compressible three-dimensional magnetohydrodynamic (CMHD3D) turbulence in presence of a strong mean magnetic field are compared with simulations of reduced magnetohydrodynamics (RMHD). Periodic boundary conditions in the three spatial coordinates are considered. Various initial conditions are chosen to explore the applicability of RMHD and to evaluate how far/close the solution remains to the full compressible MHD solution as both evolve in time. First, an initial state is prepared that satisfies the conditions assumed in the derivation of RMHD, namely, a strong mean magnetic field, and plane-polarized fluctuations, varying weakly along the mean magnetic field. For that case, the simulations show that RMHD and CMHD3D solutions are almost indistinguishable. When some of the conditions are relaxed, for instance with initial isotropic gradients of the fluctuations at large scales, then, the agreement of the two solutions worsens, however, RMHD remains close to the CMHD3D solution, especially for large mean magnetic field. Development of spectral anisotropy helps to achieve the conditions for RMHD applicability as the system evolves. Global quantities (mean energies, mean square current, vorticity) and energy spectra from the two solutions are compared as well as point-to-point error (distance) estimations are computed. The specific results shown here give support to the use of RMHD as an approximation of compressible MHD with a mean magnetic field under certain but quite practical conditions, often thought to be attainable in coronal plasma conditions.

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THREE-DIMENSIONAL MHD MODELS OF WAVES IN ACTIVE REGIONS: APPLICATION TO CORONAL SEISMOLOGY.

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We present results from three-dimensional MHD simulations of the behavior of MHD waves in realistic models of coronal active regions and loops. The models of the active regions are constructed by using the observed photospheric magnetic field, and gravitationally stratified coronal density structure with individual loops. We compare the main features of the model with those seen recently by the SOHO and TRACE satellites and investigate the application of the results to coronal seismology. We discuss the possible application of STEREO data to the improvement of our model.

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DRIFT INSTABILITIES IN CORONAL FUNNEL WITHIN THE MULTI-FLUID DESCRIPTION

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The collisionless multi-fluid model is used to study obliquely propagating drift waves and instabilities driven by cross-field current in the low-β coronal plasma. The cross-field current results from relative drifts of electron and ions induced by the presence of a background density gradient. Neglecting the electron inertia, this model allows one to consider ion-cyclotron wave effects that are absent from the one-fluid MHD model. A 2-D funnel model is used to define the background magnetic field in the open-field region of a polar coronal hole. A local linear mode analysis is employed in order to derive the local dispersion relation for a two-fluid and a three-fluid model; we consider a second ion population of alpha particles (He^{2+}). Dispersion curves and growth rates are presented for representative parameters of the solar polar region.

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ON KINETIC MODELS OF THE SOLAR WIND.

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The kinetic approach is applied to the solar wind modeling based on the common assumption (steady flow with spherical symmetry, quasyneutral currentless fully ionized hydrogen plasma, and some other). The models are considered from the view point of the adequate description of the solar plasma flow acceleration. The analytical radial dependences for the number density and speed of the solar wind are derived on the base of the analytical solution of the kinetic equation. The models are constructed without and with taking in account the Sun rotation and its magnetic field (as a given field). The related results are compared with other models and consistent with the observational data.

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LARGE AMPLITUDE VELOCITY FLUCTUATIONS AS PRECURSOR OF FLARES IN THE SOLAR CORONAL LOOP

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A model of MHD turbulence in a coronal loop is presented. This model shows that the occurrence of high values (of the order of 100 km/s) of the large scale fluctuating velocity can represent an efficient trigger to burst of dissipated energy, which represent in this framework the impulsive energy releases in the solar corona (solar flares). The model support the interpretation according to the idea that the increase in the values of the velocity fluctuations can be interpreted as precursor of flares. We develop the loop model assuming a homogeneous ambient longitudinal magnetic field, a low beta and an high aspect ratio, which allows us to use the set of reduced MHD equations (RMHD). The model takes advantage of the shell model technique to override the computing difficulties associated to the very large Reynolds number of the corona. The shell technique is used in the wave vector space orthogonal to the ambient magnetic field, while the dependence on the longitudinal coordinate is preserved. In the numerical simulation we apply a forcing at the base of the system with velocity amplitudes characteristic of the photospheric motions, and we obtain inside of the system velocity fluctuation values in agreement with non thermal mass motions deduced from coronal observations. The numerical results of the model, furnish a well supported physical explanation of the reason why large velocity fluctuations represent the flare trigger rather than the result of the later energy deposition. In this framework the magnetic system work like resonance cavity for the velocity fluctuation, which drive the nonlinear cascade, so the dissipation spikes. Nonlinear interactions give rise to an energy cascade towards smaller scales where energy is dissipated in an intermittent way. The statistical analysis on the intermittent dissipative events compares well with all observed properties of nanoflare emission statistics. These results naturally emerge from the dynamical evolution without need of ad-hoc hypothesis.

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RESONANTLY DAMPED MHD WAVES IN A SYSTEM OF TWO CORONAL LOOPS

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The damping of a system of two coronal loops is studied in slab geometry. The period and damping rate of the collective resonantly damped mode is computed for different values of the equilibrium parameters, such as the width of the inhomogeneous layers, the distance between the slabs and their density contrasts. The obtained results are then compared with the results for single-loop equilibrium models.

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H, O, MG, AND FE DENSITY MEASUREMENTS IN THE SOLAR WIND

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Using the MTOF (Mass Time Of Flight) sensor of the CELIAS (Charge, Element, and Isotope Analysis System) investigation on SOHO we have studied the behavior of the oxygen to proton ratio, magnesium to proton ratio, and the iron to proton ratio in different solar wind flow types, such as high speed streams, interstream solar wind, and coronal mass ejections. Abundance ratios for iron, magnesium, and oxygen as derived from specific events and from yearly averages are compared to photospheric and meteoritic values.

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ON THE RADIATIVE SIGNATURE OF HEATING IN A CORONAL LOOP

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Using a reduced MHD model we built the energy input for a multi-stand loop hydrodynamic model. This energy has a distribution that follows a power law with index -1.6. Here we investigate if and under which conditions this specific property can be transmitted to the plasma response. Our results show that only the high temperature emission conserves a power law distribution with index close to that of the input energy.

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THE NATURE OF DYNAMIC 3D MAGNETIC SKELETON EVOLUTION

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Magnetic fragments in the photosphere are in continual motion and, due to the complex nature of the magnetic field in the solar atmosphere, these motions are likely to drive a lucrative coronal energy source: the passing of initially-unconnected, opposite-polarity fragments that release energy through both closing and then re-opening the same field lines. Using a combination of three-dimensional, time-dependent MHD and potential models opposite-polarity fragments passing in an overlying field are investigated to determine the exact nature of the magnetic skeleton evolution and, hence, the exact nature of the reconnection. In particular, the evolution of the dynamic MHD magnetic skeleton is determined and is shown to evolve through 5 phases containing up to 5 separators. In deed, we show that the magnetic field both closes and opens through multiple-separator reconnection. We focus on this reconnection and reveal exactly how separator reconnection occurs - it is not as straight forward as one might imagine! Furthermore, the rates of reconnection vary considerably at each separator and we explain the reasons for this. In turn this leads to varied deposition of energy, spatially and temporally, during the event.

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CORONAL LOOP HEATING BY NANOFLARES: NON-THERMAL VELOCITIES

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Spectroscopic observations show non-negligible non-thermal velocities under coronal conditions. These motions place tight constraints on any coronal heating mechanism that should be able to reproduce them. We calculate the non-thermal velocities predicted by the nanoflare model. We perform 1D time-dependent hydrodynamic simulations of nanoflares occurring at sub-resolution strands, that make up the observed coronal loops and calculate profiles for representative spectral lines. We show that: (1) the calculated non-thermal velocities compare favorably with observations of cool and warm spectral lines and (2) the profiles of hot lines, that would be available in observations from the Extreme Ultraviolet Imaging Spectrometer (EIS) spectrometer onboard the SOLAR-B mission, can exhibit significant blue-wing asymmetries which can be used as a monitor of nanoflare properties. Research supported by NASA and ONR.

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FLARE HEATING VS. STEADY CORONAL HEATING

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A long debated issue is whether the heating of the corona is somehow related to flares and, in particular, whether it could be due to micro-flares. In a related context, very active stars show a large excess of emission measure around 10^{7} K which many authors claim to be related to the continuous presence of multiple flares on the star, with overlapping light curves. Our scope is determining whether the solar corona shows any excess of this kind when we average the flares over a long enough time interval and, therefore, how does the flare heating compare with "steady" coronal heating in this context. We adopt a global view of the corona and of its emission measure distribution, using Yohkoh/SXT data, and deriving the emission measure distribution vs. temperature of the solar corona over an extended time interval. We do the same with GOES data, after proper cross-calibration of the two instruments, as far as flares are concerned. We derive implications on the steady, and on the flare-induced, coronal heating as well as on the micro-flare heating paradigm.

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OBSERVATIONAL CONSTRAINTS FOR THE SOLAR TRANSITION REGION AND COMPARISON TO 3D MHD MODELING

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The transition region from the chromosphere to the corona is highly structured and very dynamic. Observations with instruments on SOHO, most notably with the SUMER spectrograph, revealed a wealth of data putting new constraints on modeling of this complex part of the solar atmosphere. A number of observational achievements through SOHO will be summarized, among them the average net red- and blueshifts of EUV emission lines, the temporal and spatial variability of line shifts and intensities, the emission measure throughout the atmosphere, and non-Gaussian line profiles. These observational constraints will be compared to results from recent 3D forward models of the low corona as well as 1D loop models. Especially the new 3D models match the SUMER observations remarkably well and through this show ways to understand the structure and dynamics of the transition region. Nevertheless many (new) questions remain open, on the observational side as well as for the modeling efforts. New instruments are needed providing improved spatial and temporal resolution as well as information on the line profile over a large 2D field of view. On the modeling side we have to progress to include a more realistic (physical) description of the coronal heating processes.

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LARGE TEMPERATURE ANISOTROPIES IN POLAR CORONAL HOLES: HOW RELIABLE ARE THEY?

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Reliable interpretation of high quality observations of the coronal holes is crucial to obtain the needed information to understand what heats and accelerates the different species of the fast solar wind. It is therefore important to know how strongly assumed values of atmospheric parameters affect the interpretation. We examine the influence of the electron density stratification on coronagraphic spectral observations aimed at determining the coronal macro- and microscopic velocity structure and distribution. In particular, we investigate the profiles of H I Ly-α, the O VI and Mg X doublets spectral lines emitted in the corona employing an analytical 2-D model of the large scale coronal magnetic field and solar wind. We concentrate on the polar coronal holes and take into account the integration along the line of sight. We present results (line widths, total intensities and intensity ratios) obtained by using different density profiles measured in the coronal holes. We find that at distances greater than $1R_{\square}$ from the solar surface the widths of the emitted lines are significantly affected by the details of the adopted electron density profiles. In particular, the densities deduced by Doyle et al. (Sol. Phys., 188, 73, 1999; A&A, 349, 956, 1999) from SoHO data result in O VI profiles whose widths and intensity ratio are relatively close to the values observed by UVCS/SoHO although only isotropic velocity distributions are employed. Hence we expect the magnitude of the anisotropy of the velocity distribution to depend strongly on the density stratification adopted when analysing the data.

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TURBULENT CORONAL HEATING OF MAGNETIZED LOOPS INDUCED BY PHOTOSPHERIC MOTIONS: DIRECT 3D REDUCED MHD SIMULATIONS.

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We present direct 3D reduced magnetohydrodynamic (MHD) simulations modeling the heating of coronal loops in the solar atmosphere via the tangling of coronal field lines by photospheric footpoint motions. We carry out long-time 3D simulations with both the highest resolution and the longest time extent to date. We reach resolutions sufficient to derive scaling properties with Reynolds numbers, loop length, and ratio of photospheric velocity to coronal Alfven speeds. We show that the injection energy rate is not given solely by the forcing, but is determined by the internal dynamics of the system. The system self-organizes by reaching a statistically steady state in which the injection and dissipation rates dinamically balance. Only the large scale dynamics determines the injection energy rate, which then cascades and gets dissipated at the small scales. The heating rate is hence independent of the Reynolds number. The scaling and spectral properties of the system will be discussed. In physical space the strong anisotropy, due to the dominant axial magnetic field, leads to the formation of current sheets elongated along the axial direction, where the bulk coronal heating takes place. Line-tying of the axial field lines plays a significant role by inhibiting coalescence and inverse cascades in the loop cross-sections, which dominate dynamics in 2D models.

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DIAGNOSTICS OF CORONAL LOOPS FROM MULTI-BAND OBSERVATIONS

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Spectral and imaging coronal observations provide complementary information that are potentially powerful for investigating the structure, evolution and heating of coronal loops. With specific examples with SoHO, TRACE and Yohkoh data, we discuss the power of currently available diagnostic tools and the perspectives.

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THE SOLAR CYCLE AS SEEN FROM THE SOHO/UVCS WHITE LIGHT CHANNEL

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The UVCS White Light Channel (WLC) is designed to measure the linearly polarized radiance (pB) of the extended corona, in the wavelength band from 450 nm to 600 nm. The pB is the most direct way to derive coronal electron densities. The WLC coronagraph has performed daily observations of the solar corona at several polar angles from 1.75 to 3 solar radii from April 1996 to present. By using the UVCS synoptic program that provides almost daily measurements of the pB at the same locations in corona, it is possible to plot time evolution of this parameter throughout the solar cycle. The WLC time evolutions are of particular interest between 1.75 to 2.4 solar radii because of their uniqueness, providing a link between ground based (Mauna Loa) and space borne (SOHO/LASCO C2) coronagraphic observations. The WLC pB data, with the up-to-date radiometric calibration, will be made available by means of a facilitated access provided by the UVCS Data Analysis Software (DAS) Catalog. The authors acknowledge support from ASI-INAF contract I/035/05/0

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LASCO C1 CORONAL IMAGING SPECTROSCOPY

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The Large Angle Spectrometric Coronagraph (LASCO) includes an imaging spectrometric coronagraph channel (C1) that collected data from which the first three moments of the E-corona green emission line could be extracted. The moment images may be used to investigate the mechanisms responsible for solar wind acceleration, coronal heating, and the onset of coronal mass ejections. The coronal spectrometric imaging function was performed using a fixed etalon band-pass filter in tandem with a tunable Fabry-Perot interferometer (FPI). The etalon 40 Angstrom FWHM bandwidth isolates a spectral interval encompassing the selected emission line while a single narrow 0.5 Angstrom FWHM bandwidth and tunable central wavelength FPI order serves as a resolver. Spectrometric information is developed by executing a FPI pass-band central wavelength step scan within the isolated interval and recording the transmitted coronal image at each step to form a spectral image cube. The spectral image cube is subsequently processed on the ground to generate a fitted emission line profile at each 5.8 x 5.8 arc-second pixel within a 1.1 to 3.0 solar diameter full field of view. The quality of the C1 spectrometric imaging is contingent on the exact mechanical state of the FPI and the details of the strong instrumental stray light background accompanying internal occultation coronagraphy. Since the etalon, FPI and instrumental background have moderate temporal dependences, the coronagraph was designed to accommodate the dependencies with in-flight calibration. This presentation describes the instrument in-flight calibration, the calibration algorithms, the spectrometric image reduction methods and presents examples of integrated line intensity, Doppler shift, and Doppler width images of the corona obtained with the 5303 Angstrom “green” coronal emission line.

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ARE NANOFLARES RESPONSIBLE FOR CORONAL HEATING? RESULTS OF A SIMPLE STATISTICAL MODEL

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Nanoflares have been proposed as the main source of heating of the solar corona. However, detecting them has so far proved elusive and extrapolating to them from the properties of larger brightenings generally gives too few of them to be relevant for coronal heating. Here we present a simple statistical model of quiet Sun EUV light curves based on a power law distribution of micro- and nanoflare energies. The basic assumption is that all the observed radiation in a chosen spectral line is the result of nano- and microflares. The flare-energy distribution is constrained by simultaneously fitting the radiance distribution (which follows a lognormal function) and the power spectrum of the time series. A comparison of the simulated time series with SUMER data reveals a good match for power law exponents greater than 2. Large power law exponents are needed in order to reproduce the nearly unchanging background radiation between the brightening events. This result is consistent with nanoflares being the primary source of coronal heating.

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COMPARISON OF UVCS STREAMER PROPERTIES WITH 1 AU SOLAR WIND MEASUREMENTS

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The Ultraviolet Coronagraph Spectrometer (UVCS) on SOHO has made detailed observations of coronal streamers in the extended corona (1.5 < r < 10 solar radii) for almost a complete solar cycle. Measurements of ultraviolet line profiles and intensities and polarized white light intensities are used to determine plasma parameters (proton and oxygen kinetic temperatures, electron densities, and outflow speeds) for these large scale coronal structures. In this paper we compare the variations in streamer properties obtained in the extended corona with the properties found in the solar wind at 1 AU. Solar wind velocities and densities derived from ACE and WIND data are used for these comparisons. Such information may be used to distinguish between solar wind variations due to changes in physical parameters of streamers at the Sun as opposed to changes in flow geometry. This work was supported by NASA grants NAG5-12781 and NNG05GG38G to the Smithsonian Astrophysical Observatory.

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SPECTROSCOPIC OBSERVATIONS OF THE EXTENDED SOLAR CORONA ABOVE QUIET SUN REGIONS

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We present an analysis of ultraviolet spectra observed in diffuse regions that are devoid of structure and appear not to have any contribution from coronal holes and streamers. The observations were made with the Ultraviolet Coronagraph Spectrometer (UVCS) onboard the Solar and Heliospheric Observatory (SOHO). The measurements were observed during several periods throughout 2005. The observations were performed at 1.72 and 2.54 solar radii. We measured the intensities and line ratios of the O VI doublet (1032 and 1037 Angstrom), Lyα, and Lyβ. We compared the line widths and ratios we measured in the unstructured corona to those measured previously in streamers and coronal holes. We examined Lyα and O VI profiles and compared them to those of coronal holes and streamers. These comparisons of the observed UVCS data over the Quiet Sun regions should provide insight toward the understanding of whether there are other stable structure (i.e., Quiet Corona) besides coronal holes and streamers in the extended solar corona.

This work is supported by NASA under Grant NNG05GG38G to the Smithsonian Astrophysical Observatory, by the Italian Space Agency, and by the ESA PRODEX program (Swiss contribution).

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SPECTROSCOPIC MEASUREMENT OF OVI KINETIC TEMPERATURE AND OUTFLOW VELOCITY IN A POLAR CORONAL HOLE

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A new diagnostic method has been developed to evaluate the OVI kinetic temperature in a polar coronal hole. In the analysis of the OVI 1031.9, 1037.6 Armstrong spectral lines, observed with UVCS/SOHO, many aspects have been considered, such as the effect of merging of the OVI lines and that of HI at 1025.7 Armstrong, the instrumental broadening, the stray light contribution including that due to HeI and FeIII, detectable only at large heliocentric distance, and the line broadening caused by the macroscopic velocity field. The quadrupolar magnetic model by Banaszkiewicz et al., 1998 and electron density by Guhathakurta et al., 1999 have been used to determine the macroscopic velocity field. It is possible to calculate the Doppler dimmed and Doppler shifted emission along the line of sight and thus derive the observed line broadening, by fully taking into account the Doppler effect due to the outflow velocity, evaluated from the mass flux conservation along the flow tube, and the emissivity as a function of heliocentric distance. This analysis leads to a new estimate of OVI kinetic temperature. These ones reach a maximum value of two hundred million Kelvin degrees for about 2.8 solar radii and then decrease for larger heliocentric distances. It has been also possible to derive, from the intensity ratio of the OVI coronal lines, the outflow velocity of the fast solar wind, that is monotonically increasing outward to reach 450-500 km/s at about 4 solar radii. Isotropic distribution of the ions can't explain the observed outflow velocity and for heliocentric distances larger than 2 solar radii the anisotropic one is necessary. Finally the most important heating seems to occur from 2.3 to 2.8 solar radii.

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ON A POSSIBLE SOLUTION TO THE CORONAL HEATING PROBLEM: A NEW MECHANISM FOR PARALLEL ELECTRIC FIELD GENERATION IN THE MHD LIMIT

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Using Particle-In-Cell simulations i.e. in the kinetic regime Tsiklauri et al. and Genot et al. recently reported on a discovery of a new mechanism of parallel (to the ambient uniform magnetic field) electric field generation, which results in electron acceleration. This new effect takes place when an Alfven wave moves along the field in the plasma which has transverse density inhomogeneity. The progressive distortion of the Alfven wave front due to differences of Alfven speed then generates the parallel electric field. In this work we show that the parallel electric field generation can be explained in much simpler framework using MHD description, i.e. without resorting to complicated wave particle interaction effects. Further, in the context of the coronal heating problem a new approach to the plasma heating is presented by putting emphasis on the generation of parallel electric fields, rather than focusing on the enhanced dissipation mechanisms of the Alfven waves. It is shown that in the case of substantially short wavelength (longitudinal wave-numbers approx. 10 inverse Alfven scales) the generated parallel electric fields can account for the necessary coronal heating requirement.

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MULTIWAVELENGTH ANALYSIS OF A SOLAR QUIET REGION

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We present observations of a solar quiet region obtained by ground-based telescopes (THEMIS, DOT), TRACE and several instruments on board SOHO (SUMER, CDS and MDI) during a campaign in October 2005. The aim of this work is to study the rich diversity of fine-scale structures that appear at the network boundaries, their inter-relationship and their appearance in the different spectral lines that range from the chromosphere to the corona. These studies are crucial to understanding the dynamics of the solar atmosphere, as well as the role such structures play in the mass balance and heating of the overlying solar atmosphere.

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HA CHROMOSPHERIC MOTTLES AND THEIR UV/EUV COUNTERPARTS SEEN BY SOHO/SUMER

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We report on our observations made during the SOHO-GBO campaign in October 2005. In particular, we focus here on coalignment of Hα mottles observed by Themis with those seen in OV 629 A and NV 1238 A lines by SUMER. Hα MSDP data provide us with the diagnostics of the line opacity and this can be correlated with the opacity of the hydrogen Lyman continuum, using the non-LTE simulations. This continuum opacity is then critical for explaining the mottle contrast in OV 629 A line. The fact that we see a similar contrast also in NV 1238 A rises a question how these two lines, one below and one above the Lyman-continuum head, are actually formed within the highly structured chromosphere.

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AN INVESTIGATION INTO THE VARIABILITY OF ACTIVE REGION HEATING: COOLING LOOPS IN AR8731.

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Previous studies have indicated that both steady and impulsive heating mechanisms play a role in active region heating. In this paper, we present a detailed study of 20 hours of soft X-ray and EUV observations of solar Active Region 8731, an active region dominated by short lived, bright structures. We examine the evolution of six representative loop structures that evolve during the time of the observations: they first brighten and fade from X-ray images, then later appear and fade in the EUV images. We determine their lifetime and the delay between their appearance in the different filters. We find that the lifetime in the EUV filters is much longer than expected for a single cooling loop. We measure the loop lengths and determine that the delays in the loops' appearance in the X-ray and EUV filters are proportional to the loop lengths. We determine the temperature evolution of the loops using the X-ray filter ratios and find that some of the loops appear to be cooling, while others appear to have a steady temperature. Finally, we model one representative loop using a hydrodynamic model with both impulsive and quasi-steady heating functions and find that neither of these simple heating functions can well reproduce the observed loop characteristics in both the X-ray and EUV images. Hence, though this active region is dominated by variable emission and the characteristics of the observed loops are qualitatively consistent with a cooling loop, the timescale of the heating in this active region remains unknown.

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A COMPARISON OF THE PHYSICAL PROPERTIES FOR MULTIPLE STREAMERS

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In this presentation we provide a comparison of the physical properties derived for multiple streamers from data collected by the Ultraviolet Coronal Spectrometer (UVCS) and the Large Angle Spectroscopic Coronagraph, both instruments aboard the Solar and Heliospheric Observatory (SOHO). The UVCS derived properties include photospheric normalized absolute elemental abundances, kinetic and electron temperatures. The elemental abundances of O, Si, Fe, S, and Ar are examined with regards to the first ionization potential (FIP) effect. The electron density results are provided from LASCO pB measurements. These measurements are conducted along varies latitudinal and radial positions within each of the streamers. The streamers were observed during different periods of the solar cycle.

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TIME DEPENDENT SIMULATIONS OF SIDEWAYS DRIVEN CORONAL LOOP OSCILLATIONS

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We use the computer code PET to study the time evolution of a two dimensional cylindrical coronal loop. The coronal loop is driven monoperiodically from the side in the framework of linear MHD. When the driver period matches the kink quasi-mode frequency closely, a resonant layer is formed and damping occurs.

As a result of the resonance, three phases in the time evolution can be distinguished. Initially, we have a build-up phase when the resonant layer is set up. In this phase the amplitude of the global oscillation increases linearly. Secondly, a steady state is obtained. In this state, the driver energy is exactly dissipated in the resonant layer. Consequently, the amplitude of the oscillations is constant.
As a last phase, we distinguish the time interval when the driver is stopped. As expected, in this phase, the global kink oscillation damps out exponentially. The measured damping times correspond very closely to the values obtained in the eigenvalue problem (Arregui et al. 2005).

When considering a radially highly inhomogeneous coronal loop and a large density contrast between the interior of the loop and the surroundings, the oscillations are heavily damped. As a result, the build-up phase is very short (only a few periods) and the amplitude in the steady state is small. Consequently, after a few cycles, much more driver energy than the energy in the global oscillation is dissipated.

The classical argument that not enough oscillatory energy is observed in the solar corona to sustain the heating, is therefore invalid. The fact that little oscillations are observed, does not mean that no oscillation energy is dissipated. The amount of observed oscillatory energy is not related to the total energy dissipated by waves.

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OXYGEN ABUNDANCE VARIATIONS IN CORONAL STREAMERS AFFECTED BY CMES

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We present a study on the variation of the oxygen abundance within equatorial streamers affected by coronal mass ejections (CMEs). We select CME events during the period of minimum solar activity May 1996 - March 1997, from the Large Angle Spectroscopic Coronagraph (LASCO/SoHO) CME catalog. The selected events have diverse intensities and affect the coronal streamer belt structure. For each event, we derive the oxygen abundance within the streamer belt from spectroscopic coronal observations performed with the Ultraviolet Coronagraph Spectrometer (UVCS/SoHO). We analyze UVCS data typically obtained before and after the actual CME occurrences. Within the streamer belt core structure the oxygen abundance usually exhibits a depleted region, presumably due to gravitational settling. We analyze how this degree of depletion changes within streamers observed before and after CME events of diverse intensities. We report our main results and discuss their implications for the dynamics of the streamer region.

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ALFVÉN WAVES AND ALFVÉNIC TURBULENCE IN THE SOLAR PHOTOSPHERE AND CHROMOSPHERE.

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Alfvénic turbulence in the solar photosphere and chromosphere is believed to play an important role in the plasma heating of the solar corona and acceleration of the solar wind. The emerging wave flux in the corona can in fact accelerate the wind directly (wave pressure) and indirectly (plasma heating), but both the amount of the flux transmitted in the corona and the wave energy spectrum are necessary to give precise quantitative estimate. The source of the alfvénic fluctuations is to be found in the footpoint motions of the magnetic field lines anchored in the photosphere. The stochastic velocity field, resulting from the plasma dynamics in the convection zone, shakes the magnetic field lines and launches Alfvén waves propagating upward at the Alfvén speed along the mean magnetic field (organized in flux tubes). The stratification of the atmosphere and the flux tube expansion cause the wave reflection so that a strong nonlinear cascade in the perpendicular wave number can develop. The high reynolds numbers and the wide range of length-scales involved in the process allow numerical simulations which only partially reproduce the phenomenology despite high computational costs. Given that some simplifications are needed, and that the wave reflection is fundamental for the development of the turbulent cascade (it triggers nonlinear interaction), we choose to treat as rigorous as possible the wave propagation in a highly stratified atmosphere while we adopt a 2D shell-model to reproduce the turbulent cascade (hence loosing the spatial dependence in the perpendicular plane). The evolution with distance of the frequency spectrum is studied in variety of initial condition (different period of the forcing field, different energy distribution in the perpendicular plane, different flux tube geometry) in order to quantify the plasma heating and the amount of flux transmitted to the coronal layer.

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THE EFFECT OF DENSITY STRATIFICATION ON CORONAL LOOP OSCILLATIONS AND WHAT WE COULD DEDUCE FROM IMPROVED SPATIAL RESOLUTION OF IMAGING

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It is very difficult to interpret observations of the Sun's corona or lower atmosphere with the purpose of measuring the variation of plasma density along fine structures such as coronal loops using emission measure. Existing magnetohydrodynamic wave theory has therefore been developed to compliment this work, with the aim of using observations of loop oscillations to provide another way of deriving the same diagnostic information about their density structure. We discuss the theory of amplitude dependence on density stratification of coronal loop oscillations and the feasibilty of using this new result as a more advanced tool for coronal seismology.

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03 Atmospheric Heating and Solar Wind Origin: MHD vs. Plasma Physics

ALFVEN WAVES AND ION ENERGIZATION OBSERVED BY SOHO AT 1.5-3 SOLAR RADII

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Strong energization of heavier ions across the background magnetic field at 1.5-3 solar radii is observed by UVCS onboard SOHO. The commonly accepted interpretation of this phenomenon is based on the ion-cyclotron resonant heating by high-frequency waves. In our opinion, it is reasonable to expect more power in oblique low-frequency waves rather that in ion-cyclotron waves at 1.5-3 solar radii. Oblique Alfven waves can be generated by phase mixing and nonlinear interaction of MHD Alfven waves propagating from the coronal base. We discuss two basic effects that oblique Alfven waves can produce on ions: cross-field acceleration and field aligned trapping. The first effect can be responsible for the cross-field ion heating observed by SOHO, and the second one can be responsible for the formation of ion beams observed in-situ in the solar wind at larger distances from the Sun.

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ION SOUND IN HIGHLY COLLISIONAL PARTIALLY IONIZED PLASMA

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The excitation of ion sound oscillations in a partially ionized plasma, propagating obliquely to the magnetic field lines is discussed. Collisions of plasma species with neutrals in such plasmas play a decisive role and involve possibly different sets of (kinetic) equations for ions, and (fluid) equations for electrons. Due to same reasons electrons may behave as magnetized while ions remain un-magnetized and, consequently, the dynamics of the two species becomes very different. In the case of an ion sound, there is no preferential direction for the ion motion, while electron dynamics is influenced by the magnetic field. As a result the spectrum and the increment/decrement of the mode becomes different compared to standard ion-electron case. This is particularly obvious for the mode increment, which in a plasma with neutrals may become higher and in the same time the instability threshold may become lower. The mode is shown to be angle dependent, having a minimum instability threshold at a large angle of propagation with respect to the magnetic field lines. This feature is primarily due to the collisions. An additional specie of hot electrons, introduces certain changes in the mode behavior. These hot electrons are more collisional and therefore they perform a motion similar to ions. As a result the instability threshold is changed and becomes higher. We underline an essential difference between the standard electron drift (current) driven instability and our results. We have shown that although the necessary instability condition in the standard case is more easily satisfied compared to our case, the actual sufficient instability condition is in fact much more easily satisfied in the present case.

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DETERMINING SOLAR PLASMA LOOP THERMAL STRUCTURE: PROS AND CONS OF AN EUV COLOUR-COLOUR METHOD

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Recent interest in solar atmospheric loops has focussed upon whether any observed spatial variation in the thermal profile along one of these features can be related to the possible energy deposition within the loop itself. Determining this heat input profile would produce be a very important constraint upon the current, suggested heating mechanisms for loops. This paper concentrates upon the proposed two filter ratio or colour-colour method for determining unambiguous temperature values for the plasma throughout the solar atmosphere (Chae et al, 2003). Essentially, this analysis makes use of two filter ratios (195/171 Angstroms and 284/195 Angstroms) plotted against each other (as shown in the Figure). It was found that outside the range of 0.7 - 4 MK the errors for the SOHO/EIT instrument response functions were so large that the resultant temperature values lacked confidence. With this limited temperature range, a SOHO/EIT data set of loops at the solar limb was analysed. However, it was found that few of the points taken from along the loop structure sat fully on the colour-colour curve. Thus more generally, these investigations suggest under what specific conditions the colour-colour method can be most usefully applied. The time lapse between the three EUV wavelength images, the limited spatial resolution of SOHO/EIT, the possibility of plasma flows along the loop or the possibility of observing through a multi-thermal atmosphere are all discussed and possible solutions modelled. Considering the latter, using a simple two temperature approach, it was found that it is possible to reproduce the SOHO/EIT loop analysis. These results will have a profound impact upon the interpretation of the six EUV channels that will be available to through the Solar Dynamics Observatory and lay the necessary groundwork for how the huge datasets from that mission could be employed to diagnose loop plasma.

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DETERMINING SOLAR PLASMA LOOP THERMAL STRUCTURE: WHAT CAN WE EXPECT FROM SOLAR-B EIS?

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Recent interest in solar atmospheric loops has focussed upon whether any observed spatial variation in the thermal profile along one of these features can be related to the possible energy deposition within the loop itself. Determining this heat input profile would produce be a very important constraint upon the current, suggested heating mechanisms for loops. The advantages and limitations of undertaking such an investigation using a rastering spectrometer (in this case with the spatial and temporal resolution that will be available to us through Solar-B EIS) will be presented. A 1-D simulation of a plasma strand evolving through a specified heating/cooling cycle is folded through the "spatio-temporal smearing" that occurs as the EIS slit rasters across its target. Depending on the loop geometry relative to the slit position, the resulting "EIS-observed" thermal structure can be quite different from the actual energy input. Therefore, when compared to a hydrostatic plasma stand model, an erroneous conclusion on the preferred spatial location of the heat input can occur. Possible solutions for a more robust approach to dealing with this problem will be discussed.

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HYDRODYNAMIC SIMULATIONS OF DYNAMIC HEATING WITHIN A BUNDLE OF SOLAR ATMOSPHERIC PLASMA STRANDS

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One Dimensional (1D) hydrodynamic (HD) modelling of a loop as plasma evolving along an individual field-line has been popular since late 1970's. However it must be recognised that if the range of loop structures we can observe do consist of many ''sub-resolution'' elements, then this 1D models are really only applicable to an individual plasma element or strand. Thus a loop is an amalgamation of these strands. They could operate in thermal isolation from one another with a wide range of temperatures occurring across the structural elements. This scenario could occur when the energy release mechanism consists of localised, discrete bursts of energy that are due to small scale reconnection sites within the coronal magnetic field- the nanoflare coronal heating mechanism. These energy bursts occur in a time-dependent manner, distributed along the loop/strand length, giving a heating function that depends on space and time.

An analytical approach to how the solar plasma evolves in response to being heated rapidly (shorter than the cooling time) by a nanoflare-type energy release has already been developed (Cargill & Klimchuk 1997, 2004). This basic concept is that each strand is characterised by a single temperature and density and that the cooling of heated plasma (from 10^7K say) is split into two parts – first cooling is by conduction and then later by optically thin radiative losses. The advantage of this approach is that it can simulate the evolution of many thousands of strands with relative ease and calculate ''global loop'' observables such as the filling factor and emission measure. However, the disadvantages are that the ''loop'' is reduced to a single point and that the important effects of gravitational stratification and the energy and mass carried away by proper field-aligned flows are ignored.

Such modelling needs nanoflare heating that considers properly the thermal evolution of many strands together. We present preliminary results where, by using a fully HD model of multiple strands followed by the calculation of various instrument observables, we investigate how a ''global'' loop evolves under these heating conditions. Thus this research is the natural extension of the semi-analytical approach outlined above.

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SLOW MAGNEO-ACOUSTIC WAVES IN CURVED CORONAL MAGNETIC SLAB

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Recent observations by SUMER spectrometer on SOHO show the existence of damped slow standing magneto-acoustic waves in hot coronal loops. Several different mechanisms can be responsible for the damping of the oscillations but, so far, only straight magnetic tube has been used for modelling the waves. However the loop curvature can be of importance in dynamics of the first or second harmonics of standing slow waves. Here we study the role of loop curvature on the standing slow wave characteristics (period, phase speed) and damping time and show that first and second harmonics of standing slow magneto-acoustic waves are damped in a curved magnetic slab by the leakage of energy due to the curvature. The damping time is shorter for higher temperature loop. The result is compared to the observation of slow magneto-acoustic waves in hot coronal loops (Wang et al. 2003).

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4 Solar Variability and its Effects on the Heliosphere and the Earth

DIFFERENT PARTICLE INJECTION SITES IN THE LOWER CORONA DURING A GLE

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Comparing remote solar and in-situ space-based diagnostics Klassen et al. (JGR 110, A09S04, 2005) evidence different components of energetic particles released during the impulsive phase and the following hour of posteruptive energy release of the X-class flare in and around AR10486 on 28 October 2003 (a Ground Level Event). We reconsider the question if the distinct release processes of energetic particles take place in the lower solar corona, or if they are connected with acceleration at CME-driven shocks. The analysis of radio spectral and imaging data (Potsdam and Nancay), RHESSI, SOHO-EIT and MDI, as well as TRACE data reveals that the different energetic particle ensembles can be associated with the occurrence of at least two spatially different radio source sites in and around the flaring active region. In the radio spectra an 8 min duration decimeter continuum with fiber burst fine structure occurs during the backextrapolated injection time of relativistic protons. Radio data and EIT images point on a source site north of AR 10486, in a magnetic link between AR10491 and 10488. We discuss if the occurrence of fiber bursts can be taken for an independent hint on simultaneous proton injection into this magnetic structure together with the escape of relativistic GLE protons into space. The injection of the different electron ensembles in space can be associated with the occurrence of a radio-spectrally identified outflow termination shock source for the first injection. Almost the same source site is reactivated 40 min later showing a less specific radio spectral signature. Our analysis does not exclude particle acceleration at CME-driven shocks but, in the present case, is in favour of acceleration at different sites in the post-CME lower corona.

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INTERACTIVE SOLAR DATA VISUALIZATION: THE SOLAR WEATHER BROWSER

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The Solar Weather Browser (SWB) is a client/server tool developed for easy visualisation of solar images in combination with any context information that can be overlaid on the images. The server side preprocesses a wide variety of solar images and context data into a highly compressed format that is accessed by the client side on the user machine. On the client side, the user can interactively combine background images (e.g. EIT, MDI) with overlays (e.g. sunspot or filament locations, CME detections, potential field extrapolations, LASCO C2 and C3). This allows an enormous number of image/overlays combinations which would not be feasible in a non-interactive set-up. This feature is particularly useful for the presentation of the results of automated solar image recognition/processing chains. Given its highly optimized image compression and transmission, the SWB is also potentially useful in the context of distributed solar image archives where it could play the role of quicklook previewer. The SWB is an open-source development, readily downloadable for all major platforms. We will present the current state of the SWB and invite contributions for further development.

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THE LASCO-ARTEMIS CATALOG OF CMES

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We have developed a new automated method of detection of CMEs on LASCO-C2 synoptic maps based on their morphological properties. The approach is based on an adaptive filtering and segmentation, followed by a merging with high-level knowledge step. The program builds a catalog which lists the CMEs detected in a given synoptic map together with their main estimated parameters: time of appearance, position angle, angular extent and average velocity. Our final catalog LASCO-ARTEMIS (Automatic Recognition of Transient Events and Marseille Inventory from Synoptic maps) is compared with existing catalogs (LASCO CME catalog, CACTUS catalog). We find that i) we detect many more events that the visual detection method but in good agreement with the automated CACTUS detection ii) our rate of events follows very well the pattern of solar activity like the LASCO CME catalog, which has been highlighted by a correlation study with the sunspot number. The total number of detected CMEs is heavily controlled by the sensitivity to small, faint and numerous events. Adapting the thresholding step, we show that a continuous distribution of CMEs must exist. Two classes of CMEs can be distinguished according to their velocity and their morphology : i) fast and huge CMEs disturbing the whole solar corona ii) slow plasmoïds, or blobs, forming the slow solar wind.

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04 Space Weather and Space Climate: Flares, CMSs and Energetic Particles

INTERPLANETARY PROPAGAGTION OF CORONAL MASS EJECTIONS: RESULTS FROM CO-ORDINATED SOHO|LASCO AND RADIO SCINTILLATION OBSERVATIONS

Breen, Andy[1]; Jones, R.A.[1]; Tappin, S.J.[2]; Thomasson, P.[3]; Fallows, R.A.[1]; Bisi, M.M.[1]
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We present the results from a study of solar eruptions which combines LASCO observations of coronal mass ejections (CMEs) with radio scintillation measurements of their interplanetary counterparts (iCMEs). Comparisons of CME speeds through the corona (from LASCO observations) with the speeds seen in interplanetary space and ambient solar wind speeds ahead of the events indicates that iCMEs are accelerated or decelerated towards the background solar wind speed, with most of this acceleration or deceleration taking place inside 0.5 AU. Radio scintillation observations can also provide information on non-radial velocities in iCMEs, and we report a case of rotation of flow direction from slightly (1-2 degrees) equatorwards (in the background solar wind) to 3-4 degrees polewards during the iCME passage.

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CME MODELING: AN A POSTERIORI APPROACH

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

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MULTI-WAVELENGTH ANALYSIS OF FILAMENT ERUPTIONS AND ASSOCIATED FLARES

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We present a multi-wavelength analysis of two solar flares associated with filament eruptions which occurred in the NOAA active region 10792 in July 2005. The wavelength coverage for these events is particularly good, ranging from microwave (17 GHz and 34 GHz) observations from the Nobeyama Radioheliograph, EUV data from TRACE and SOHO/EIT as well as soft and hard X-ray observations taken with RHESSI. Such observations are complemented with SOHO/MDI magnetograms. We discuss pre-flare conditions and the evolution of these events, as well as correlations between filament motion and HXR source separation.

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FRACTAL PROPERTIES OF SOLAR ERUPTIONS AND INTERPLANETARY MAGNETIC FIELDS IN GEOMAGNETIC EVENTS

Cotten, Donald; Marchese, P. J.; Wong, P. K.; Tremberger, Jr., G.; Cheung, T. D.
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The bandpass 17.1 and 19.5 nm signal fluctuation across the solar disc and the interplanetary magnetic field (IMF) fluctuation across time were investigated for their fractal properties. The studied events were strong geomagnetic storms as measured by large negative Dst values. One atmospheric gamma ray burst event was also included. The selection criteria were based on our previous studies that the coronal mass ejection speed, solar energetic particle flux, and Dst index are strongly related to the IMF fluctuation and its fractal property (American Meteorology Society Space Weather Symposium 2006, paper 3.10). The spatial series of the temperature increment across the solar disc shows fractal dimension from 2.3 to 1.5 in various conditions and appears to be correlated to that of the IMF time series. Fractal analysis on MHD model simulations gave consistent results. Applications to large solar flare events and space weather forecasting were also discussed.

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REVEALING THE INSIDE OF CORONAL MASS EJECTIONS

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The magnetic nature of CMEs has become evident after the recurring identification of flux ropes in the unprecedented SOHO LASCO dataset. This finding allows the association of features of CMEs near the Sun with certain magnetic structures detected in-situ, i.e. magnetic clouds. However, the magnetic flux rope can be discerned only in a small fraction of the CMEs, mostly originating near the solar limb; in contrast to halo CMEs related to in-situ events, which originate near disk center. A general insight into the internal magnetic field configuration of CMEs is needed, in order to correlate properly near-Sun CME features and their interplanetary CME counterparts. The inner structure of CMEs is revealed with the help of a powerful image processing technique. The procedure is based in a multi-level decomposition scheme that mainly relies in the à trous wavelet transform. This way, linear and circular features found within CMEs can be unambiguously recognized and characterized, towards a better understanding of the CME magnetic field configuration.

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THE EUV SPECTRAL IRRADIANCE AND THE PHYSICAL CHARACTERISTICS OF THE SOLAR CORONA DURING THE 10 YEARS OF SOHO MEASUREMENTS.

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The SOHO instruments have performed extremely well and provided us for the first time detailed measurements in the EUVs, from solar minimum (1996) through the maximum (2001-2002) and up to now. These measurements enable us to describe the characteristics and long-term variations of the EUV spectral irradiance and overall of the solar corona. First, we present EUV (150-800 Angstroms) radiance measurements obtained with the SOHO/Coronal Diagnostic Spectrometer - Normal Incidence (NIS) and Grazing Incidence (GIS) from 1996 to now. Then we discuss the evolution (from minimum to maximum) of the physical and morphological characteristics of the solar corona that we can infer from the spectra. We discuss the contribution of active regions to the entire corona and the total EUV irradiance during maximum. We complement the CDS measurements with SOHO/EIT images, discuss the center-to-limb variations, and obtain irradiance measurements in the lines observed by CDS. These are the first long-term continuous measurements of the solar EUV spectral irradiance. We compare the results with the TIMED measurements and with the previous 'historical' ones, mostly made in the 1970s. A discussion of the CDS calibration and cross-calibration of the instruments on board SOHO (CDS,EIT,SEM) is presented.

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SEGMENTATION OF SOLAR STRUCTURES USING FUZZY CLUSTERING

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We present a few applications of a signal processing technique called "fuzzy clustering" for automatic identification of various regions seen in solar images. This technique gives for each pixel a probability of belonging to a particular class. By assigning each pixel to the class for which it has the greatest probability of belonging, we obtain an image segmentation. This generic technique can be used for separating zones in the different layers of the solar atmosphere thanks to an adapted representation of pixel information. Moreover, information from several channels can be used as inputs of the method, and we show that this improves the quality of the segmentation.

In EIT coronal images, we are able to distinguish Quiet Sun, Coronal Holes, and the Active regions. Extracting the Active Regions or the Quiet Sun is useful when one wants to further characterize e.g. the complexity of these regions. Separating Quiet Sun, Coronal Holes and Active regions also allows us to monitor their respective contribution to EUV irradiance and the evolution of their area along the solar cycle. In EIT transition region image (30.4nm), we extract the plages and the network. Similarly to coronal images, we can build time series of their evolution, as well as integrated intensity of these structures.

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THE EFFECT OF THE BACKGROUND SOLAR WIND ON CMES INITIATED BY FLUX EMERGENCE

Dubey, Govind; Van Der Holst, B; Poedts, S
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We have numerically simulated the initiation of Coronal Mass Ejections (CMEs) by magnetic flux emergence, including the effect of the background wind. We have extended previous spherical, axi-symmetric models with a static background dipole field configuration to a more realistic model including a full magnetohydrodynamic (MHD) steady solar wind. The initial configuration consists of a magnetic flux rope embedded in a gravitationally stratified solar atmosphere with a background (stationary) state-of-the-art solar wind. The initial force balance yields a flux rope that is in static equilibrium due to an image current below the photosphere. Next, an emerging flux triggering mechanism is used to make this equilibrium configuration unstable. As a result, a catastrophic behavior similar to previous models is seen when flux is emerged within the filament below the flux rope. Consequently, the flux rope rises and a current sheet forms below it. It is shown that the magnetic reconnection in the current sheet below the flux rope in combination with the outward curvature forces and the effect of the out-flowing solar wind results in a fast ejection of the flux rope as observed for some CMEs. Furthermore, we show the impact of the drag caused by the solar wind on the obtained CME speeds. This drag prevents the CME speed from decreasing below the solar wind speed. We have done an extensive parameter study of the flux emergence rate and compared the results with our previous work where a static magnetic dipole field background was used instead of the more realistic solar wind.

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THE EFFECT OF THE BACKGROUND SOLAR WIND ON CMES INITIATED BY FLUX EMERGENCE

Dubey, Govind[1]; van der Holst, B.[1]; Poedts, S.[2]
[1]K.U. leuven; [2]K.U Leuven

We have numerically simulated the initiation of Coronal Mass Ejections (CMEs) by magnetic flux emergence, including the effect of the background wind. We have extended previous spherical, axi-symmetric models with a static background dipole field configuration to a more realistic model including a full magnetohydrodynamic (MHD) steady solar wind. The initial configuration consists of a magnetic flux rope embedded in a gravitationally stratified solar atmosphere with a background (stationary) state-of-the-art solar wind. The initial force balance yields a flux rope that is in static equilibrium due to an image current below the photosphere. Next, an emerging flux triggering mechanism is used to make this equilibrium configuration unstable. As a result, a catastrophic behavior similar to previous models is seen when flux is emerged within the filament below the flux rope. Consequently, the flux rope rises and a current sheet forms below it. It is shown that the magnetic reconnection in the current sheet below the flux rope in combination with the outward curvature forces and the effect of the out-flowing solar wind results in a fast ejection of the flux rope as observed for some CMEs. Furthermore, we show the impact of the drag caused by the solar wind on the obtained CME speeds. This drag prevents the CME speed from decreasing below the solar wind speed. We have done an extensive parameter study of the flux emergence rate and compared the results with our previous work where a static magnetic dipole field background was used instead of the more realistic solar wind.

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REVERSE DRIFT BURSTS IN THE 0.8-4.5 GHZ RANGE AND X-RAY EMISSION

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In last three years (2002-2005) the Ondrejov radiospectrograph, working in the frequency range of 0.8-4.5 GHz, observed about 60 groups of the reverse drift bursts. In 25 cases, observed at times of RHESSI observations, the association of the reverse drift bursts with the X-ray emission is studied in detail. For the analysis the EIT/SOHO images and MDI/SOHO magnetic field maps are also used. In most cases the reverse drift bursts were observed at the beginning of flares. The frequency drift of the bursts and the time delays of the associated X-ray peaks were found to be in intervals 20-2500 MHz s-1 and 1-6 s, respectively. The detailed positional analysis of the X-ray sources at the times of the reverse drift bursts show fast changes of source positions in the most studied cases. Among them the most interesting ones were observed in October 31, 2003, when a new X-ray source appeared just at the moment of the reverse drift burst observation, and in July 26, 2004, when very slowly drifting reverse drift bursts (20 MHz s-1) were associated with a continuously prolongating X-ray source. While in the most cases the model of the reverse drift bursts with electron beams is compatible with the observations, in the July 26, 2004 event the reverse drift bursts are probably generated by a shock wave propagating downwards in the solar atmosphere with the speed of about 600 km s-1.

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SOHO/COSTEP OBSERVATIONS OF THE NOVEMBER 1, 2004 SOLAR ENERGETIC PARTICLE EVENT.

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On November 1, 2004 at 06:06 UT, the LASCO C2 coronagraph onboard SOHO observed a 925 km/s Coronal Mass Ejection (CME) over the west solar limb. The event was accompanied by type III radio emission, but X-ray flux registered by GOES satellites did not show significant increase. EIT observations and the lack of X-ray flare suggest that the source of the event was located on the backside of the Sun, probably in the NOAA active region 10684, more than 30 degrees behind the west limb. COSTEP/EPHIN instrument detected a solar energetic particle event associated with this backside CME, showing clear velocity dispersion, proton acceleration up to at least 50 MeV and electron acceleration up to at least 10 MeV. Onset times, temporal evolution of energy spectra and abundance ratios observed during the event have been analyzed and compared to other events with backside origin in order to discuss different scenarios to explain particle propagation, including: cross-field transport, spatially extended acceleration at a coronal shock wave and alterations in the interplanetary medium caused by previous CMEs.

TOPICS
04 Space Weather and Space Climate: Flares, CMSs and Energetic Particles

OBSERVATIONAL PROPERTIES OF CMES FROM A DECADE-LONG OBSERVATIONS OF SOHO

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SOHO has observed about 10,000 episodes of coronal mass ejections (CMEs) over the past decade. These observations represent an extensive data set with high degree of uniformity and quality over an unprecedented field of view. An overview of the CME properties derived from the coronagraph and EUV images will be presented. Thanks to the synergy provided by solar wind, radio and energetic particle observations from Wind and ACE spacecraft, it was possible to improve our knowledge on CMEs not only near the Sun but also in the heliosphere. This paper will summarize the observational properties of CMEs and compare them with those obtained from pre-SOHO coronagraphs. Results that are significantly different from the pre-SOHO era will be highlighted. Halo CMEs, one thought to be a rare occurrence, have proved to be the most important players in the heliosphere, especially in the Sun-Earth connected space. SOHO has significantly extended the list of historical extreme events known since the time of Carrington. The excellent coverage of these events provided by SOHO and other spacecraft will be presented and an assessment of the extreme sizes and severity of these eruptive events will be discussed.

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THE SOHO/LASCO CME CATALOG

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The SOHO/LASCO CME catalog contains all CMEs manually identified since 1996 from LASCO images. Currently the catalog has been completed up to the end of 2005. The top-level of the catalog is a year-month matrix, each element giving the monthly lists of CMEs. The monthly list contains most of the information assembled from measurements from LASCO images and compilation from online databases. Entries in this list have links to additional information on CMEs. At the top of the monthly lists, simple explanation is provided for getting information from additional layers. Link to the list of data gaps during the month is also provided. Data gaps of 3 h and above are listed. Each row in the monthly list corresponds to one CME. The first three columns of the monthly list serve as an ID for each CME: the date and time of first appearance in the LASCO/C2 field of view (FOV) and the central position angle (CPA). More than 10 CMEs can occur on a single day, and many CMEs can appear at the same time in the C2 FOV. The CPA can essentially distinguish these CMEs appearing simultaneously. CMEs with an apparent width of 360 deg are marked as "Halo" in the CPA column. The first column is linked to direct and difference LASCO/C2 movies with direct and difference EIT images superposed. Column 4 is the sky-plane width of CMEs, when the measured value becomes stable (early on, the width often increases). Information as to when the width was measured (#WDATA) is available in the text data containing original measurements as a sub-layer of column 2. Each CME is characterized by three speeds: the linear speed in column 5 (from a straight-line fit to the height-time measurements), (2) quadratic speed in column 6 (from a parabolic fit) at the time of final height measurement, and (3) speed when the CME is at 20 solar radii in column 7. Clicking on any of the speeds displays the height-time plots with the fitted curves superposed. A minimum of three height-time measurements are needed for an estimate of the acceleration (column 8), but the accuracy increases when there are more measurements. Each CME is also characterized by a mass (column 9) and a kinetic energy (column 10). Column (11) gives the measurement position angle (MPA). Even though there is no CPA for a halo CME, there is an MPA, corresponding to the PA of the fastest moving segment of the CME leading edge. Column (12) links to a number of movies and composite plots related to the CME in question. The last column (13) contains some remarks regarding the number of data points and other limitations, as well as links to the halo CME alerts from the LASCO operator. This catalog can be searched from the VSO site and from the catalog page. It can also be searched by the SolarSoft routine ssw_getcme_list.pro . SSW users may use that function directly for application development and to access this CME catalog within an SSW session. The catalog search returns an html table similar to the monthly list in the catalog, and an event summary. In addition to the display of actual pages from the catalog, a summary of the basic attributes of CMEs derived from the catalog entries will be presente

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NANOFLARES IN THE QUIET SUN CORONA: A COMPARATIVE SOHO-EIT AND TRACE STUDY OF SMALL EUV BRIGHTENING EVENTS.

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We present results of a comparative statistical study of small-scale transient events observed in quiet sun regions by the Extreme Ultraviolet Imaging Telescope (EIT) on SOHO and simultaneously by TRACE. High-cadence observations in the 171 A, 195 A and 304 A bands allowed us to detect nanoflares in the transition region and corona at the limits of the spatial and temporal resolution of the instruments. We investigate assumptions made in the event detection algorithm and their effect on the derived frequency distributions. The goal of this study is to prepare analysis methods for the forthcoming Solar Dynamics Observatory and to investigate whether the rate of detected nanoflares is sufficient to heat the solar corona.

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04 Space Weather and Space Climate: Flares, CMSs and Energetic Particles

ERUPTING FILAMENTS AND THE SIGMOIDAL CHARACTERISTICS OF ACTIVE REGIONS

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The nature of sigmoidal, or S-shaped, soft X-ray features in active regions is of interest in the area of space weather due to the increased likelihood of eruption in these regions. Sigmoids are widely accepted to be precursors of coronal mass ejections however their exact physical nature has not been established. Current ideas for soft X-ray sigmoids fall into 3 main models. Firstly sigmoids have been described as being flux ropes which erupt due to the onset of the kink instability. The second interpretation comes from models of kink unstable erupting flux ropes which suggest the formation of sigmoids to be the result of heating along field lines field lines that pass through a current sheet formed beneath the flux rope. The third group of models find the occurrence of sigmoids to be the result of highly sheared magnetic fields. On the observational side sigmoidal soft X-ray loops have been seen to have co-spatial filaments and the shape of the filament structure has been used to infer the sign of twist in the magnetic field in that region. Since an erupting flux rope or sheared field may contain filament material they can be used as a tracer for the evolution of the magnetic field helping to understand better the relation between the filament and sigmoid and which part of the magnetic configuration takes part in the eruption. This work analyses a number of active region filament eruptions and their relation to the sigmoidal nature and helicity sign of the coronal field. The observations are related to the current competing theories and examines the physical nature of sigmoidal features in EUV, X-ray and H-alpha wavelengths as well as the role that kink unstable flux ropes may play.

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04 Space Weather and Space Climate: Flares, CMSs and Energetic Particles

COMPARISON OF SOHO AND DEBRECEN PHOTOHELIOGRAPHIC DATA SUNSPOT AREAS FOR THE YEARS 1996 AND 1997.

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An important attribute of the sunspots is their areas. For example, sunspot area data are used in the investigation of the evolution of sunspots and in study of their impact on solar irradiance. For a long time, these data have been derived from ground-based observations. But for 10 years, these areas can be determined from space-borne observations of SOHO, too. Based on SOHO observations, two sunspot catalogues are compiled: the SOHO Debrecen Data (SDD) at Debrecen Observatory and the Solar Feature Catalogue (SFC) at University of Bredford . In this presentation, we compare SDD and SFC areas with each other and with the ground-based DPD (Debrecen Photoheliographic Data) areas for the years 1996 and 1997. Moreover, as among the SOHO images there are solar magnetic flux images too, we investigate how the magnetic flux (averaged separately over the penumbra and the umbra) of the sunspots depends on the penumbral and umbral areas, respectively.

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MODULATION OF VELOCITY DISPERSION OF SOLAR ENERGETIC PARTICLES BY PRE-EVENT BACKGROUND

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Solar Energetic Particle event onset times have been traditionally studied by using the velocity dispersion analysis. Those studies often report non-nominal path lengths for the first observed particles. The derived apparent path lengths can vary between 0.5 AU and 3 AU, while the distribution tends to peak at the nominal range of the expected path lengths (1-1.5 AU, spacecraft at 1 AU). Unlike the traditional studies, the recently introduced simulation approach to the onset research takes into account the effect of the interplanetary scattering on the arrival time of the first particles. These studies have shown that scattering can easily explain the large apparent path lengths. So far, the main focus of the simulation studies has been in the particle transport. In this study, we focus on the effect of the background spectrum to the observed velocity dispersion. This is achieved by overlaying a simulated event on backgrounds of different spectral shapes and relative intensities, emulating various onset conditions. The validity of the traditional onset analysis in various backgrounds is discussed.

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MICROFLARES AND LOOP OSCILLATIONS

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Microflares are small A to C class X-ray brightenings that occur at a rate of about 10 per hour in an average active region (Shimizu et al., PASJ, 44, L147, 92). They show signatures of non-thermal emission in RHESSI X-ray spectra and are seen as an important link between large-scale flares and the intangible nanoflares that have been proposed as the energy source for the corona. In this contribution we analyze microflare loop brightenings seen in the Fe XIX line with SUMER. For the two active regions studied, we find an Fe XIX loop brightening rate consistent with soft X-ray microflares. Almost half the events have Fe XIX Doppler shift oscillations. We summarize the basic characteristics of the oscillations and discuss their importance in the context of models of microflare loop excitation.

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04 Space Weather and Space Climate: Flares, CMSs and Energetic Particles

SOHO COSTEP AND ULYSSES COSPIN OBSERVATIONS DURING THE SERIES OF SOLAR ENERGETIC PARTICLE EVENTS IN SEPTEMBER 2005

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Between 7 and 16 September 2005 the NOAA sunspot Region 808 produced a series of X-class flares, some of them related to Earth-directed coronal mass ejections. These events generated powerful and long-lasting energetic solar particle events created a significant geomagnetic disturbances, and were recorded at near-Earth spacecraft and at farther heliospheric distances as well. The flux variations of 40 keV-53 MeV/n ions and of 40 keV-9 MeV electrons as observed by COSTEP aboard SOHO and that of 5-125 MeV protons and 2.5-7 MeV electrons by COSPIN KET aboard Ulysses, their energy spectra are analyzed to assess the acceleration and propagation characteristics of particles over a wide energy range and their variation between 1 and 4.8 AU from the Sun.

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04 Space Weather and Space Climate: Flares, CMSs and Energetic Particles

COSTEP/SOHO OBSERVATIONS OF ENERGETIC ELECTRONS FAR UPSTREAM OF THE EARTH'S BOW-SHOCK

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We have analyzed 61 electron bursts at energies above 0.25 MeV observed with the COSTEP/EPHIN instrument onboard the SOHO spacecraft far upstream of the Earth's bow shock. Some of these upstream bursts were accompanied by energetic protons < 1 MeV). Most of the bursts were observed during low solar activity (in 1996-1997) and were not associated with solar particle events. A close correspondence between the event rate and enhancements in both solar wind speed (Vsw) and geomagnetic activity index (Ap) indicates that the observed events can be explained in terms of leakage of magnetospheric particles during enhanced geoactivity rather than acceleration at the Earth's bow shock. We compare these data with measurements of particle bursts as well as magnetic field and solar wind parameters obtained with the Wind spacecraft.

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CHARGE-TRANSFER INDUCED HELIOSPHERIC SOFT X-RAY EMISSION AS POTENTIAL SPACE WEATHER FORECASTING

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Charge transfer between solar wind high charge state ions and solar system neutrals is the source of EUV-Soft X-ray emission. Using distributions of interstellar hydrogen and helium in the heliosphere, updated according to SOHO SWAN and UVCS results, as well as recently calculated cascading photon spectra of individual ion recombination, we have calculated soft X-ray emission maps for stationary solar wind in minimum and maximum solar activity. We also show how the X-ray intensity and its spectral properties vary in time in response to a temporary solar wind enhancement for various geometries and discuss the potential soft X-ray monitoring and forecasting of solar wind.

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04 Space Weather and Space Climate: Flares, CMSs and Energetic Particles

A STATISTICAL ANALYSIS OF SOLAR EUV IRRADIANCE TIME SERIES INCLUDING FLARES

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Royal Observatory of Belgium

The SEM instrument onboard SOHO has provided high cadence time series of solar irradiance in the Extreme-Ultraviolet (EUV) range. The time resolution allows to resolve irradiance fluctuations due to various solar events, such as flares. We will study the statistical features of these solar irradiance fluctuations, and their scaling behavior and evolution with solar activity. The results will be discussed in the framework of Space Weather and of the study of the non-equilibrium dynamics of the Sun.

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THE HELIUM SPECTRUM IN MOVING SOLAR PROMINENCES

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We present the first computations of the helium line profiles emitted by an eruptive prominence. The prominence is modelled as a plane-parallel slab standing vertically above the solar surface and moving upward as a solid body. The helium spectrum is computed with a non local thermodynamic equilibrium radiative transfer code. The effect of Doppler dimming / brightening is investigated in the resonance lines of He I and He II formed in the EUV. We focus on the line profile properties and the resulting integrated intensities. We also study the effect of frequency redistribution in the line formation mechanisms. We discuss the results in view of observations provided by SOHO, and by the EUS spectrometer on SOLAR-B.

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AUTOMATIC CME DETECTION FROM CORONAGRAPH IMAGE PAIRS

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We have developed a technique for the automatic detection of coronal mass ejections using two sequential coronagraph images. The technique is based on tracking arc-like features from one image to the next; the feature's velocity is also determined. The method has been developed and tested using LASCO C2 and C3 data. The goal of this work is to develop an automatic CME detection algorithm that can be used on board the STEREO spacecraft to preferentially downlink data containing CMEs from an onboard "rotating" data buffer. Results for this detection technique compare very favorably with CMEs identified in the LASCO CME catalog (http://cdaw.gsfc.nasa.gov/CME_list/). For the periods when results were compared, no time periods with significant CMEs were missed using the automatic technique.

TOPICS
01 Solar Interior: From Exploration to Experimentation

INTERACTION OF CME'S WITH THE STREAMER BELT

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On January 2007 the LASCO_C2 coronagraph will achieve 11 years of quasi continuos observations of the solar corona in the 2.5 to 6.5 rolar radii range. Such period corresponds to a full cycle of solar activity. We present a global view of the interactions between CME and the streamer belt over 10 years (1996-2005) based on synoptic maps of the K corona of unprecedented angular and temporal resolutions constructed from the LASCO-C2 images. Such maps display in detail the evolution of the coronal structures during the last solar cycle, the evolution of the streamer belt and a rich diversity of interactions with the CMEs. Many different situations are indeed observed, from the quasi absence of interaction to a full reconfiguration of the belt with the emergence of new neutral sheets. Recurrent ejections of CMEs from the same region are frequent during the maximum of solar activity. We attempt to link the CMEs morphology with their interaction with the belt, and we show the differences between geometric and intrinsic effects. We also discuss the statistics of the different "CME- streamer belt" events.

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ENERGETIC PARTICLE OBSERVATIONS AT 5 AU DURING THE DECLINING PHASE OF SOLAR CYCLE 23: ULYSSES COSPIN/LET OBSERVATIONS

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In the present work, we analyze recent energetic particle data observed by the *Ulysses* spacecraft during the declining phase of the current solar cycle. *Ulysses*-the first spacecraft ever to fly over the poles of the Sun- has began its third orbit during the period under study, starting its ascent to high southern latitudes. This phase of the *Ulysses* mission provides a unique opportunity to study the effects of solar activity from a near-ecliptic vantage point at intermediate heliocentric distance, some 5 AU from the Sun. Energetic particle observations in the 1-20 MeV/nucleon range as measured by the COSPIN/LET instrument onboard *Ulysses* are reported in the context of the changing heliospheric state. We focus, in particular, on the origin of the complex particle increases observed at the location of the spacecraft. Composition analysis can provide useful clues in this regard, allowing distinction between particles accelerated in transient events associated with Coronal Mass Ejections (CMEs) (referred to as Solar Energetic Particles, SEPs) and particles accelerated at Stream Interaction Regions (SIRs) or Corotating Interaction Regions (CIRs). It is emphasized that our investigation also incorporates the study and interpretation of the composition signatures observed at ~5 AU during periods of CME/CIR combinations (e.g. January 2005, September 2005 events).

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GENERATION OF RELATIVISTIC ELECTRONS DURING SOLAR FLARES

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During solar flares electrons are accelerated up to high energies. They are responsible for the non-thermal radio and hard X-ray radiation. During the flare on October 28, 2003 an enhanced flux of γ-rays up to 10 MeV has been observed as signature of the production of relativistic electrons. Magnetic reconnection is one possible mechanism for flares. Hot jets appear in the outflow region of the reconnection site. If these jets penetrate into the surrounding plasma, standing shocks are estrablished as seen in the solar radio radiation. Electrons can be accelerated up to high energies due to multiple encounters with such a shock. This process is described in a fully relativistic manner. If the highly energetic electrons travel along the magnetic field lines towards the denser chromosphere, they can emit hard X- and γ-ray radiation via bremsstrahlung. The theoretically obtained results are compared with the radio and SOHO data of the solar event on October 28, 2003, since signatures of relativistic electrons have been observed during this event.

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DAYSIDE AURORAL ACTIVITY AND VARIATIONS OF SOLAR WIND PARAMETERS

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We report preliminary results of a statistical analysis on the relationship between the dayside (cusp) auroral activity and key parameters of the solar wind (velocity, pressure, magnetic field, etc.). The present study covers the 2003-2004 and 2004-2005 winter seasons, consisting of about three months each, close to the winter solstice. Data collected by the ITACA2 auroral monitor (IFSI), located at the Italian Arctic base (Dirigibile Italia, Ny-Ålesund, Svalbard), were used in this study. Our statistical approach is based on the analysis of the 630.0nm keograms (magnetic latitude vs. time) between 04:00-13:00UT, that is, a window of eight-hours centered on the local magnetic noon (~09:00 UT), where the probability to observe the transit of the geomagnetic cusp is maximum. The solar wind conditions were derived from the ACE, WIND and GEOTAIL satellite data. It was also studied if and how the dayside auroral activity are directly influenced by the impact of interplanetary perturbations, linked to solar transient phenomena, as coronal mass ejections (CME), on the dayside magnetosphere. Halo or partial halo CME events were selected from the on-line catalogue (NASA/GSFC, http://cdaw.gsfc.nasa.gov/CME_list/index.html) derived by LASCO coronograph observations. We used the cosmic ray data recorded by the SVIRCO station (IFSI – Univ. Roma 3), to help in identifying the associated interplanetary perturbation at the Earth orbit (Forbush decrease). From cross checking dayside aurora activations and abrupt variations of solar wind parameters (IMF, pressure, etc.) likely connected to the selected CMEs, we found interesting cases of a direct cause-effect relationship between the two phenomena.

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TURBULENCE AND COMPLEXITY OF THE SOLAR ATMOSPHERE

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New multiscalar and multifractal approaches to quantifying magnetic complexity are presented and discussed in relation to understanding and characterising solar active region and predicting solar flares in near real time. The power-law frequency distribution of flares is a clear signature of the self-organised criticality (SOC) of an externally driven, dissipative, dynamical system (Bak et al. 1987). This system arises from competition between the input (flux emergence and rearrangement in the photosphere) and output (electrical current build up and resistive dissipation) in the corona. Although localised, this redistribution affects neighbouring regions and an avalanche occurs. It is already understood that simple monofractal and Fourier studies of magnetic field data give a good, though imperfect, understanding of active regions (i.e., active regions with a larger fractal dimension (McAteer, Gallagher & Ireland, 2005) and steeper energy cascade (Abramenko, 2005) tend to produce more, larger flares.) In this talk we present more detailed multifractal and multiscalar approaches to this issue using longitudinal magnetic field data from MDI onboard SoHO.

The multiscalar approach uses wavelet analysis to retain localised spatial information on the energy cascade spectrum. This is vital is viewing which section of the active region may be responsible for driving solar flares in the corona. This figure shows a comparison of the Fourier (crosses) and wavelet (diamond) approaches for one active region example, where the three vertical green lines correspond to the size scales of the three images. We find that locally increased energy spectra are a clear precursor of flaring activity.

The multifractal approach uses the generalised correlation dimensions, including a fuzzy logic approach, to calculate the degree of complexity of active region magnetic fields. It is shown that large, flare productive active region can be characterised as having a broad multifractal spectrum and high degree of fractality during the early stages of their evolution. This is in obvious contrast to the more simple quiet sun, or decaying active regions.

We will use these differing but complimentary approaches on a large dataset to study the predictability of solar flares and make these available in near-realtime on solarmonitor.org. We also wish to extend this to full vector data which will be available from Solar B

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THE DIARAD/VIRGO 1996-2006 DATA RECORD

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The dual cavity differential absolute radiometer DIARAD/VIRGO on SOHO is measuring the Total Solar Irradiance for almost one Solar cycle since 1996. The ageing of the continuously exposed cavity is determined by comparison with the backup one and is as low as 0.8 W/m² over its 10 years lifetime. We present an update of the ageing correction taking into account an accelerated ageing in the last few years. An upper limit of the ageing corrected DIARAD/VIRGO TSI uncertainty is determined by comparison with all other available independent TSI radiometers having at least an overlap with DIARAD/VIRGO, PMO6/VIRGO, ACRIM II, ACRIM III, TIM/SORCE and ERBS. Finally, from these comparisons we determine an upper limit of the uncertainty of the long term TSI trend measured during the last 10 years.

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OBSERVATIONAL EVIDENCE FOR GENTLE AND EXPLOSIVE CHROMOSPHERIC EVAPORATION DURING THE IMPULSIVE PHASE OF SOLAR FLARES.

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Observational evidence for chromospheric evaporation during the impulsive phase of two solar flares is presented using data from the Reuven Ramaty High-Energy Solar Spectroscopic Imager (RHESSI) and the Coronal Diagnostic Spectrometer (CDS) on board SOHO. For the first time, cospatial imaging and spectroscopy have been used to observe both gentle and explosive evaporation processes within HXR emitting regions. For a GOES C9.1 flare, a flux of nonthermal electrons of $\geq 5 \times 10^{9}$ ergs cm^{-2} s^{-1} was found to produce low-velocity upflows of 13±16, 16±18, and 110±58 km s^{-1} in the cool He I and O V emission lines and the 8 MK Fe XIX line, respectively, indicative of gentle evaporation. A GOES M2.2 flare, on the other hand, showed downflows of 36±16 and 43±22 km s^{-1} in the He I and O V lines and high-velocity upflows of 230±38 km s^{-1} in the Fe XIX line, for an electron flux value which is an order of magnitude higher ($\geq 4 \times 10^{10}$ ergs cm^{-2} s^{-1}), indicative of an explosive process. These findings confirm that the dynamic response of the solar atmosphere is sensitively dependent on the flux of incident electrons as predicted by current hydrodynamical simulations.

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OVER-AND-OUT CORONAL MASS EJECTIONS: BLOWOUTS OF MAGNETIC ARCHES BY EJECTIVE FLARES IN ONE FOOT

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Streamer puffs from compact ejective flares in the foot of an outer loop of the magnetic arcade under a streamer were recently identified as a new variety of coronal mass ejection (CME) (Bemporad, Sterling, Moore, & Poletto 2006, ApJ Letters, in press). In the reported examples, the compact flares produced only weak to moderate soft X-ray bursts having peak intensities no stronger than GOES class C3. Here, we present two examples of this type of CME in which the compact flare in the flank of the steamer base is much stronger (one M-class, the other X-class in GOES X-rays) and the resulting streamer puff is wider and brighter than in the discovery examples. Coronal dimming observed in SOHO/EIT Fe XII images in the launching of each of these two CMEs further supports the view that these CMEs are produced by a high loop of the steamer arcade being blown out by magnetoplasma ejecta exploding up the leg of the loop from the flare. In addition, we present evidence that this same type of CME occurs on larger scales than in the above examples. We examine a sequence of flare eruptions seated on the north side of AR 8210 as it rotated across the southern hemisphere in late April and early May 1998. Each flare occurs in synchrony with the launching of a large CME centered on the equator. Coronal dimming in EIT Fe XII images shows the trans-equatorial footprints of these CMEs extending north from the flare site. The set of flare-with-CME events includes the trans-equatorial loop eruptions reported by Khan & Hudson (1998, GRL, 27, 1083). Our observations indicate that these CMEs were not driven by the self-eruption of the trans-equatorial loops, but that these loops were part of a trans-equatorial magnetic arch that was blown open by ejecta from the flares on the north side of AR 8210. Thus, a relatively compact ejective flare can be the driver of a CME that is much larger in lateral extent than the flare and is laterally far offset from the flare. It has previously been thought that such spatial disparities between the flare and the CME prohibited the flare explosion from being the driver of the CME (e.g., Kahler 1992, ARA&A, 30, 113). This work was supported by NASA's Science Mission Directorate through the Solar & Heliospheric Physics SR&T program and the Guest Investigator program of its Heliophysics Division.

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ACCELERATION OF CMES RELATED TO EXPANSION SPEED.

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Acceleration of Coronal Mass Ejections (CMEs) has been modelled analytically and measured from observations. The Solar and Heliospheric observatory (SoHO) has registered around 10000 CMEs since 1996 and the dynamical parameters of them are evaluated and published in the SoHO/LASCO CME Catalogue. These parameters, especially speed and acceleration, are highly influenced by projection effects and the values on the plane of the sky are components of the corresponding real radial values. From the data in the catalogue no patterns for acceleration seem to be present. On the other hand, expansion speed has shown to be a good approximation of CME radial speed occurring on the solar limb and can be evaluated for any other kind of events apart of limb CMEs as well. In this work we evaluated the expansion speed for a group of CMEs and calculate the acceleration related to the radial speed within LASCO-C2 and C3 fields of view. We found most of the events show constant speed in C3 while acceleration is dominant in C2 transit.

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MAGNETIC CLOUDS OF 29-30 OCTOBER 2003 AND 09-10 NOVEMBER 2004: QUATIFICATION OF GLOBAL MAGNITUDES UNDER AN EXPANSIVE MODEL

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The major transient expulsions of magnetized solar mass are the so called Coronal Mass Ejections (CMEs); these appear in the interplanetary medium as magnetic clouds (MCs). CMEs are the most important transient agents that transport magnetic flux and helicity (two magnitudes that are conserved in several solar and interplanetary structures) from the Sun to the interplanetary medium. Thus, studies of solar sources of CMEs and the associated MCs are a key to understand and constrain solar and interplanetary models from the quantification and the comparison of these two magnitudes. MCs are generally modeled, using in situ observations, as rigid helical flux ropes. However, if the velocity profile of a MC presents clear signatures of significant expansion, rigid models do not represent well their structure. We present here the analysis of the magnetic structure of two expanding MCs observed during 2003 and 2004 by the spacecraft Advance Composition Explorer (ACE). We consider a dynamical model, based on a self-similar behaviour for the cloud radial velocity with a free expansion, and a cylindrical linear force-free field (i.e., the Lundquist's field) as the initial condition for its magnetic configuration. We derive theoretical expressions for the magnetic flux across a surface perpendicular to the cloud axis, for the azimuthal magnetic flux, for the magnetic helicity and for the decay of the magnetic energy (the three last magnitudes per unit length along the tube), using this self-similar model. Finally, we compute these magntitudes fitting the free parameters of the expanding model to in situ magnetic observations, and compare them with those obtained from the linear force free static model. Of the two examples discussed here, the one in October 2003 presents a poorer fit between data and model due to its high magnetic complexity. This later MC, originated from active region (AR) 10486 (NOAA number), has been associated to the ejection of the central portion of the filament that lain along the main AR magnetic inversion line. This eruption acompanied the X17 (GOES X-ray class) on 28 October at ~11:01 UT. However, at ~12:00 UT on the same day the southern curved section of the filament started to activate, and a less intense two-ribbon flare ocurred. We present here observations of this second event from the Hα Solar Telescope from Argentina (HASTA) and discuss the magnetic field evolution as observed by the Michelson Doppler Imager (SoHO/MDI). We propose that the very complex magnetic structure of the October cloud is probably due to the overlap of the two solar ejections from AR 10486.

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EFFECT OF THE CORONAL MAGNETIC FIELD ON THE PROPAGATION OF CMES IN THE OUTER CORONA.

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We investigate the role of the magnetic field in confining the CME thermal exchange with the surrounding corona and the mass motion, focusing on a specific event well observed with LASCO, EIT and UVCS on board SoHO. We model the CME propagation as a kinematic perturbation moving upward in the outer corona and, for our purpose, we compare CFD simulations with and without B-field (we consider several B-field intensities and topologies). We find constraints on the coronal B-field (intensity and topology) and explore diagnostics relevant for SoHO.

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FRONT-TO-BACK SIDE ASYMMETRY IN CME BRIGHTNESS

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Coronal mass ejections (CMEs) are detected in coronagraphs by the Thomson scattering of photospheric light off of free electrons in the CME plasma. The brightness of Thomson-scattered light has a rather sensitive dependence on the geometry between the observer and the scattering plasma. The maximum scattering occurs when the CME plasma lies on a spherical surface that intersects both the limb of the Sun and the location of the observer. The shape of this surface of maximum scattering introduces an asymmetry in the brightness of CMEs originating in front of and behind the limb of the Sun. In this paper, we analyze the brightness profiles of halo CMEs detected by the SOHO/LASCO coronagraphs to determine whether this asymmetry can be used as a means of distinguishing front side (Earth-directed) events from back side (anti-Earth-directed) events without independent knowledge of the location of the CME source region.

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3D EVOLUTION OF "DENSITY-DRIVEN'' CME EVENTS

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The shocks in the solar corona and interplanetary space caused by Coronal Mass Ejections (CMEs) are simulated numerically and their structure and evolution is studied in the framework of ideal magnetohydrodynamics (MHD). In an earlier study, the effect of the background wind on the evolution of interplanetary shock waves was investigated, and this in an axi-symmetric configuration (2.5D). The shocks were generated by launching a high density plasma blob in a prescribed direction at a certain speed. We came to the conclusion that the used model for the background wind influenced the shock speed, the shock strength, the spread angle and the mass distribution of the CME. In this study the previous results will be extended to a fully three dimensional (3D) configuration. A 3D plasma blob is launched at the same speed as in the 2.5D case and the preliminary results of the 3D CME evolution will be presented. This study enables us to point out the major differences between 2.5D and 3D simulations and to see if those differences are substantial or not.

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OSCILLATIONS IN A SOLAR FILAMENT: OBSERVATION OF STRONG OSCILLATIONS BEFORE A FILAMENT ERUPTION, INTERPRETATION IN TERMS OF MHD WAVES

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Solar filaments often exhibit oscillatory movements. These oscillations may result in instability, thus causing the ejection of some of the prominence's mass, which contributes to the solar wind. By studying the oscillations that occur inside filaments, we would intend to infer characteristic predicting signatures of CMEs. We present different observations of large amplitude oscillations affecting some filaments before an eruption. The observations were carried out in HeI with CDS (the Coronal Diagnostic Spectrometer) and in Hα with the Sac Peak Observatory, during several hours, with a temporal resolution of less than 1 min. The Fourier analysis of the Doppler velocities in the filaments allows us to detect strong oscillations in both cases. The periods observed are typically 20 min, and the oscillations are quickly damped, in less than one hour. These oscillations are then interpreted in terms of MHD waves.

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TRANSITION REGION LUMINOSITIES DURING THE IMPULSIVE PHASES OF SOLAR FLARES

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During the impulsive phase of a bright solar flare, photons from O VI can scatter off the O VI ions in the corona. From the excess brightness of these lines as detected by UVCS it is possible to derive the luminosity at transition region temperatures during the 10 minutes or so before the CME arrives at the UVCS slit position. These luminosities generally exceed the X-ray luminosities and the heating expected from thermal conduction, but they are smaller than the inferred electron beam energies. We compare the O VI luminosities with RHESSI hard X-ray and gamma ray observations and with models.

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RECONNECTION PROCESS TRIGGERING C-CLASS FLARES IN ACTIVE REGION 8210

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The active region 8210 observed on May 1st 1998 has produced numerous C-class flares. To understand the physical process associated with these eruptive events, we describe the evolution of AR 8210 using a time series of nonlinear force-free equilibriums. We study the time evolution of the magnetic configurations in terms of the storage and the release of magnetic energy, of the change of connectivity and the exchange of magnetic flux between different domains of connectivity, and of the evolution of the topology. It is shown that the release of magnetic energy is consistent with the triggering of C-class flares and is associated with the injection of magnetic energy due to transverse photospheric motions. The study of connectivity and topology changes has evidence magnetic reconnection of field lines close to a separatrix surface. The comparison with observations (Halpha spectroheliograms, EUV and soft X-ray images) is supporting our conclusions.

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A COMPLETE LASCO CME-CATALOG BASED ON AUTOMATED DETECTION

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We present our new CME catalog, a result of the large scale application of our software (CACTus) on the LASCO archive. We recently improved the algorithm and upgraded the test-version of the catalog, available online at www.sidc.be/cactus. The automatic detection of a CME is done in two steps and is applied simultaneously on c2 and c3 running difference images: (1) detection of bright features moving radially outward (2) clustering detections into CMEs. The recent improvements are undertaken in the second step of this process. Unique for our detection method is that we use the condition 'moving radially outward' as part of the detection criterion. The detection itself is done using the stroboscopic method, i.e. in [height,time] slices where height means radial distance from the sun. An outwardly moving feature appears then as a bright ridge, extracted by a modified version of the Hough transform. Per month the output consists of a table containing the CME characteristics and an overview map in a [angle,time]-coordinate system that clearly shows all detected CMEs. As a result of our method we also have for each CME a (linear) speed profile along the angular width of the CME. We studied the characteristics of the CMEs detected with CACTus over the solar cycle and compared them with results obtained from other catalogs. This paper shows that relevant characteristics of CMEs over the solar cycle are successfully recovered with the automated procedure. Recent tests prove that in general automated procedures detect far more small features than human operators do. This can create new possibilities in the small-scale research domain.

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MULTI-SPACECRAFT STUDY OF CMES

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The study of CMEs in the interplanetary medium (ICMEs), by means of in-situ data, represents only a 1D view through a full 3D structure. In this way, important features of ICMEs have to be inferred from models, or simply assumed. Multi-spacecraft studies of CMEs have become an important tool to clarify important features which are not possible to discern by using single datasets.

We have identified a series of ICMEs detected by several spacecrafts (mostly SOHO, ACE and Ulysses). EUV and white light data are used in order to correlate characteristics seen during eruption with those measured in-situ. Multi-spacecraft studies are best suited to help unveil open questions regarding the internal structure of CMEs. In interplanetary space, the charge states of the heavy ions contained in ICMEs are analysed. It is known that these composition data varies depending on the solar wind type and, furthermore, depending on the magnetic structure of the ICME (i.e. magnetic clouds show increased charge states with respect to non-clouds). Since charge states are established early during the eruption process, the combination of in-situ and remote sensing data can provide a link between CME and their interplanetary counterparts. A flux rope model is applied to those ICMEs which present a cloud structure, using data from the different satellites, in order to get a better approximation of what the global structure of magnetic clouds may look like.

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MAGNETIC HELICITY TRANSPORT IN ACTIVE FILAMENTS

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Many filament eruptions can be interpreted in the framework of the kink instability model, although it is not always possible to determine whether the helical flux rope writhes due to new magnetic flux emerging from subphotospheric layers or to horizontal motions occurring in the photosphere. In this work we investigate the emergence of magnetic flux and the photospheric horizontal motions at the filament ends in order to understand how the twisted flux rope is formed. The preliminary analysis of high resolution SOHO/MDI magnetograms shows that a sudden and strong increase in coronal magnetic helicity preceded and accompanied the eruption of some filaments.

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MODELLING OF FAST SOLAR WIND FLOW INTERACTION WITH SLOW DENSE LAYERS.

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Three-dimensional self-consistent MHD simulation is used to monitor the effect of coronal hole flow loading by dense material from a disappearing filament. This is an important mechanism for generation of geo-effective structures in the interplanetary medium. Two originally non-geoeffective pulses can produce a disturbance containing strong negative Bz in its interior.

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MOTION OF TOROIDAL MAGNETIC CLOUDS IN THE SOLAR CORONA AND INNER HELIOSPHERE

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Recently derived formulas for the calculation of the ambient magnetic field around a toroidal magnetic cloud are used to find the diamagnetic force acting on the cloud and the cloud dynamics. The calculated moment of the force provides a way to learn how the orientation of the body changes in time. Our study resulted in three dimensional velocity profiles and trajectories, as well as profiles of angles determining the cloud axis orientation. The method applied in this study is the following: first, the r-component of the magnetic field at r = 2.5 Rs is derived from a spherical harmonic analysis. Next, the field distribution in the entire heliosphere with spiral structure is constructed, consistent with this boundary condition at r = 2.5 Rs and with actual measurements at 1 AU. Then, a toroid is launched at a point obtained from solar observations and the initial size, orientation, and velocity of this toroid is estimated from observational data as well. The motion is governed by three main forces: the diamagnetic force, the drag force, and gravity. Rotation takes place since the minimum energy state corresponds to a situation when the plane of toroid's central circle is along the ambient field.

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A SURVEY OF MAGNETIC HELICITY INJECTION IN SOLAR ACTIVE REGIONS

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Virtually all X-class flares produce a coronal mass ejection (CME), and the average CME carries ~10^42 Mx^2 of magnetic helicity from the Sun. Using magnetograms from the Michelson Doppler Imager on the Solar and Heliospheric Observatory, we surveyed magnetic helicity injection in 48 X-flare producing active regions recorded by the MDI between 1996 July and 2005 July. Magnetic helicity flux was calculated according to the method of Chae (2001) for the 48 X-flaring regions and for 345 non-X-flaring regions. Our survey shows that a necessary condition for the occurrence of an X flare is that the peak helicity flux has a magnitude > 6 x 10^36 Mx^2/s. X-flaring regions also consistently had a higher net helicity change during the ~ 6-day measurement intervals than non-flaring regions. We also found that the time required by most of the X-flare regions to generate the helicity in a CME is a few days to a few hours.

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MAGNETIC SOURCES OF FLARES AND CMES FROM MULTI-WAVELENGTH FLARE STUDIES

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We will present the data analysis of two observation campaigns (October 2002 and October 2003) with the objective of understanding the onset of CMEs. The magnetic field was observed with THEMIS and MDI, the chromosphere with the MSDP operating on the German telecope VTT and on THEMIS, the EUV images with SOHO/CDS and TRACE, the X-rays with RHESSI. We will show how important is the magnetic configuration of the active region to produce CMEs. Two examples of flares will be presented: the 28 Oct 2003 X17 flare and the 20 October 2002 M1.9 flare. The magnetic field analysis of the active regions is done using a linear-force-free field code. The X17 flare gave a halo CME while the M1.9 flare has no corresponding CME. Before the X17 flare there was a pre-flare event which allowed to change the connectivities in a first phase and to relax the stressed field in a second phase producing the X17 flare. A compact twisted emerging flux was responsible of the M1.9 flare, which remains a compact flare due to very tied overlaying loops. RHESSI showed that even during the M1.9 flare both components thermal and non thermal component are present.

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LABORATORY SIMULATIONS OF PLANETARY SURFACES SPACE WEATHERING INDUCED BY SOLAR WIND AND COSMIC IONS

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An ongoing research program performed at our laboratory has the aim to investigate the Visible and near-IR (0.3-2.7 μm) reflectance spectra of materials representative of the surfaces of asteroids and Trans Neptunian objects. Spectra are obtained before, during and after ion irradiation, to simulate space weathering by solar and cosmic ions [1-4]. The studied materials include terrestrial silicates and carbons, meteorites, and frozen ices such as methanol, methane, and benzene. Samples have been irradiated with different ions (H, He, N, Ar) having different energies (from 30 keV to 400 keV). All the irradiated materials have shown important spectral changes, usually reddening and darkening. The spectral slopes of silicatic materials, namely olivine and pyroxene, have been compared, at increasing ion fluence, with those of some S-type near Earth asteroids. We find that formation of vacancies by solar wind ion irradiation is a physical mechanism that can redden their surfaces on a time-scale of about 0.1 Myears, that renders the studied process the most efficient to explain the observed variety of colors. The results obtained for carbon rich frozen ices evidence a strong reddening and darkening of the spectra, and the formation of an organic (C-rich) refractory residue. The spectral colors have been compared with those of some Centaurs and Trans-Neptunian objects; we find that many icy objects in the outer Solar System may have grown an irradiation mantle, produced by cosmic ion irradiation of simple hydrocarbons and/or alcohols, in time-scales of 100 Myr.

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WIDE AND NARROW CMES AND THEIR SOURCE EXPLOSIONS OBSERVED AT THE SPRING 2003 SOHO-SUN-ULYSSES QUADRATURE

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At the time of the spring 2003 Ulysses-SOHO-Sun quadrature, Ulysses was off the East limb of the Sun at 14.5 degrees north latitude and 4.91 AU. LASCO/C2 images show small transient events that originated from near the limb on May 25, 26 and 27 in the north-east quadrant, along with a large Coronal Mass Ejection (CME) that originated from an active region near disk center on May 26. Ulysses data bear clear signatures of the large CME, specifically including an enhanced abundance of highly ionized Fe.

SOHO/UVCS spectra at 1.75 solar radii, near the radial direction to Ulysses, give no evidence of emission from high temperature lines, even for the large CME: instead, for the small events, occasional transient high emission in cool lines was observed, such as the CIII 977 Angstrom line usually absent at coronal levels. Each of these events lasted ca. 1 hour or less and never affected lines from ions forming above ca. 10^6K. Compact eruptions in Helium 304 Angstrom EIT images, related to the small UVCS transients, were observed at the limb of the Sun over the same period. At least one of these surge events produced a narrow CME observed in LASCO/C2. Most probably all these events are compact magnetic explosions (surges/jets, from around a small island of included polarity) which ejected cool material from lower levels. Ulysses data have been analyzed to find evidence of the cool, narrow CME events, but none or little was found.

This puzzling scenario, where events seen by UVCS have no *in situ* counterparts and *vice versa*, can be partially explained once the region where the large CME originated is recognized as being at the center of the solar disk so that the CME material was actually much further from the Sun than the 1.7 Rsun height of the UVCS slit off the limb. Conversely, the narrow events may simply have missed Ulysses or been too brief for reliable signatures in composition and ionization state.

A basic feature demonstrated by these observations is that large magnetic explosions produce wide-angle CMEs whereas compact magnetic explosions produce narrow CMEs. The results show that quadrature observations need some luck to be successfull: that is, events must be in the plane of the sky to allow SOHO/UVCS and Ulysses to sample the same plasma. This will most easily occur in winter 2007 and winter 2008, when the quadrature geometry will allow for prolonged observations.

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MODELING OF CMES WITH SOHO DATA

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We present a forward modeling technique of CME observed with SOHO-LASCO. Based on the work of Cremades and Bothmer (A&A 2004), we show how by using multiple instruments (MDI, Hα , EIT, LASCO) we were able to fit a CME electron density model to the LASCO data using the assumption of self similar expansion. For this technique a synthetic image of either total or polarized brightness is computed from an assumed electron density model. The model we defined and used is an empirical model of flux rope: the graduated cylindrical shell (GCS). Using that technique, we studied a large set of events and verify the level of validity of the self similar expansion assumption. We will discuss also how we fit locally the electron density in the CME leading edge.

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WHAT HAVE WE LEARNED FROM 200 EIT WAVES?

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EIT waves are phenomena named for the instrument that first observed them. They generally are transient brightenings which propagate over a wide range of distances with speeds of 50-600 km/sec. However, these speeds are only relevant for the inner corona represented by the 195 Angstrom emission; it is generally agreed that the propagating disturbance observed by the EIT is merely the lower portion of an inhomogeneous three-dimensional disturbance.

A number of heliospheric phenomena, namely shocks and energetic particle events, are found to have associations with EIT waves. However, most of the observations with the EIT are only relevant in diagnosing the evolution of the "closed field line" corona, while most heliospheric phenomena deal with access to open field lines. An understanding of the three-dimensional nature of EIT waves, and their connection to the large-scale coronal and heliospheric structure is absolutely necessary if we are to make the complete connection between EIT waves, CMEs, shocks, and other Earth-impacting phenomena.

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A UNIFIED MODEL FOR SLOW AND FAST CORONAL MASS EJECTIONS

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Coronal mass ejections (CMEs) show a wide range of rise velocities, ranging from about 50 km/s to more than 2500 km/s. It has been proposed before and early in the SOHO mission that there are two classes of CMEs, slow and fast CMEs. Typically, slow CMEs were found to possess velocities < 600 km/s, to show nearly constant acceleration within the whole LASCO field of view (2-30 solar radii), to originate from prominence eruptions outside active regions, and not to be accompanied by strong flares. The typical properties of fast CMEs are: velocities > 750 km/s, no or slightly negative acceleration in LASCO's field of view, origin in active regions, and association with significant flare activity. However, the concept of two CME classes may not be valid, since the significantly enlarged data set of nearly a decade of SOHO observations now available does not show two distinct peaks in the CME velocity distribution and reveals that both slow and fast CMEs can be accompanied by both weak and strong flare activity. We show that a flux-rope CME model permits describing slow and fast CMEs in a unified manner. We consider a force-free coronal magnetic flux rope embedded in the potential field of model bipolar and quadrupolar active regions. The eruption is driven by an ideal MHD instability, which we refer to as the torus instability and which occurs if the field overlying the flux rope decreases sufficiently rapidly with height. The acceleration profile depends on the steepness of this field decrease, corresponding to fast CMEs for rapid decrease (as is typical of active regions) and to slow CMEs for moderate decrease (as is typical of the quiet Sun). Quadrupolar active regions lead to the fastest CMEs. A simple analytical description of the instability is confirmed by numerical simulations that are performed for a range of magnetic field height profiles.

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MULTI-WAVELENGTH INVESTIGATION OF A SIGMOIDAL ACTIVE REGION AR 8059

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An isolated active region (AR 8059) was tracked from the east to the west limb over a period of 6 days (July 3-8, 1997) in order to study its evolution. This region was observed during the rising phase of solar activity. The observations are taken from SXT (Soft X-ray Telescope) aboard Yohkoh, CDS (Coronal Diagnostic Spectrometer), EIT (Extreme-ultraviolet Imaging Telescope) and MDI Michelson Doppler Imager) aboard SoHO (Solar and Heliospheric Observatory). The active region showed a clear "sigmoid" shape in the CDS Fe XVI and Si XII lines, and -SXT images. The sigmoidal shape is also evident in the EIT images taken at 195 Å. In this study we analyse the evolution of the photospheric magnetic field magnetic field and its effects on the coronal structures and activity. Moreover, we investigate the variations of physical parameters such as density and temperature, based on line ratio techniques using the CDS data, in specific areas in the active region.

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SOHO/EIT OBSERVATION OF A BRIGHT CORONAL DOWNFLOW

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A distinct 'bright' coronal downflow was discovered on 05-Mar-2000 by the Extreme-ultraviolet Imaging Telescope (EIT) at 195 Å after a filament eruption associated coronal mass ejection (CME). The prominence seen by EIT was tracked into the LASCO (Large Angle Spectrometric Coronagraph) C2 and C3 field of view (FOV) where it developed as the core of a typical three-part CME. The downflow was only seen in the EIT FOV and had an onset time coinciding with the deceleration phase of the core of the CME. The downflow showed a rapid acceleration followed by strong deceleration. The downflow followed a curved path which may be explained by material following the apex of contracting magnetic loops sliding down along other field lines, although other explanations are possible. In any case, this observation supports the pinching off of the field lines drawn-out by erupting prominences followed by the contraction of the arcade formed by the reconnection.

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SOHO OBSERVATIONS OF CME-DRIVEN SHOCK AND EIT WAVES

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We report an observation of a CME-driven shock wave on 05-March-2000 based on the Large Angle Spectrometric Coronagraph (LASCO) and the UltraViolet Coronagraph Spectrometer (UVCS) onboard the SOlar and Heliospheric Observatory (SOHO). The CME was first observed in the LASCO/C2 data at 17:06 UT with a speed (projected on the plane of the sky) of about 860 km/s. Visual evidences for the shock waves is shown based on the propagation of the kink along a streamer belt where no CME-material is present to cause such an effect. Moreover, large Doppler shifts and signature of plasma heating are also observed based on the UVCS data. Interestingly, on-disk waves are also observed in EIT images. We present preliminary results on the relationship of these different phenomena observed by the different instruments onboard SOHO.

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THE MAGNETO-FRICTIONAL METHOD FOR MAGNETIC FIELD EXTRAPOLATIONS

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The understanding of the instability mechanisms, and therefore the forecast, of coronal mass ejections and flares requires a detailed knowledge of the coronal magnetic field structure, which is impossible to obtain by direct measurements. The numerical calculation of coronal magnetic fields from boundary data (vector magnetograms) is then the only available technique that can provide the missing information about the magnetic field in the critical volume. In our code, the calculation of the coronal field is performed by modifying an initially potential field into a nonlinear force-free field, with the vector magnetogram as photospheric boundary condition, by means of magnetohydrodynamic relaxation techniques. We present extrapolations from magnetograms of both theoretical models and measurements. Among the former, solar-relevant magnetic equilibria containing flux ropes are considered as test cases. Test cases offer the possibility of assessing the reconstruction quality of the method quantitatively, without any influence of magnetogram errors. We show that our implementation of the magneto-frictional method can reconstruct force-free magnetic fields to a very high degree of accuracy, despite the fact that information about the nonlinear field is limited to one boundary only. The code can now also extrapolate measured magnetograms into a sufficiently relaxed force-free field, which allows for comparing models of solar eruptions with real measurements. However, the generally complex magnetic field topology as well as errors and inconsistencies in the magnetogram make the extrapolation task more challenging in this case. As an example, we present a successful extrapolation of a measured magnetogram. The obtained magnetic field structure is discussed, together with the influence of small-scale structures and possible inconsistencies (e.g. the so-called 180-degree ambiguity) on the reconstructed field.

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INTERPLANETARY MAGNETIC CLOUDS OF 2000-2005.

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In recent years we proposed various new solutions of magnetic flux rope configuration as models for magnetic clouds: symmetric and asymmetric ones, force-free with constant and variable alpha, non-force-free, cylindrical with circular and elliptic cross-sections, toroidal, etc. In this study we analyze the most clear clouds of the period 2000-2005, for which general parameters for each suitable model are found and intercompared.

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04 Space Weather and Space Climate: Flares, CMSs and Energetic Particles

A TURBULENCE MODEL FOR ACCELERATION OF THE HIGH LATITUDE FAST SOLAR WIND

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Observations such as Spartan and SOHO UVCS have challenged ideas for the acceleration of the solar wind by constraining models to produce >1.5 Million K protons, several hundred km/s radial outflows, and >700 km/s terminal speeds in the wind emanating from polar coronal holes, with coronal electrons remaining cooler than protons. Observed properties of the solar wind at 1AU and by Ulysses provide additional constraints on these models.

It was recognized some time ago [e.g., 1] that these conditions probably require adding internal energy in sufficient quantities at altitudes <1.5 Rsun, but the origin of this energy and its method of transport and conversion to heat have remained unclear. The involvement of turbulence in this process was suggested some time ago [2], but various issues regarding the physics of cascade and dissipation have persisted [e.g., 3] so that a wind model consistent with magnetohydrodynamic theories of turbulence, including the physics of low frequency anisotropic cascade, has not been presented until now.

Here we present preliminary results from a study of solar wind acceleration which, though simplified in its treatment of expansion, correlation scale, and dynamics, incorporates important features of the turbulent cascade. Combining a simple turbulence closure model [4] with a one-dimensional model of a coronal hole, the model solves the continuity equation, momentum equation with ponderomotive force due to turbulence, an internal energy equation with turbulent dissipation, and the turbulence closure equations for upward- and downward-propagating low frequency turbulence amplitudes. The results shown here are promising, with wind accelerating in the lower corona, and attaining reasonable terminal speeds, densities and temperatures. In addition, the turbulence amplitude, at the base and at 1AU, are compatible with known observational constraints.

[1] S. R. Habbal et al, GRL 22, 1465 (1995), J. F. McKenzie et al, Astron. Astrophys., 303, L45 (1995) [2] P. A. Coleman, Astrophys.J., 153, 371 (1968), J. V. Hollweg, Geophys. Res., 91, 411 (1986), Velli A&A, 270, 304-314 (1993), W. H. Matthaeus et al, Astrophys. J., 523 L93 (1999) [3] Velli Grappin Mangeney, PRL, 70, 14 (1993), W. H. Matthaeus et al, Nonlinear Proc. Geophys, 101, 93 (2003) [4] P. Dmitruk et al, Astrophys. J., 548 482 (2001)

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04 Space Weather and Space Climate: Flares, CMSs and Energetic Particles

HELIUM LINE FORMATION DURING THE DECAY PHASE OF A SMALL TWO-RIBBON FLARE

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During a coordinated campaign (SOHO JOP 139) which took place in May 2001, a small C-class flare was observed both with SOHO instruments and with the Dunn Solar Telescope of the National Solar Observatory at Sacramento Peak. Data for helium line formation in the active region prior to the flare have been analyzed and discussed by Mauas et al. (2005), while some dynamical aspects of earlier phases of the flare have been discussed by Teriaca et al. (2003). Here we show results of the analysis extended to the decaying phase of the flare. In addition to the construction of semiempirical models of the chromosphere and low transition region, we discuss also the possibility of obtaining an estimate of ambient abundance of helium during a flare.

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MAGNETOHYDRODYNAMIC INTERPRETATION OF SOHO/LASCO/EIT/MDI OBSERVATIONS FOR THE UNDERSTANDING OF THE INITIATION AND PROPAGATION OF CORONAL MASS EJECTIONS (CMES)

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This paper consists of two parts:

(i) Summarize our MHD simulation results for the understanding the LASCO/EIT observations. These results include the disconnected event (July 28-29, 1996), plasma blob event (April 30, 1996), LASCO shocks, (April 2, 1999), EIT waves (May 12, 1997) and Sun-Earth connection event (January 6-12, 1997). All these studies did not pay enough attention to the source region of the observed CMEs.

(ii) Utilization of a recently developed three-dimensional active region data driven model together with SOHO/LASCO/EIT/MDI observation to investigate the source region of a CME. Specifically, the NOAA/AR8100, Oct 31 – Nov 4, 1997 is used to illustrate this comprehensive study. The results show the build-up of the non-potential field parameters through the magnetic flux emergence could lead to the initiation of a CME.

On the basis of these studies, we suggest that the use of sequential observations, from the photosphere through the chromosphere to the corona, as inputs to the model, is necessary to understand the physics of CME initiation and propagation which could be used for development of a space weather forecasting model.

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THE APPLICATION OF RIDGET AND CURVELET TRANSFORMS TO SOLAR IMAGE DATA

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Wavelets have been very successfully used as a tool for noise reduction and general processing of images. Despite this, wavelets have inherent limitations with 2-D data. Wavelets are well suited for describing point singularities but much of the interesting information in images is described by edges, lines or curves. Newly developed multiscale transforms address some of these issues. The ridgelet transform takes the multiscale concept of wavelets but applies it to 1-D objects (lines) instead of 0-D objects (points). The curvelet transform likewise applies to multiscale curves. We present a preliminary study of the use of these new multiscale transforms with solar image data.

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SOHO/EIT OBSERVATIONS OF CMES

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Coronal Mass Ejections (CMEs) are traditionally observed by white-light coronagraphs. However, ten years of SOHO observations have demonstrated that EIT can well observe the initiation stage of the most of frontside CMEs detected by LASCO. The restructuring of the corona above the limb allows us to see even the origin of some of backside CMEs. ''CME Watch'' data series (one image every 12 minutes) taken in any of the four EIT bandpasses is well suited for the detection of low corona CME counterparts. They are better observed in hotter channels (195, 171, 284 A), but the 304 A channel is also appropriate. EIT detects the CME signatures that were known before (coronal dimmings, post-eruption arcades, prominence/filament eruptions, restructuring at the limb). It had also discovered a new CME-associated phenomenon - EIT waves. It is rare that a CME has all of these signatures. It appears that coronal dimmings are the most frequent CME counterparts. The identification of CME source regions by EIT also helps to determine CME geoeffectiveness. A complete physical picture including all these phenomena observed by EIT is not yet established. Main questions that still remain unanswered are discussed.

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HIGH ENERGY PARTICLE TRANSPORT IN STOCHASTIC MAGNETIC FIELDS IN SOLAR CORONL LOOPS

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We study particle transport in the solar corona in the presence of magnetic fluctuations by analysing the motion of particles injected at the center of a model coronal loop. We perform numerical simulations by varying the turbulence correlation length l_c, the turbulence level, and the particle energy. For large l_c, the ratio between the Larmor radius and turbulence wavelength is small, and the magnetic moment is conserved. In this case, a fraction of the injected particles, which grows with the fluctuation level, is trapped by magnetic mirroring at the top of the magnetic loop near the injection region. The rest of the particles propagates freely along $\vec B$, corresponding to ballistic transport. Decreasing l_c, that is increasing the ratio ρ/λ, the magnetic moment is no more well conserved, and pitch angle diffusion progressively sets in. Pitch angle diffusion leads to a decrease of the trapped population and changes progressively their characteristics from ballistic to superdiffusive, and finally, for small l_c, to diffusive. We point that particle dynamics inside the magnetic loop is never Gaussian and the statistical description of transport properties in stochastic magnetic fields in the solar corona requires the use of such ideas like L\'{e}vy random walk, and long range correlations.

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04 Space Weather and Space Climate: Flares, CMSs and Energetic Particles

CORRELATION BETWEEN FLARES, ENERGETIC PARTICLE PROPAGATION IN SOLAR WIND TURBULENCE, AND THE ANGULAR SIZE OF CORONAL MASS EJECTIONS

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Solar energetic particle (SEP) events are often associated with solar flares. Such particles propagate through the interplanetary medium, where significant levels of magnetic turbulence are found. We study the magnetic connection from the Earth to the solar corona in three dimensional magnetic turbulence. In the numerical simulation, different turbulence levels and solar wind velocities can be used. Input to the simulation is from web-based data sets, and comparison is made with the solar flare observations contained in the Goes catalogue for the years 1996, 1997, 1998, following solar minimum. For this data set, we find that SEPs can reach the Earth when the difference in the heliographic longitudes of the flare and of the magnetic foot point of the Earth is 25°--30° at most. On the other hand the longitudinal angular semi-width of the magnetic field line random walk in the solar wind, when mapped to the solar corona, is found to be typically 6°--10°. The discrepancy between the two values can be explained either by the presence of a flare - associated coronal mass ejection shock, with a longitudinal semi-size of $\sim 20^\circ$, or by the presence of magnetic shear between the fast and the slow streams which enhances the longitudinal spread of field lines.

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SUPER-RADIAL EXPANSION OF THE FAST SOLAR WIND: RESULTS FROM CO-ORDINATED SOHO|LASCO AND RADIO SCINTILLATION OBSERVATIONS

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Co-ordinated SoHO|LASCO and radio scintillation observations from the EISCAT and MERLIN systems have been used to investigate the large-scale structure of the fast solar wind at heliocentric distances from 2.5 to 85 solar radii. The results provide clear evidence for equatorwards over-expansion of the fast solar wind at interplanetary distances. In this poster we present these results and discuss possible explanations.

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ABSOLUTE ACCURACY AND IN-FLIGHT VERIFICATION OF THE DIARAD/VIRGO TOTAL SOLAR IRRADIANCE

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Absolute accuracy and in-flight verification of the DIARAD/VIRGO Total Solar Irradiance S. Dewitte, S. Mekaoui A recent controversy has arisen around the absolute accuracy of Total Solar Irradiance (TSI) measurements. While all other TSI instruments agree to each other within their stated accuracy of the order of +/- 1 W/m², the TIM/SORCE instrument - with stated better accuracy - differs by about 5 W/m². This unexplained difference has triggered a critival review of the absolute accuracy of all TSI instruments; in this paper we present the results for the DIARAD/VIRGO instrument on SOHO. We review the different parameters that influence the absolute accuracy and summarise the uncertainties from their pre-flight on-ground characterisation. We also present the results of some non standard measurement modes proper to the DIARAD/VIRGO side by side cavity radiometer, which are used in-flight to verify some of these parameters.

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SOLAR WIND COMPOSITIONAL DATA FROM METALLIC GLASS FLOWN ON GENESIS

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Element- and isotope abundances in the solar atmosphere provide the baseline to compare the composition of matter in the solar system. Of particular importance for cosmochemistry are precise isotopic ratios of volatile elements, as these values cannot be inferred from, e.g., the analysis of meteorites. This is the main goal of NASAs Genesis mission, which sampled the solar wind (SW) for 887 days at the Lagrange point L1. The technique of Genesis, to trap SW ions in passive targets, has already been applied with the Solar Wind Composition (SWC) experiment at the occasion of the Apollo lunar missions. The main improvement of Genesis is its extended exposure time, the use of a wide variety of target materials and the possibility to sample different SW regimes separately. The various regimes are known to differ in their elemental abundances (FIP-effect) and possibly also in their isotopic composition. Thus, another goal of Genesis is to constrain compositional variations for different regimes. A further topic of investigation is an isotopically heavy component which appears to be present in lunar soil grains. The search for this putative high-energy component, dubbed SEP, was the main reason for selecting a metallic glass target, of which first results are presented here. We report on mass spectrometrical He and Ne measurements from the metallic glass, which sampled the bulk SW during the entire exposure time of Genesis. Isotopic as well as elemental ratios and abundances for the bulk SW differ only slightly from values as reported from the SWC experiments. However, regarding the relatively large variation of the individual SWC foil data, results from both experiments are consistent within uncertainties. Depth- and thus energy-dependent data show varying isotopic ratios, with a trend becoming isotopically heavier with increasing implantation depth. Depth profiles of isotopes modelled by the SRIM ion implantation code using constant isotopic ratios, independent of SW speed, fit the experimental data very well. The model explains the fractionation from a lighter isotopic composition in shallow depth to a heavier one at larger depths as a function of slightly different penetration ranges due to the different isotope masses. According to SRIM, the gas released from greatest depth would have had an implantation energy of about ~3 keV/amu or a velocity of ~770 km/s respectively. This is just below the maximum SW velocity of ~850 km/s measured with the Genesis ion monitor. The comparison of experimental data and SRIM model suggests that the isotopically heaviest composition can be explained by a uniform SW that undergoes fractionation within the target while being implanted. In this case the putative SEP component would have remained in the metallic glass as a small, not measurable fraction. The question whether the SEP component is isotopically heavier than the SW therefore still keeps open. Measurements of samples with a larger surface containing a larger amount of high-energy ions are in progress to tackle this problem.

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JOVIAN ELECTRONS IN THE THREE DIMENSIONAL HELIOSPHERE

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One of the fundamental problems in modern astrophysics is the propagation of cosmic rays in turbulent magnetic fields, which can be studied by way of in-situ measurements of energetic particles in the heliosphere. Between 1 and 10 AU Jovian, and galactic particles contribute continuously to the few-MeV electron intensities. As a result of this a 13 month period in the MeV electron intensity time profiles is observed at Earth. During it's recent approach to low latitudes the Ulysses spacecraft approached the planet Jupiter within 1~AU. 3-20~MeV electrons were measured by the Kiel Electron Telescope (KET) on-board Ulysses from 1990 to 2006. At solar maximum Jovian electrons could unambiguously be identified at heliographic latitudes beyond 40 degree N and ~10 AU from the planet. In this contribution we will present results of an analysis of Ulysses KET MeV electron measurements from the recent third out-off ecliptic path and compare these data with observations obtained in 1992 to 1994 when the spacecraft was leaving the planet. In order to interpret the Ulysses data set, it is necessary to investigate the time history at Earth by using the SOHO EPHIN data and compare with results from sophisticated transport models.

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ONE DECADE OF OBSERVATIONS OF ENERGETIC NEUTRAL ATOMS WITH SOHO/CELIAS/HSTOF AND THEIR IMPLICATIONS ON MODELING THE HELIOSPHERE

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Since 1996, energetic hydrogen and helium atoms (ENAs) have been identified and their fluxes are monitored by the High-Energy Suprathermal Time-of-Flight sensor (HSTOF) of the Charge, Element, and Isotope Analysis System (CELIAS) on the Solar and Heliospheric Observatory (SOHO) near the Lagrangian point L1. Potential sources of ENAs in the heliosphere are CIRs, solar energetic particle events, pre-accelerated pickup ions as well as low-energy (up to few hundred keV) anomalous cosmic ray (ACR) ions in the outer heliosphere, close to and beyond the solar wind termination shock. ENAs, neutralized via charge transfer reactions, can penetrate into the inner solar system, unaffected by the interplanetary magnetic field. The observed ENA fluxes set limits on potential theories of the dominant sources of the energetic neutral atoms and we discuss the implications of the ENA observations on models of the outer heliosphere.

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SUNGRAZING AND SUNSKIRTING COMETS DISCOVERED WITH THE LASCO CORONAGRAPHS

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After ten years of operation, the LASCO-C2 and C3 coronagraphs have detected over 1000 comets. A large fraction belongs to the Kreutz family of Sungrazing comets but LASCO has discovered a new family, the Sunskirting comets which approach the Sun to 6.5-12Rs and survive their perihelion passage, contrary to the Sungrazers. We discuss the distribution of orbital elements of these families, addressing in particular the question of the existence of distinct groups in these families. We report on our on-going effort to perform the photometry of all detected comets. Examples of light curves will be presented and characterized. The distributions of peak magnitudes will be shown to be typical of each group of comets and to offer an estimate of the distribution of the mass of the nuclei.

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6 The SOHO Roller-Coaster: Mission History and Personal Memories

10 YEARS OF SOHO DATA INFRASTRUCTURE

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We describe the current SOHO data infrastructure, both software and hardware, and its evolution during the 10 years the mission has been flying. Special attention is given to the current SOHO archive serving science data, and the plans for developing it further in the future, in particular to provide additional data products and capabilities to the scientific community.

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06 The SOHO Roller-Coaster: Mission History and Personal Memories

PLANNING OF EIT AND LASCO OBSERVATIONS

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The four telescopes that comprise the EIT and LASCO instrument complement are controlled by a single on-board computer. After the SOHO launch, the original concept for the operation of the EIT and LASCO instruments evolved and they received an additional telemetry allocation. This has resulted in almost one million images being taken. The operation of the EIT and the LASCO/C1 were much more involved than the LASCO/C2 and C3. A planning tool was developed to help plan the observations, reducing the load on the operations staff, which was significantly reduced by generating one-hour schedule blocks. These blocks included several synoptic programs with varying amounts of telemetry available for special observations such as for supporting JOPs. Other special observations include periodic calibration and CCD "bake-outs".

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From SOHO to ILWS and Beyond: Visions for Solar Research from Space

THE HELIOSEISMIC AND MAGNETIC IMAGER - THE NEXT SOLAR CYCLE

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The Michelson Doppler Imager (MDI) instrument has been making helioseismic and magnetic field observation of the Sun for most of solar cycle 23. In order to continue these important measurements from space into the next solar cycle, the Helioseismic and Magnetic Imager (HMI) instrument is being prepared for launch in the fall of 2008 aboard the Solar Dynamics Observatory (SDO) spacecraft. The HMI instrument is an evolution of the successful MDI design with key improvements in resolution, image cadence and vector magnetic field measurement capabilities. Measurements of the Fe I spectral line at 617.3 nm with the HMI tunable narrow band filter determine motions of the solar photosphere to study solar oscillations. Measurements of the polarization in this same spectral line enable determination of all three components of the photospheric magnetic field. The primary goal of the HMI investigation is to study the origin of solar variability and to characterize and understand the Sun's interior and the various components of magnetic activity. An overview of the HMI science goals, the HMI instrument and its expected performance, and the science data products will be presented. See: http://hmi.stanford.edu for more information.

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07 From SOHO to ILWS and Beyond: Visions for Solar Research from Space

NEED FOR THE CONTINUATION OF THE LONG TERM TOTAL SOLAR IRRADIANCE DATA RECORD.

Dewitte, Steven
RMIB

Need for the continuation of the long term Total Solar Irradiance data record. S. Dewitte The most likely mechanism for an influence of changes in the sun on the climate of the earth is through long term variations of the Total Solar Irradiance causing a relative heating or cooling of the earth. The benchmark for understanding this mechanism is to provide a quantitative explanation for the estimated temperature increase from the little ice age in Europe around 1700 - corresponding to the solar Maunder minimum - up to the 19th century. We need a historical reconstruction of the long term TSI variations, and as a constraint to this reconstruction with need 'recent' TSI measurements with good stability. Good stability is to be obtained from a combination of low instrument drift and long lifetime. With the VIRGO/SOHO radiometers we have an unprecedented demonstrated stability of 0.2 W/m^{2}decade, which however still is lower then the required limit of 0.1 W/m^{2}decade which is needed for a direct measurement of the long term TSI trend. Therefore a continuation of the Total Solar Irradiance measurements on future solar missions, e.g. Solar Orbiter, remains needed to reach the 0.1 W/m^{2}decade stability limit.

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A FUTURE FOR DOPPLER DIMMING

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An important new diagnostic technique was introduced into the SOHO instrument payload by the UVCS instrument team. This involves the measurement of the reduction of intensity of a resonance scattered spectral line due to the Doppler shift between the source and the moving scattering region. This potentially invaluable diagnostic for the solar wind, which measures for the first time Doppler velocities transverse to the line-of-sight, is however subject to some difficulties. Not only the outflow velocity, but other physical quantities influence the measurements. This was long known and it was always understood that the interpretation would be "model-dependent". Early measurements from UVCS were immediately useful in fixing a contour of outflow velocities around 100 km/s, and thereby putting important constraints on the acceleration. Other different measurements from the same observations, those of the profiles of the scattered spectral lines, were of more dramatic interest and have become recognised as one of the outstanding discoveries to come from SOHO. However these are not concerned directly with Doppler Dimming and are not what I want to discuss here. As far as the actual Doppler Dimming measurement is concerned, its ability to measure outflow velocities as a function of distance has been rather disappointing. What are the limitations that lead to this? Let us consider the measurement of the intensity ratio of the oxygen VI multiplet at 1032 A, which is by far the most useful spectral feature. Although many local plasma parameters influence this ratio, they are mostly second order effects, with the exception of the electron density, and of course the outflow rate. Inevitable uncertainties in electron density lead to quite unacceptable uncertainties in the outflow velocity. With UVCS measurements limited to beyond 1.4 Ro there is no easy solution to this difficulty, except in the magic region around 100 km/s, where the density sensitivity miraculously vanishes. However, in recent years, there have been a number of efforts to add SUMER observations of the oxygen VI multiplet to the UVCS data (Patsourakos, Teriaca, Gabriel, etc). Although the availability of suitable joint data sets is limited, it is now clear that extending these measurements closer to 1 Ro, provides a sort of "calibration" for the local electron density. This "calibration" can be extended to all heights as long as we make some assumptions regarding flux tubes and conservation of flow. This remains "model-dependence", but in a more physically accessible regime. So, why does Doppler Dimming fail to feature in the payloads of any of our future major solar projects? Largely because we have been slow to realise the potential of the recent advances. What is needed is the measurement of the oxygen VI multiplet intensity ratio, over a range of off-limb heights, from the limb outwards; - no intensity calibration, only relative intensities over the 6 A that separates the two lines, a relatively simple task; - too late for STEREO and SDO ! but perhaps not for the Solar Orbiter, where the current baseline EUS instrument could be optimised to achieve this objective.

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TOPOLOGICAL TECHNIQUES FOR ANALYSING MAGNETIC FIELD DATA

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The next generation of solar telescopes will quickly produce a huge quantity of high-quality magnetogram data requiring analysis. Realistic magnetic fieldline extrapolations (e.g. nonlinear force-free) are useful but can be overcrowded and difficult to interpret, as well as time consuming. Focussing on the magnetic topology is an elegant way to pick out the key features of the structure and connectivity of the magnetic fieldlines. This technique allows easy and clear visualisation of 3D magnetic structures in the solar atmosphere, highlighting the important regions where dynamical and energetic processes will be concentrated. A new topological code currently being developed at St Andrews will enable the construction of the magnetic field topology from observational or computational magnetic field measurements, providing a new way of understanding both observational data and results from numerical (MHD) simulations.

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HELAS - EUROPEAN HELIO- AND ASTEROSEISMOLOGY NETWORK

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The Helio- and Asteroseismology Network (HELAS) is a Coordinated Action funded by the FP6-Infrastructure-Programme of the European Commission. Currently, HELAS consists of the following ten members: - Kiepenheuer-Institut für Sonnenphysik, Germany (Co-ordinator of the network) - Instituto de Astrofísica de Canarias, Spain - University of Sheffield, United Kingdom - Institut for Fysik og Astronomi, Denmark - Centro de Astrofísica, Portugal - Max-Planck Institut für Sonnensystemforschung, Germany - Istituto Nazionale di Astrofisica, Italy - Instituut voor Sterrenkunde KULeuven, Belgium - Instytut Astronomiczny Uniwersytet Wroclaswki, Poland - Observatoire de Côte d'Azur, France, The objective of HELAS is to co-ordinate European activities in helio- and asteroseismology. HELAS will transfer knowledge and data analysis techniques, and will prepare the European research community for important missions in the immediate future, e.g. the NASA space mission Solar Dynamics Observatory (SDO), the CNES missions COROT (Convection, Rotation & planetary Transits) and PICARD, and the ESA mission Solar Orbiter. Moreover HELAS will embed many of the activities of the European Network of Excellence in Asteroseismology (ENEAS), and will help organizing coordinated asteroseismic observations. HELAS will combine the core competences of the individual research groups through its six network activities in order to - ensure European competence and competiviness in this research area by spreading expertise, - enhance the synergy between helio- and asteroseismology, - improve the public understanding and interest in solar and stellar physics. These objectives shall be achieved by organizing workshops of smaller group within the individual network activities, by organising annual conferences for the international audience, and by providing a common platform for the exchange of data and software among the participants.

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NUMBER OF EIT BRIGHT POINTS OVER THE SOHO MISSION

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Coronal Bright Points (CBP) were discovered on the very first x-ray images of the Sun from a sounding rocket. Later, their properties were extensively studied using observations from Skylab, as well as occasional data from several sounding rocket experiments. Results of these sporadic observations prompted J.Davis (Sol.Phys. 88, 337, 1983) to suggest the existence of a secondary cycle of magnetic activity running in opposite phase to the sunspot cycle. We applied the same technique and criteria as Davis to the Yohkoh data to study the variation of X-ray bright points number between 1992 and 2000. In addition we employed full-dick longitudinal magnetograms from the National Solar Observatory at Kitt Peak. The number of bright points in Sattarov et al (ApJ, 2002, 564, 1042) data showed clear cyclic variations, while the number of magnetic bipoles with particular size and separation did not show such variations. In this report we present a cycle variation number of CBP at different latitudes over the SoHO mission. We apply an automatic procedure to identify CBP to the EIT/SoHO 195 Å data taken from 1996-2006.

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DEVELOPMENT OF AN SI TRACEABLE ABSOLUTE RADIOMETER FOR SPACE AND GROUND-BASED USE

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Absolute radiometers with a phase-sensitive signal analysis are already being used in space successfully (Total Irradiance Monitor TIM, Lawrence et al. (2000)). They represent state-of-the art technology for measuring solar irradiance. However, because of constructional (size) and operational limitations (vacuum operation only; low cadence) they cannot be calibrated against either the World Radiometric Reference (WRR) or SI primary standards (cryogenic radiometers). Hence they define their own scale of total irradiance (WMO/CIMO guide). The rather large difference between the absolute scales of the TIM and WRR-calibrated classical radiometers in space clearly demonstrates this major drawback of current phase-sensitive absolute radiometers.On the other hand, although classical radiometers are calibrated against the WRR (but not strictly traceable to SI) they are outperformed by the phase-sensitive instruments in terms of noise level. We will present the progress of our current project to combine the best of both worlds in a phase-sensitive radiometer of small size that can be used in either air or vacuum. Moreover, this new instrument will be calibrated against both the WRR and SI standards before being sent to space. The technical problems that have to be overcome include finding a trade-off between thermal capacity and high shutter cadence. Phase-sensitive radiometers usually have a large thermal capacity and are therefore operated with a relatively low shutter frequency of 0.01 Hz, which makes them insensitive to short-term variations and thus unsuitable for ground-based solar observations. The aim of this project is to develop a radiometer with a relatively small cavity and thermal capacity, which is based on a phase-sensitive signal analysis. We will establish a connection between the advantages of phase-sensitive signal analysis and a reference scale such that the problem of uncertainty in absolute accuracy is addressed. This reference scale will be the SI standard. Additionally, we plan to build the new radiometer suitable for ground-based use. Thus, it will additionally become comparable to the WRR.

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MEASURING THE CORONAL MAGNETIC FIELD USING THE HANLE EFFECT

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One of the major hindrances to making further progress in understanding the physics of the solar corona is the relative lack of knowledge of the coronal magnetic field. Whereas the magnetic field produces most of its major effects in the corona, it is usually observed in the photosphere. Different techniques for measuring the field in the solar corona or near its base are available and have been increasingly applied in recent years. However, each technique has its own limitations and although new instrumentation (e.g. the Frequency Agile Solar Radiotelescope, FASR) will help, the problem that the solar corona is so strongly structured and inhomogeneous, means that a single technique and type of measurement will never be enough to get a sufficient measure of the coronal magnetic field. One promising technique to observe the weak coronal magnetic field, which has so far hardly been applied, is through the application of the Hanle effect measured in EUV lines. It requires the measurement of linear polarisation of the emission lines, either on the solar disk (particularly near the limb) or off limb. Typical instruments that could carry out such measurements are an EUV disk imager (EIT or TRACE type) or a coronagraph observing in an EUV line. Both instruments would have an added polarization modulator. Here we present feasibility computations, a discussion of the best spectral lines (and line combinations), discuss the possibilities and limitations of such measurements as well as instrumental requirements. In particular we point out that some of the most restrictive shortcomings of coronagraphic Hanle effect measurements (due to the line-of-sight integrated character of the measurements)can be overcome by using recently developed vector tomography techniques (by Kramar and Inhester). Similarly, problems with the interpretation of on-disk EUV Hanle-effect measurements may be greatly reduced by combining such measurements with magnetic field extrapolations starting from the photosphere.

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PAST AND FUTURE SOHO-ULYSSES QUADRATURES

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With the launch of SOHO, it again became possible to carry out quadrature observations. In comparison with earlier observations, the new capabilities of coronal spectroscopy with UVCS and in situ ionization state and composition with Ulysses/SWICS enabled new types of studies. Results from two studies serve as examples:
(i) The acceleration profile of wind from small coronal holes.
(ii) A high-coronal reconnecting current sheet as the source of high ionization state Fe in a CME at Ulysses.

Generally quadrature observations last only for a few days, when Ulysses is within ca. 5 degrees of the limb. This means luck is required for the phenomenon of interest to lie along the radial direction to Ulysses. However, when Ulysses is at high southern latitude in winter 2007 and high northern latitude in winter 2008, there will be unusually favorable configurations for quadrature observations with SOHO and corresponding bracketing limb observations from STEREO A/B. Specifically, Ulysses will be within 5 degrees of the limb from December 2006 to May 2007 and within 10 degrees of the limb from December 2007 to May 2008. These long-lasting quadratures and bracketing STEREO A/B observations overcome the limitations inherent in the short observation intervals of typical quadratures. Furthermore, ionization and charge state measurements like those on Ulysses will also be made on STEREO and these will be essential for identification of CME ejecta - one of the prime objectives for STEREO.

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THE ATMOSPHERIC IMAGING ASSEMBLY ON THE SOLAR DYNAMICS OBSERVATORY

Title, Alan[1]; AIA team, the[2]
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The Atmospheric Imaging Assembly (AIA) on SDO will provide revolutionary coverage of the entire visible solar hemisphere, observed from photospheric to coronal temperatures, at 1-arcsecond resolution, with a characteristic cadence of 10 seconds for each channel. The AIA comprises four dual normal-incidence telescopes that enable it to cycle through a set of EUV channels centered on strong emission lines of iron (ranging from Fe IX through XXIII) and helium (304A), plus two UV channels near 1600A and a broad band visible channel. Combined with the (vector-)magnetic imagery from SDO/HMI, the AIA observations will significantly further our understanding of the dynamics of the magnetic field in the solar atmosphere and heliosphere, both in quiescent and eruptive stages. The comprehensive thermal coverage of the corona will open new avenues of study for coronal energetics and seismology, which will benefit from the excellent calibration against the SDO/EVE spectral irradiance measurements. The AIA data will be easily accessible on the web, with a time delay that is expected to be of the order of 15 minutes to 1 hour. Users will be able to browse the data through summary web pages that are complemented by a comprehensive metadata catalog. Data analysis will be supported through the freely available SolarSoft libraries and through modules in a flexible, evolving pipeline data-analysis system to be operated at the AIA-HMI Joint Science Operations Center. We plan to incorporate feature recognition software, automated movie making, coronal field modeling, and other supporting analysis software. We invite the broad ILWS community to contact us with ideas to collaborate on any aspect of the AIA Investigation. Details on the AIA instrument, the Science Investigation, and related news can be found at http://aia.lmsal.com.

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THE SPACE DYNAMICS PROJECT

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The DynaMICS space project (Dynamics and Magnetism of the internal core of the Sun) is a french spanish collaboration prepared first for a microsatellite observation that we hope to launch in 2010. It is devoted to the search for solar gravity and acoustic modes, and also chromospheric modes from space. This instrument which is a successor to GOLF/SOHO will contribute to improve our knowledge of the dynamics of the solar radiative zone. It is a 15 points resonant scattering spectrometer, working on the D1 sodium line. A ground-based prototype GOLFNG is under construction to validate the difficult issues. It will be installed at the Teide Observatory, on Tenerife in 2006 to analyse the separation of the effects of the magnetic turbulence of the line from the solar oscillations. With the space version, we will determine properly the core rotation and magnetic field, through precise measurements of oscillation mode frequency splittings. Understanding the magnetic field of the radiative zone is important for progressing in the study of solar activity sources, an important player for the long-term Sun-Earth relationship. Turck-Chieze, S. et al., Adv. Space. Reseach, in press.

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WHAT WE LEARNED ABOUT SOLAR ERUPTIONS AND WHAT KNOWLEDGE IS STILL MISSING AFTER 10 YEARS OF SOHO OBSERVATIONS?

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Several new facts based on SOHO and other spacecraft observations can be summarised as follows: 1) Eruptions on the Sun are broadly different in their dimensionless scaling parameters ranging between flare-like and CME-like events according to their Ve numbers which represent the ratios of emitted electromagnetic power to that of plasma kinetic energy. 2) Eruptions are also different in other dimensionless parameters, in their sizes measured by their linear scales, characteristic times, energy, power etc. 3) Eruptions are different in their geometry shapes, though loop-like and arcade structures are omnipresent reflecting the role of magnetic fields and electric currents. 4) Solar flares and mass ejections are not related by any cause-to-sequence chains, but represent merely two different channels of the free energy releases in the solar atmosphere. 5) They are driven by the same subphotospheric processes and do not appear purely as the consequence of some coronal instabilities: they are essentially non-local phenomena with many different space-time scales coupled simultaneously in direct and inverse energy cascades. 6) Large-scale topological transformations of the magnetic field ('magnetic reconnection') are not always necessary for eruptions: spurious reconnections are common in observations due to projection effects of twisted and sheared loops with false islands, cusps etc. On the other hand, many questions have no conclusive answers as yet because of scarce or lacking observational information: 1) The real knowledge of the white light contribution during eruptions is still very poor. Only future telescopic high resolution and absolutely calibrated measurements can resolve the problem of solar flare and coronal mass ejection free energy origins, storage and releases. 2) The energy, momentum and mass fluxes, as well as geometry configurations associated with eruptions need further studies with deeper and broader space-time resolutions before any deterministic forecasts, which are limited now. 3) Electric fields in the solar atmosphere should be measured before we understand the real role of plasma drifts and acceleration during eruptions. 4) The available magnetic field and velocity field measurements are not sufficient for this purpose. 5) Electric current circuits associated with solar eruptions are still poorly evaluated. 6) The physical nature of extremely quiet and active states of the solar atmosphere and possible limits (if any) in this respect are open questions, which are scientifically interesting and also could be practically important.

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THE PENDING ISSUE OF SOLAR FINE STRUCTURES (OF PROMINENCES)

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The stability of solar prominences (not to mention formation and disappearance) remains an open question in spite of recent progress in modelling. For an overall presentation of prominences, see Tandberg-Hanssen's book (1995) and a recent study of the stability issue, see Karpen et al. (2005). By stability, we mean here both the force support against gravity and the energy insulation from the chromosphere and the corona. The comparison between the various theories and the observations has been hampered by the uncertainties in the basic parameters used (such as density, ionization degree, flows) which are related to the poor knowledge of the fine structure. There have been many hints at the existence of this fine structure even since e.g. the famous observations of Dick Dunn (1960). To remain with this example, Dunn's movies showed evident small-scale downward motions that later spectroscopic measurements contradicted. Other evidences of fine structure came from spectroscopic measurements (e.g. the determination of a filling factor by Cirigliano et al. 2004). Moreover, in the strict frame of empirical modelling, the whole corpus of various observations cannot be reconciled without some fine structuring. In our view, it is crucial to address the fine structure of prominences from the observational standpoint without any prejudice. If "one good spectrum is worth a thousand images" as Andrea Dupree is said to have said, a poor resolution spectrum can lead to erroneous (or contradictory) conclusions. Moreover, spectroscopy is often not synonymous of time resolution, a big handicap for the study of such dynamical structures. We want to attract the attention to the NEED of a better combination of spectral AND spatial observations. Although one does not know the actual size of elemental structures in prominences (certainly smaller than 100 km) nor can we aim at observing the real size of some processes, we certainly are able in a not so far future, to reach a spatial (and spectral) resolution allowing to answer basic questions such as : what are filling factor, actual density, ionization degree, flow in prominences ? is there really any stability of the plasma within ? It is quite obvious that answers to these questions will provide a crucial test for models of formation and disappearance. It is also obvious that such observational tools will naturally be available for solving the issue of fine structure of other solar structures. It will be interesting to elaborate on these instruments of which some could combine both spectroscopic and imaging properties in a single design.

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ASPIICS, A GIANT EXTERNALLY OCCULTED CORONAGRAPH FOR THE PROBA-3 FORMATION FLYER MISSION

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Formation flyers open new perspectives and allow to conceive giant, externally-occulted coronagraphs using a two-component space system with the external occulter on one spacecraft and the optical instrument on the other spacecraft at approximately 100 m from the first one. ASPIICS (Association de Satellites Pour l'Imagerie et l'Interférométrie de la Couronne Solaire) is a mission proposed to ESA in the framework of the PROBA-3 program of formation flyers which is presently in phase A to exploit this technique for coronal observations. ASPIICS is composed of a single coronagraph which performs high spatial resolution imaging of the corona as well as 2-dimensional spectroscopy of several emission lines from the coronal base out to 3 Rs. The selected lines allow to address different coronal regions: the forbidden line of FeXIV at 530.285 nm (coronal matter), Fe IX/X at 637.4 nm (coronal holes), HeI at 587.6 (cold matter). An additional broad spectral channel will image the white light corona and derive electron densities. The classical design of an externally occulted coronagraph is adapted to the detection of the very inner corona as close as 1.01 Rs and the addition of a Fabry-Perot interferometer using a so-called etalon. ASPIICS will address the question of the coronal heating and the role of waves by characterizing propagating fluctuations (waves and turbulence) in the solar wind acceleration region and by looking for oscillations in the intensity and Doppler shift of spectral lines. The combined imaging and spectral diagnostics capabilities available with ASPIICS will allow to map the velocity field of the corona both in the sky plane (directly on the images) and along the line of sight by measuring the Doppler shifts of emission lines. This will attempt to determine how the different components of the solar wind, slow and fast are accelerated. ASPIICS will observe the corona during the maximum of solar activity, insuring the detection of many Coronal Mass Ejections (CMEs). By rapidly alternating high resolution imaging and spectroscopy, CMEs will be thoroughly characterized. In addition, ASPIICS will attempt to characterize the topology of the magnetic field in the corona.

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