Magnetic Coupling between the Interior and the Atmosphere of the Sun

"Centenary Commemoration of the discovery of the Evershed Effect"

Indian Institute of Astrophysics, Bangalore
December 2 – 5, 2008

ABSTRACT BOOK

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Social Programme:

- Half-day Local sight seeing tour: 1st December, 2008: (Departure 1 PM)
- Welcome Reception: 1st December, 2008, 6.00 PM, Venue: Bhaskara Building
- Conference Banquet: 4th December, 2008, 7.30 PM

Conference Web-site: http://www.iiap.res.in/ever
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Scientific Programme

Day 1 December 2

08:30 - 09:30 Registration

09:30 - 10:30 Inaugural Session

10:30 - 11:00 Coffee break

11:00 - 13:00 Session IA: Magnetic field generation
Chair: S. M. Chitre

11:00 - 11:40 **D. Gough:** *Angular-momentum coupling through the tachocline*
11:40 - 12:05 **A. S. Brun:** *The Solar Global Dynamo*
12:05 - 12:30 **D. Nandi:** *Dynamo Models of the Solar Cycle*
12:30 - 12:45 **A. R. Choudhuri**: *Prediction of the next solar cycle 24 from solar dynamo model*
12:45 - 13:00 **P. Chatterjee:** *A Theoretical Explanation for the solar Torsional Oscillations Preceding the Sunspot Cycle*

13:00 - 14:30 Lunch

14:30 - 15:50 Session I B: Magnetoconvection and transport
Chair: J. Leibacher

14:30 - 15:10 **A. Nordlund:** *Magnetoconvection*
15:10 - 15:50 **D. Longcope:** *Active region emergence and its effect on the solar corona*

15:50 - 16:20 Coffee break

16:20 - 17:00 Session I C: Local Seismology

16:20 - 16:45 **S. P. Rajaguru:** *Seismology of sunspots: old needs, new ideas and new needs*
16:45 - 17:00 **S. M. Hanasoge:** *Numerical models of MHD wave interactions for sunspot seismology*

17:00 - 18:30 Posters

Day 2 December 3

9:00 - 11:00 Session II A: Magnetic field measurement
Chair: P. Venkatakrishnan

9:00 - 9:40 **J. O. Stenflo:** *Measuring the hidden aspects of solar magnetism*
9:40 - 10:05 **K. SankarSubramanian:** *Spectro-Polarimetry with NLST*
10:05 - 10:30 **S. K. Mathew:** *MAST update and the back-end instruments*
10:30 - 10:45 **C. DeForest:** *Stereoscopic Magnetography with SHAZAM*
10:45 - 11:00 **B. Schmieder:** *Vector magnetic field in emerging flux*

11:00 - 11:30 **Coffee break**

11:30 - 12:40 Session II B: Chair: R. J. Rutten

11:30 - 12:10 **J. Trujillo Bueno:** *Some Recent Advances in Polarized Radiation Diagnostics Methods for "Measuring" Chromospheric and Coronal Magnetic Fields*
12:10 - 12:25 **M. Sampoorna:** *Probability distribution functions (PDFs) to represent the Solar surface magnetic fields*
12:25 - 12:40 **E. Rebecca Centeno:** *Determining the magnetic field of solar spicules*

12:40 - 14:00 **Lunch**

14:00 - 15:35 Session II C: Chair: R. J. Rutten

14:00 - 14:40 **B. W. Lites:** *The New Renaissance of Solar Magnetic Field Measurement*
14:40 - 14:55 **A. O. Carbonell:** *Polarimetry at the SST: CRISP*
14:55 - 15:20 **R. Ishikawa:** *Statistical properties of transient horizontal magnetic fields*
15:20 - 15:35 **J. Okamoto:** *Emerging helical flux rope associated with prominence formation*

15:35 - 16:00 Coffee break

16:00 - 17:55 Session III A: Sunspots and Active regions
Chair: N. O. Weiss

16:00 - 16:40 **J. H. Thomas:** *Theoretical Models of Sunspot Structure and Dynamics*
16:40 - 17:05 **L. R. Bellot-Rubio:** *The Evershed flow and the brightness of the penumbra*
17:05 - 17:30 **S. P. Bagare:** *A revisit to the phenomenon of classic Wilson Effect in sunspots*
17:30 - 17:55 **E. Khomenko:** *Observations and interpretation of waves in sunspots*

17:55 - 18:30 Posters

18:30 Vainu Bappu Memorial Lecture by Douglas Gough

Day 3 December 4, 2008

9:00 - 11:05 Session III B: Sunspots and active regions
Chair: K. R. Sivaraman

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9:40 -10:05	**K. Ichimoto:** *Evershed Effect Observed by SOT/Hinode*
10:05 -10:20	**G. B. Scharmer:** *Convection and the origin of Evershed flows*
10:20 -10:35	**T. Shimizu:** *Frequent occurrence of high-speed local mass downflows on the solar surface*
10:35 - 10:50	**K. Nagaraju:** *Sunspot observations from Kodaikanal*
10:50 - 11:05	**M. Sobotka:** *Evolution of sunspot small-scale features*

11:05 - 11:35 Coffee break

11:35 - 12:55 Session III C: Quiet Sun and Polar regions
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11:35 - 12:15	**T. Tsuneta:** *Polar region, quiet Sun and Aflven waves as observed with Hinode*
12:15 - 12:40	**D. Banerjee:** *Waves in the coronal Holes*
12:40 - 12:55	**P. Antolin:** *Predicting observational signatures of coronal heating by Alfven waves and nanoflares*

12:55 - 14:00 Lunch

14:00 - 15:45 Session IV A: Magnetic coupling through the atmosphere
Chair: B. Fleck

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14:40 - 15:05	**R. Erdelyi:** *Heating diagnostics with MHD waves*
15:05 - 15:45	**B. De Pontieu:** *Coupling the dynamics of the chromosphere and transition region*

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16:10 - 17:45 Session IV B: Chair: M. Carlsson

16:10 - 16:50 **J. A. Klimchuk:** *Coronal Heating*
16:50 - 17:15 **V. H. Hansteen:** *Results from simulations extending from the convection zone to the corona*
17:15 - 17:30 **R. Ramesh:** *Low frequency radio observations of magnetic field in the solar corona*
17:30 - 17:45 **P. K. Manoharan:** *Evolution of Solar Wind Density Turbulence in the near-Sun Region*

17:45 - 18:45 **Posters**

19:00 - **Departure for Conference Banquet**

Day 4 December 5, 2008

9:00 - 11:00 Session V A: Eruptive phenomena
Chair: J. Karpen

9:00 - 9:40 **N. Gopalswamy:** *The Rate of Coronal Mass Ejections and the Sunspot Number*
9:40 - 10:20 **T. G. Forbes:** *Recent Developments in the Modeling of CMEs and Flares*
10:20 - 10:45 **P. Subramanian:** *Energetics of CMEs*
10:45 - 11:00 **M. Zhang:** *Coronal mass ejection as a result of magnetic helicity accumulation*

11:00 - 11:30 **Coffee break**

11:30 - 13:15 Session V B: Eruptive phenomena
Chair: T. Tsuneta

11:30 – 12:10 **C. Parnell:** *Three-dimensional Magnetic Reconnection*
12:10 – 12:35 **N. Srivastava:** *Statistical studies on CMEs*
12:35 – 13:15 **K. Shibata:** *Theoretical models of flares*

13:15 – 14:30 **Lunch**

14:30 – 15:55 Session VI: Solar-Stellar connections
Chair: J. Stenflo

14:30 – 15:10 **J. H. M. M. Schmitt:** *The Sun as a Star*
15:10 – 15:25 **A. Bhardwaj:** *Monitoring Solar Wind in the Near-Earth Environment with SWIM of the SARA Experiment aboard the Indian lunar Mission Chandrayaan-1*
15:25 – 15:40 **P. Testa:** *Coronal activity in non solar-like stars*
15:40 – 15:55 **B. E. Reddy:** *FIP effect: stellar-solar connection*

15:55 – 16:25 Closing Session

15:55 – 16:25 **N. O. Weiss:** *Conference Summary & Perspective*

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Session I A: 11:00 – 13:00 Magnetic field generation

Angular-momentum coupling through the tachocline

D. Gough
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Astronomical observation of stellar rotation suggests that at least the surface layers of the Sun have lost a substantial amount of the angular momentum that they possessed at the beginning of the main-sequence phase of evolution; and solar-wind observations indicate that magnetic coupling is still draining angular momentum from the Sun today. In addition, helioseismological analysis has shown that the specific angular momentum at the top of the almost uniformly rotating radiative interior is approximately the same as the spherically averaged value at the base of the (differentially rotating) convection zone, suggesting that angular momentum is being transported through the tachocline. The mechanism by which that transport is taking place is not understood. Nor is there a consensus of opinion. I shall review some of the suggestions that have been put forward, biassing my discussion, no doubt, according to my own prejudices.

The Solar Global Dynamo

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We present recent 3-D high resolution MHD simulations made with the ASH code to model self-consistently the solar global dynamo in a turbulent convection zone coupled with a stable sheared region below. We show that the introduction of such a stable layer indeed favors the emergence of strong axisymmetric magnetic field which otherwise would not exist in a purely unstable convective layer rotating at the solar rate. The dynamo action operating in the convection zone is found to be highly intermittent both in space ant time. Further it is found that large scale meridional flows, magnetic diffusion and turbulent convective plumes serve to pump down magnetic field in the stable sheared layer. There, the Ω-effect acts efficiently to organize the field into strong toroidal structures (the mean toroidal energy being about 100 times higher). This field is found to be antisymmetric with respect to the equator, as observed in the Sun and is associated with a deep poloidal (dipolar like) field. This stable organised poloidal field seems to stabilize the poloidal field generated by the turbulent and intermittent convection envelope.

Dynamo Models of the Solar Cycle

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Magnetohydrodynamic dynamo theory lays the theoretical foundation for explaining the origin and variability of the solar magnetic cycle. Most of our advances in understanding this magnetic cycle has come from the kinematic approach to dynamo modeling, in which, one solves for the mean magnetic field with given velocity fields; additionally, key physical processes such as turbulent diffusion, magnetic buoyancy and the dynamo alpha-effect have to be parameterized appropriately. In this lecture, I will review the development of ideas in solar kinematic dynamo theory, present our current state of understanding, and highlight outstanding issues.

Prediction of the next solar cycle 24 from solar dynamo model

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In order to predict a future sunspot cycle, it is necessary to feed some appropriate information about the past cycles in a kinematic solar dynamo model. I shall discuss the methodology for doing this and the physics behind it. Our model predicts that cycle 24 will be about 30-35% than the last cycle 23.

A Theoretical Explanation for the Solar Torsional Oscillations Preceding the Sunspot Cycle

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Theoretical models of torsional oscillations have been developed by several authors by assuming that they are driven by the Lorentz force of the Sun's cyclically varying magnetic field associated with sunspot cycle. If this is true, then one would expect the torsional oscillations to follow the sunspot cycles. The puzzling fact, however, is that this oscillation begins 2-3 yr before the sunspot cycle. We provide a theoretical explanation of this with the help of a solar dynamo model having a meridional circulation penetrating slightly below the bottom of the convection zone, because only in such dynamo models the strong toroidal field forms a few years before the sunspot cycle and at a higher latitude.

Session I B: 14:00 – 15:20 Magnetoconvection and transport

Magnetoconvection

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I will review current understanding of magnetoconvection, in particular solar magnetoconvection, and especially aspects related to magnetoconvection in sunspots, and the consequences for the dynamics and appearance of sunspot penumbrae. Analyses of recent numerical simulations of sunspots have shown that the Evershed effect can be understood as a direct consequence of magnetoconvection and its interaction with the radiating surface in sunspot penumbrae.

Active region emergence and its effect on the solar corona

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The Sun's largest-scale magnetic field is generated in the tachocline deep beneath the convection zone. This rises buoyantly in the form of localized flux tubes which emerge to form new active regions. These active regions form the large-scale solar corona throughout the Sun's active phase. Their emergences endow it with its principal properties. The emerging flux tubes transport magnetic helicity which is responsible for the hemispheric chirality pattern. Their flux reconnects with existing field, reconfiguring the corona with each emergence. The reconnection also redistributes helicity within the corona. This talk reviews models and observations pertinent to the emergence of active region flux tubes and its effect on the solar corona. It will focus on the flux and helicity which is transported into the corona though the process of emergence.

Session I C: 15:50 – 17:50 Local Seismology

Seismology of sunspots: old needs, new ideas and new needs

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The various methods of local helioseismology, that attempt to probe and image the sub-surface structure and dynamics of sunspots, have progressed substantially but still without due considerations of crucial magneto-hydrodynamic processes at play. After reviewing briefly the issues and problems, we discuss some new developments and ideas in this field. We then present some new time-distance helioseismic measurements pertaining to some known properties of sunspots, namely the acoustic wave (p mode) absorption: we show travel time shifts that are non-linearly dependent on wave frequency. We show differences in the frequency dependences of waves travelling in and out sunspots, and also in measurements done in surface- and deep-focus geometry for wave paths. We discuss what these signatures mean seismically, and provide plausible interpretations. We also show, by means of Claerbout's conjecture well studied in geo-seismology literature, that there are acoustic sources directly beneath umbral photospheres and that, due to their different depths compared to quiet Sun, they contribute to the travel time asymmetries. This work utilizes data from the MDI instrument onboard SOHO spacecraft.

Numerical models of MHD wave interactions for sunspot seismology

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Our current observational understanding of sunspot interior structure and dynamics comes from the application of methods of helioseismology in conjunction with MHD wave interaction theories. However, these interaction theories rely on the assumption that the action of Lorentz forces can be indirectly modeled via changes in the underlying sound-speed. Through numerical simulations of wave propagation and interaction with sunspots, we show that these models can produce erroneous inferences because wave propagation in sunspots is overwhelmingly governed by MHD physics. Using methods of radiative heat transfer, we also attempt to place bounds on the magnitude of the phase shifts created by the depression of the tau =1 layer at the photosphere. The prospects for future investigations of sunspot structure will be discussed.

Session II A: 9:00 – 11:00 Magnetic field measurement

Measuring the hidden aspects of solar magnetism

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2008 marks the 100th anniversary of the discovery of astrophysical magnetic fields, when George Ellery Hale recorded the Zeeman splitting of spectral lines in sunspots. With the refinement of Babcock's photoelectric magnetograph it soon became clear that the Sun's magnetic field outside sunspots is extremely structured, and that the field strengths that were measured became larger when the spatial resolution was improved. It was therefore necessary to come up with methods to go beyond the spatial resolution limit and diagnose the intrinsic magnetic-field properties independent of the quality of the telescope used. Thus the line-ratio technique that was developed in the early 1970s revealed a picture where most flux that we see in magnetograms actually originates in highly bundled, kG fields with a tiny volume filling factor. This led to interpretations in terms of discrete, strong-field magnetic flux tubes embedded in a rather field-free medium, with a whole industry of flux tube models at increasing levels of sophistication. This magnetic-field paradigm has now been shattererd with the advent of high-precision imaging polarimeters that allow us to apply the so-called "second solar spectrum" to diagnose aspects of solar magnetism that have been hidden to Zeeman diagnostics. It is found that the bulk of the photospheric volume is seething with intermediately strong, tangled fields. In the new paradigm the field behaves like a fractal with a high degree of self-similarity, spanning about 8 orders of magnitude in scale size. While half of these scales are spatially resolved, the other half is in the spatially unresolved domain.

Spectro-Polarimetry with NLST

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The National Large Solar Telescope (NLST) will provide an opportunity for high spatial resolution observations on the Sun. With its large aperture, it is also feasible to do high time cadence spectro-polarimetry with moderate spatial resolution. A multi-slit spectro-polarimetry is being planned as one of the back-end instruments for this powerful telescope, primarily, to measure vector magnetic fields on the active as well as quiet regions of the Sun. An integral field unit added with the multi-slit spectro-polarimeter will enable for fast time cadence of a region-of-interest. In this presentation, the scientific requirements of the multi-slit spectro-polarimeter will be discussed. The advantages and limitations of this instrument will be presented along with the preliminary design details.

MAST update and the back-end instruments

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MAST is a new 0.5m telescope which will be installed at the lake site of Udaipur Solar Observatory, before the end of 2009. The telescope has an off-axis alt-azimuth design, which will provide a low scattered-light performance. The complete telescope including the control system will be made by AMOS, Belgium. The prototype adaptive-optics system for seeing correction is being developed at USO. The design of two back-end instruments, an echelle-scanning spectrograph capable of observing simultaneously in at least two spectral lines, and an imaging spectrometer based on double pass Fabry-Perot etalon, and a polarimeter common for both the instruments is in progress. The scientific objectives, design aspects and the current status of the above instruments will be discussed in this presentation.

Stereoscopic Magnetography with SHAZAM

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I report on the principle of operation and design of SHAZAM, a solar magnetograph being developed for deployment at the Dunn Solar Telescope and the Swedish Solar Telescope. SHAZAM is tens of times more photon-efficient than conventional magnetographs or spectropolarimeters, and is the first of a new type of magnetograph based on stereoscopic spectroscopy.

Vector magnetic field in emerging flux

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A crucial phase in the emergence process is the rising through the solar photosphere, which represents a strong transition region between the two very different environments that are the solar interior and the corona. We will present results of multi-wavelengths observations obtained with Flare Genesis experiment, TRACE, SoHO and more recently with the solar telescope THEMIS. We will explain what the observations tell us about the process of emergence, how are related the fragmented magnetic field in the emergence region with the Ellerman bombs, the AFS and the overlying coronal loops. We will show the evidence of ondulatory field lines during the emergence of flux tubes through the photosphere according to measurements of vector magnetic field.

Some Recent Advances in Polarized Radiation Diagnostics Methods for "Measuring" Chromospheric and Coronal Magnetic Fields

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Solar magnetic fields leave their fingerprints on the polarization signatures of the emergent spectral line radiation. This occurs through a variety of rather unfamiliar physical mechanisms, not only via the Zeeman effect. In particular, magnetic fields modify the atomic level polarization (population imbalances and quantum coherences) that anisotropic radiative pumping processes induce in the atoms and molecules of the solar atmosphere. Interestingly, this so-called Hanle effect allows us to "see" magnetic fields to which the Zeeman effect is blind within the limitations of the available instrumentation. This lecture reviews some of the recent advances in the polarized radiation diagnostic methods with which we may hope to explore the magnetism of the solar chromosphere and corona. As we shall see, these methods are based on the remarkable signatures that the atomic level polarization produces on the emergent spectral line radiation and on the joint action of the Hanle and Zeeman effects.

Session II B: 11:30 – 12:40

Probability distribution functions (PDFs) to represent the solar surface magnetic fields

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Numerical simulations of magneto-convection and analysis of solar magnetogram data provide empirical probability distribution functions (PDFs) for the magnetic field strength. In this paper, we theoretically explore the effects of these PDFs on the polarized Zeeman line formation. We consider several types of PDFs, namely (a) Voigt function and stretched exponential type PDFs for fields with fixed direction but fluctuating in strength; (b) a cylindrically symmetrical power law for the angular distribution of magnetic fields with a given field strength. We propose composite PDFs to account for the randomness in both strength and orientation. Good examples of such composite PDFs can be formulated through a combination of Voigt or a stretched exponential function, with an angular power law distribution (see above). We show that for magnetic field rms fluctuations of the order of 6 G, consistent with high resolution magnetogram data, Stokes I is essentially independent of the shapes of the PDFs, but Stokes Q, U, and V and also the 'dispersion around the mean values' are quite sensitive to the tail behavior of the PDF. Further, we show that the Stokes V is less sensitive to the scale of the magnetic fluctuation (micro or macro-turbulent eddies) than Stokes Q and U. The composite PDF proposed for the fluctuations of the magnetic field vector has an angular distribution peaked about the vertical direction for stronger fields (flux tube like structures) embedded in isotropically distributed weak fields. This PDF can be used to mimic solar surface random fields.

Determining the magnetic field of solar spicules

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Spectropolarimetric observations of quiet Sun spicules at various heights above the limb in the He I 10830 A triplet can be used to infer the strength and topology of magnetic fields in these chromospheric jets, which is of crucial importance for developing adequate models of these needle-shaped plasma structures. Here we present new spectropolarimetric observations of solar chromospheric spicules taken with the Tenerife Infrared Polarimeter (TIP) and report on the magnetic field vector that we have inferred through the application of HAZEL, a novel inversion code of Stokes profiles caused by the joint action of atomic level polarization and the Hanle and Zeeman effect (see Asensio Ramos, Trujillo Bueno and Landi Degl'Innocenti 2008; ApJ, 683, 542). The emergent Stokes profiles are obtained by solving the radiative transfer equation in a free-standing slab permeated by a deterministic magnetic field. The best fit to the observed Stokes profiles gives us the magnetic field strength, its inclination and its azimuth, the optical thickness of the slab and a non-thermal velocity (to account for the collective effect of having several spicules along the line of sight). We show also that the inferred optical thickness can be understood in terms of the amount of EUV radiation penetrating the chromosphere from the overlying corona.

Session II C: 14:00 – 15:35

The New Renaissance of Solar Magnetic Field Measurement

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Recent advances in observational capability have opened a new chapter in our capability to measure, hence interpret, magnetic fields in the solar atmosphere. Ground-based instrumentation in the late 20th Century paved the way for true quantitative measures of the magnetic field vector in the photosphere. High precision polarimeters cast new light on the "hidden turbulent fields" that appear to be ubiquitous in the solar atmosphere. Finally, space-based instrumentation of the 1990's and 2000's have provided continuous measurements of the evolution on the solar disk and, with the advent of Hinode, continuous coverage at high resolution of solar activity. These developments have provided a scientific bonanza, a few of the prominent results of which are discussed. Future opportunities for advancement of solar science are discussed in the context of coming advances in our measurement capabilities.

Polarimetry at the SST: CRISP

A. O. Carbonell[1], Luc Rouppe Van Der Voort
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CRISP, the new spectropolarimeter installed at the Swedish Solar Telescope in La Palma, opens a new perspective for solar polarimetry studies. With better spatial resolution than Hinode in the Fe I 6302 line and similar polarimetric sensitivity, complements (after postprocessing of the data) the SP spectropolarimeter onboard Hinode. Preliminary results from our first CRISP campaign will be shown.

Statistical properties of transient horizontal magnetic fields

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Following discovery of horizontal magnetic field with ASP (Lites et al. 1996), and the SOLIS and GONG instruments (Harvey et al. 2007), high resolution spectro-polarimetric observations with the SOT have confirmed this finding, and extended the studies considerably (Lites et al 2008, Centeno et al. 2007, Orozco Suarez et al. 2007, Ishikawa et al. 2008, Ishikawa & Tsuneta 2008, Tsuneta et al. 2008). We present statistical properties of the transient horizontal magnetic field (THMF) based on the analysis of large samples. The topics to be reported include (1) size and life time distribution, (2) vertical speed of THMF, (3) locations of emergence and disappearance in terms of granular structure, (4) PDF (probability distribution function) of intrinsic magnetic field strength, filling factor, and degree of linear polarization (5) orientation of the field vector. The extensive statistical survey reveals numbers of so far unknown unique and remarkable properties of THMFs, leading us to conclude that 1) THMFs are receptive to convective motion and 2) a local dynamo processes is essentially responsible for THMFs. We also estimate the magnetic energy flux carried by THMFs based on the statistical data and find that these magnetic energy fluxes are comparable to total chromospheric and coronal energy loss (Withbroe & Noyes 1977), implying a role of THMF for chromospheric heating and dynamism (Ishikawa and Tsuneta 2008).

Emerging helical flux rope associated with prominence formation

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Recent observations of prominences with Hinode Solar Optical Telescope have revealed the fine structures and dynamics. We focus on the evolution of photospheric magnetic field under an active-region prominence with the Spectro-Polarimeter, and discover clear evidence of an emerging helical magnetic flux. This observation provides us with the possibility of prominence formation by a helical flux rope ("flux rope model"), although lots of prominence researchers have supported the "sheared-arcade model." Here we introduce this episode, and then we show the property of the emerging helical flux: (1) Evidence of the flux tube emergence is clearly seen in Ca II H-line filtergrams. (2) No shear motion or converging flows are detected, but we find diverging flows such as mesogranules along the polarity inversion line. The presence of mesogranules may be related to the emergence of the helical flux rope. (3) The emerging helical flux rope reconnects with magnetic fields of the pre-existing prominence to stabilize the prominence for the next several days. We thus conjecture that prominence coronal magnetic fields emerge in the form of helical flux ropes that contribute to the formation and maintenance of the prominence.

Session III A: 16:00 – 17:55 Sunspots and Active regions

Theoretical Models of Sunspot Structure and Dynamics

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Understanding the structure and dynamics of a sunspot poses a formidable challenge to magnetohydrodynamic theory. The richness of detail revealed in high-resolution observations has shown the complexity of the problem but on the other hand has stimulated real progress in theoretical modeling, which we will review in this talk. Special attention will be given to the formation and maintenance of the penumbra, with its complicated interlocking-comb magnetic field and structured Evershed outflow. In understanding the penumbra, it is useful to distinguish between the inner penumbra, dominated by brig! ht filaments containing slender dark cores, and the outer penumbra, where there are dark and bright filaments of comparable width with corresponding magnetic fields differing in inclination by 30 degrees or more and where the Evershed flow is concentrated in the dark filaments with nearly horizontal and often downward-plunging magnetic fields. Recently, attention has turned from models of individual flux tubes embedded in a background structure to direct numerical simulations of overall structure. These simulations have succeeded in reproducing the salient features of the convective pattern in the umbra and inner penumbra and in explaining the existence of returning magnetic flux in the outer penumbra.

The Evershed flow and the brightness of the penumbra

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The Evershed flow is a systematic outward motion of gas that occurs in the penumbra of all sunspots. Discovered in 1908, it still lacks a satisfactory explanation. We know that the flow is often supersonic, magnetized, and that it shows conspicuous fine structure on spatial scales of 0.2 arcsec, but its origin remains unknown. The hope is that a good observational understanding of the relation between the flow and the penumbral magnetic field will help us determine its nature. Here I will review recent advances in the characterization of the Evershed flow and sunspot magnetic fields from high-resolution spectroscopic and spectropolarimetric measurements. Using this information as input for 2D heat transfer simulations, I will show that hot Evershed upflows along nearly horizontal field lines are capable of explaining one of the most intriguing aspects of sunspots: the surplus brightness of the penumbra relative to the umbra. These results support the idea that radial Evershed flows are largely responsible for the transfer of energy in the penumbra.

A revisit to the phenomenon of classic Wilson Effect in sunspots

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The classic Wilson Effect is ascribed to a geometric depth of 600 +/- 200 km in sunspot umbra, with respect to its surroundings in the photosphere. This value of the Wilson Depression is widely used in theoretical modeling of sunspots. However, observations of the phenomenon in a large number of sunspots, reported by several authors in the past, show interesting variations. It is clear that single, isolated, and mostly unipolar sunspots invariably display the depression, while sunspots associated with significant bipolarity do not seem to display the effect. In fact, some of these sunspots exhibit an opposite effect, as if the sunspot resembles an inverted sauce pan in shape. Further, there are reports of an asymmetry between the extent of Wilson Depression observed in the eastern and western hemispheres. We have therefore carefully examined transits of 253 sunspots, using the Kodaikanal Observatory white light archival data, to study the behaviour of the phenomenon. We present our results on the dependence of the effect on a magnetic polarity index, the age, and the area of sunspots. We also examine the center to limb variation and the East-West asymmetry of the effect.

Observations and interpretation of waves in sunspots

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The frontier in high-resolution observations of solar active regions with the help of state-of-art ground-based and space instruments has reached the detection of magnetic field, velocity and intensity oscillations of the spectral lines formed in the magneto-atmospheres with periods of 3-5 min. The interpretation of these oscillations in terms of MHD waves is unclear. Such interpretation is of particular importance for the field of local helioseismology. Methods of local helioseismology an provide valuable information about thermodynamic and magnetic properties of the solar interior below active regions, impossible to obtain by other methods. In this talk I will review the recent efforts of theoretical interpretation and numerical modeling of waves in sunspots. The state of realism reached by numerical simulations allows direct observational implications to be derived.

On the topology of penumbral magnetic fields

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A hundred years after the discovery, we are still discussing what is the topology of the penumbral magnetic and velocity fields that give rise to the Eveshed effect (EE). Historically, the advent of new instrumentation or new numerical simulations have been followed by claims of 'problem solved', however, the fact that the claims are repeated over and over should cautions us against naive solutions. From my point of view, the difficulty to comprehend the nature of the EE can be pinned down to insufficient spatial resolution. The relevant physical processes occur at length scales that are not optically thick, but, we insist on interpreting the observations as if the magnetic structure were spatially resolved. The unresolved nature of the fields must be properly accounted for when measuring, however, this requires a good knowledge of the 3D organization of the fields, which is precisely the problem to be constrained. This circular nature of the problem explains its longevity. I will review a set of often overlooked observations which emphasize the unresolved nature of the penumbral magnetic fields. They lead to an scenario for the sunspot magnetic field topology that may account for recent observations of upflows and downflows in penumbrae (Sanchez Almeida, 2005, ApJ, 622, 1292; Ichimoto et al., 2007, PASJ, 59, 593). According to this conjecture, short narrow magnetic loops fill the penumbral volume. Flows along these field lines are responsible for both the EE and the convective transport. This scenario seems to be qualitatively consistent with most existing observations, including the dark cores in penumbral filaments. Each bright filament with dark core would be a system of two paired convective rolls with the dark core tracing the lane where the plasma sinks down. The magnetic loops would have a hot footpoint in one of the bright filament and a cold footpoint in the dark core. The scenario also fits in most of our theoretical prejudices (siphon flows along field lines, presence of overturning convection, drag of field lines by downdrafts, etc).

Evershed Effect Observed by SOT/Hinode

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Since its discovery in 1909 (MNRAS 69, 454), the Evershed effect has been one of the longstanding mystery in solar physics on its nature and origin. The Solar Optical Telescope (SOT) aboard Hinode revealed the fine scale structure of the Evershed flow and its relation to the filamentary structures of the sunspot penumbra; The Evershed flow is confined in narrow channels with nearly horizontal magnetic fields embedded in deep layer of penumbral atmosphere. It is a dynamic phenomenon with the flow velocity close to the sound speed of the photosphere, and individual flow channels are associated with tiny upflow of hot gas (source) at the inner end and down flow (sink) at the outer end. SOT/Hinode also discovered the 'twisting' motions of penumbral filaments which may be attributed to the convective nature of the Evershed flow. We will discuss the current penumbral models, i.e., the rising flux tube model and the gappy model, in the lights of the new observations provided by Hinode.

Convection and the origin of Evershed flows

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We discuss a numerical 3D radiation-MHD simulation of penumbral fine structure in a small sunspot. This simulation shows the development of short filamentary structures with horizontal flows, similar to observed Evershed flows, and an inward propagation of these structures at a speed compatible with observations. Although the lengths of these filaments are much shorter than observed, we conjecture that this simulation qualitatively reproduces the mechanisms responsible for filament formation and Evershed flows in penumbrae. We conclude that the Evershed flow represents the horizontal flow component of overturning convection in gaps with strongly reduced field strength.

Frequent occurrence of high-speed local mass downflows on the solar surface

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New spectro-polarimetric measurements with simultaneous filter imaging observation by the Hinode Solar Optical Telescope will be discussed in this presentation, revealing the frequent appearance of polarization signals indicating high-speed, probably supersonic, downflows that are associated with at least three different configrations of magnetic fields in the solar photosphere. High-speed downflows are exited when a moving magnetic feature is newly formed near the penumbral boundary of sunspots. Also, a new type of downflows is identified at the edge of sunspot umbra that lack accompanying penumbral structures. Another class of high-speed downflows are observed in quiet Sun and sunspot moat regions, which are closely related to the formation of small concentrated magnetic flux patches. High-speed downflows of all types are transient time-dependent mass motions. These findings suggest that the excitation of supersonic mass flows are one of the key observational features to understand the dynamical evolution occurring in magnetic-field fine structures on the solar surface.

Sunspot Observations from Kodaikanal

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Systematic observations of sunspots have been carried out from Kodaikanal for more than a century using various techniques viz., narrow- and wideband imaging, spectroscopy and spectropolarimetry. We present in this talk about the results of recent spectropolarimetric observations of sunspots. A dual-beam polarimeter has been installed as a backend instrument to the spectrograph at Kodaikanal Tower Telescope. Using this instrument, measurements of velocity and magnetic field, simultaneously, at the photosphere and chromosphere has been carried out for three different active regions. The spectral lines used for this purpose are Hydrogen alpha at 656.28 nm and Fe I at 656.92 nm. Some of the major findings from these observations are: 1. quicker weakening of the line-of-sight (LOS) field strengths in the umbral chromosphere above two of the active regions 2. large concentration of horizontal magnetic field in the umbral chromosphere above a bipolar active region 3. the magnetic field topology above all three active regions inferred through H alpha observations compare very well, qualitatively, with the □avelet ultra-violet and X-ray intensity structures observed by SoHO/EIT and Hinode/XRT, respectively 4. larger LOS velocity gradients in the umbral chromosphere compared to penumbral chromosphere which is in stark contrast with what is generally observed at the photosphere.

Evolution of sunspot small-scale features

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On February 27, 2007, Hinode SOT/SP acquired a time series of I, Q, U, V spectra of a regular, medium-sized sunspot. The inversion code SIR was applied to these data and a series of 33 spatial 3D maps of temperature, line-of-sight velocity, and magnetic field vector in the umbra and penumbra was computed. The temporal and spatial resolutions of this 3 hours long series are 5.5 min and 0”.32, respectively. A simultaneous series of G-band images was utilized for complementary measurements of horizontal motions and sizes of small-scale features. Several long-lived central umbral dots (CUDs), peripheral umbral dots (PUDs), and penumbral grains (PGs) were selected to study in detail the temporal evolution of their physical parameters. PUDs often originate from PGs and keep their umbra-directed horizontal motions. In the low atmospheric layers, PUDs conserve the characteristic vertical upflows of PGs and a higher field inclination compared to the surroundings. These parameters decrease gradually during the motion of PUDs into the umbra. On the other hand, CUDs show only a very weak signature of line-of-sight velocity and magnetic field inclination. We conclude that, according to the physical characteristics, PUDs are more similar to PGs than to CUDs.

Session III C: 11:35 – 12:55 Quiet Sun and Polar Regions

Polar region, quiet Sun and Aflven waves as observed with Hinode

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The magnetic landscape of the polar region (Tsuneta et al, 2008) is characterized by vertical kilogauss patches with super-equipartition field strength, a coherence in polarity, lifetimes of 5-15 hr, and ubiquitous weaker transient horizontal fields (Lites et al 2008, Ishikawa & Tsuneta, 2008, 2009). Polar region in 2007 have abundant vertical fields much stronger than the quiet Sun. Unipolar appearance and disappearance of the kG vertical patches must be closely related to properties of the horizontal flow field in the polar region. Difference and similarity between the quiet sun and the polar region are summarized, and its implication for solar dynamo will be discussed. All the open field lines forming the polar coronal hole essentially originate from such magnetic patches, and the fast solar wind would emanate from these vertical flux tubes seen in the photosphere. We conjecture that vertical flux tubes with large expansion around the photospheric-coronal boundary serve as efficient chimneys for Alfven waves that accelerate the solar wind. Indeed, we discovered propagating Alfven waves (kink mode) with magneto-acoustic waves (sausage mode) in the solar photosphere with period of 4-13 minutes with Hinode spectro-polarimeter (Fujimura and Tsuneta, 2009). We found that these fluctuations are superposition of ascending and descending Alfven waves with almost equal intensities from the analysis of the phase relationship between transverse magnetic and velocity fluctuations. Aflven waves along flux tubes in the quiet sun appear to be efficiently reflected back probably at photosphere-corona boundary. It would be very interesting to measure possible change in the reflectivity of Alfven waves depending on the magnetic environment.

Waves in the coronal Holes

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Fast solar wind originates from the polar coronal hole regions. Recent observations from SoHO points out that solar wind is flowing from funnel-shaped magnetic fields whic h are anchored in the lanes of the magnetic network near the surface of the Sun. Using the spectroscopic diagnostic capability of SUMER on SoHO and EIS on HINODE we study the properties of the waves in the polar coronal holes. Their origin, nature and acceleration process will be discussed. Using the line width variation of spectral lines with height, one can also try to identify the properties of these waves as they propagate out of the sun. Some new results from EIS on HINODE on this subject will be also presented.

Predicting observational signatures of coronal heating by Alfven waves and nanoflares

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Alfven waves can dissipate their energy by means of nonlinear mechanisms, and constitute good candidates to heat and maintain the solar corona to the observed few million degrees. Another appealing candidate is the nanoflare-reconnection heating, in which energy is released through many small magnetic reconnection events. Distinguishing the observational features of each mechanism is an extremely difficult task. On the other hand, observations have shown that energy release processes in the corona follow a power law distribution in frequency whose index may tell us whether small heating events contribute substantially to the heating or not. In this work we show a link between the power law index and the operating heating mechanism in a loop. We set up two coronal loop models: in the first model Alfven waves created by footpoint shuffling nonlinearly convert to longitudinal modes which dissipate their energy through shocks; in the second model numerous heating events with nanoflare-like energies are input randomly along the loop, either distributed uniformly or concentrated at the footpoints. Both models are based on a 1.5-D MHD code. The obtained coronae differ in many aspects, for instance, in the flow patterns along the loop and the simulated intensity profile that *Hinode*/XRT would observe. The intensity histograms display power law distributions whose indexes differ considerably. This number is found to be related to the distribution of the shocks along the loop. We thus test the observational signatures of the power law index as a diagnostic tool for the above heating mechanisms and the influence of the location of nanoflares.

Session IV A: 14:00 – 15:45 Magnetic coupling through the atmosphere

Magnetic coupling in the quiet solar atmosphere

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Observations with the Hinode space observatory led to a new and refined picture of the magnetic field in the quiet solar atmosphere. The polarimetric capabilities of the Solar Optical Telescope directed attention to Stokes Q and U and hence led to the discovery that the magnetic field in the photosphere of the quiet internetwork region, observed at a spatial resolution of 0.3’’, is predominantly horizontal. Even though numerical simulations have since long pointed to the ubiquitousness of horizontal fields, only recently analyses of simulations with regard to the horizontal field component were carried out. Another phenomenon that numerical simulations predict (but still await definite observational confirmation) is the ubiquitous presence of shock waves that emerge from acoustic waves, which are generated by the convective granular motion at the base of the atmosphere. These lead to large fluctuations in the tenuous atmosphere above the classical temperature minimum, giving rise to a veritable “fluctosphere”. It is still a matter of debate if these waves suffice to provide the energy needed to replenish the radiative losses in the chromosphere. In combination with magnetic fields, these disturbances give rise to a rich variety of magneto-acoustic wave phenomena. As the gas pressure in the gravitationally stratified atmosphere generally drops more quickly with height than the magnetic energy density, there is a height region where sound speed and Alfven speed are of similar magnitude. Within this region, which forms a corrugated surface excursive over a wide height range in the three-dimensional atmosphere, propagating wave modes may change nature from acoustic to magnetic and change character from slow to fast and vice versa. Above this surface there is a predominant tendency for magnetic modes to get refracted and reflected due to the dispersive nature of the inhomogeneous magnetic field.

Heating diagnostics with MHD waves

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Analysing the structure of solar coronal loops is crucial to our understanding of the processes which heat and maintain the coronal plasma at multimillion degree temperatures. The determination of the physical parameters of the loops remains both an observational and theoretical challenge. A novel diagnostic technique for quiescent coronal loops based on the analysis of power spectra of Doppler shift time series is proposed. It is assumed that the loop is heated randomly both in space and time by small-scale discrete impulsive events of unspecified nature. The loop evolution is characterised by longitudinal motions caused by the random heating events. These random motions can be represented as a superposition of the normal modes of the loop, i.e., its standing acoustic wave harmonics. The idea is borrowed from helioseismology where a similar approach resulted in the advanced understanding of the solar interior. We demonstrate that the analysis of the power spectra allows the distinction between uniformly heated loops from loops heated near their footpoints. We also show how it becomes possible to estimate the average energy of a single heating event. Synthetic and direct SoHO/SUMER and Hinode/EIS observations of waves will be presented and the applicability of the method will be demonstrated and tested.

Coupling the dynamics of the chromosphere and transition region

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In the past few years, high-resolution observations with ground-based telescopes and the Broadband Filter Imager (BFI) and Narrowband Filter Imager (NFI) of the Solar Optical Telescope onboard Hinode have revolutionized our view of the dynamics and energetics of the chromosphere. We review some of these results, including the discovery of two different types of spicules and the finding that the chromosphere is riddled with strong Alfvenic waves. We describe how these observations, when combined with advanced numerical simulations, can help address important unresolved issues regarding the connection between the photosphere and corona, such as the role of waves and of reconnection in driving the dynamics and energetics of the upper chromosphere, and how chromospheric dynamics impact the transition region and corona.

Session IV B: 16:10 – 17:45

Coronal Heating

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It is generally accepted that the energy which heats the corona, at least in active regions, is derived primarily from stresses that have built up in the magnetic field. A likely scenario is that photospheric convection causes the coronal field to become tangled on a small scale, and some process dissipates magnetic energy when the stresses become too great. It is an open question as to just how this occurs. For example, is the heating gradual or impulsive? One promising mechanism is the secondary instability of electric current sheets, which produces nanoflare-like heating events. Many observations lend support to this idea, while others give reason for concern. I will review the status of theoretical and observational understanding of coronal heating, paying particular attention to recent results from Hinode.

Results from simulations extending from the convection zone to the corona

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With the advent of massively parallel computers it has finally become feasible to simulate the solar atmosphere in models that extend from the upper convection zone to the lower corona. These advances come fortuitously at a time when there is a wealth of high quality observational material available. Thus, it is to be hoped that progress can be made in understanding how the magnetic field couples the energy reservoir found in solar convection with the dynamic chromosphere and the hot tenuous corona. We will discuss recent models and compare the results derived with high resolution observations made with Hinode and at the Swedish 1-meter Solar Telescope.

Low frequency radio observations of magnetic field in the solar corona

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We report observations of circular polarized noise storm emission from the solar corona at 77 and 109 MHz during the period 11 – 18 August 2006 with the recently commissioned radio polarimeter at the Gauribidanur observatory (located about 100 km north of Bangalore). The estimated average degree of circular polarization was 0.53 and 0.63 at 77 and 109 MHz, respectively. The Stokes I flux density was found to vary as $f^{0.84}$ between the above two frequencies. Corresponding two – dimensional imaging observations at 77 MHz with the radioheliograph at the observatory revealed that the noise storm source was closely associated with the sunspot region AR 10904 during CR 2046 and co-rotated with the Sun at the rate of ~23.6 degrees/day, during the above period. We independently derived the radial distance of the corresponding 77 MHz plasma level from the above rotation rate and is ~ 1.71 R_s from the center of the Sun. Assuming that the magnetic flux at the photosphere and corona should be conserved, we calculated the magnetic field corresponding to the observed circular polarized emission from the above plasma level/radial distance and the average value is ~ 4.2 G.

Evolution of Solar Wind Density Turbulence in the near-Sun Region

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The interplanetary scintillation (IPS) at 327 MHz measured within a heliocentric distance of ~45 solar radii is strong and can provide information about the turbulence caused by the density irregularities as well as various coronal processes in the near-Sun region. In this paper, we analyse the shape of the density turbulence spectrum responsible for the near-Sun intensity scintillation using IPS measurements obtained from the Ooty Radio Telescope on different compact radio sources. The turbulence spectrum associated with the high-speed streams from the coronal hole is significantly different from that of the slow-speed wind originating above the close d magnetic field region. This study also clearly indicates that the scintillation is dominated by the density irregularities of size ~200 – 400 km. However, the scintillation at the smaller scales is although significantly less in magnitude, it has a flatter spectrum than the above dominant part. Further, the spectral power covered in the flatter portion decreases with distance from the Sun. The results on the spectral evolution of near-Sun scintillation include the effect of turbulence produced by the coronal wave phenomena.

Session V A: 9:00 – 11:00 Eruptive phenomena

The Rate of Coronal Mass Ejections and the Sunspot Number

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Sunspot number (SSN) has been the traditional measure of the level of solar activity. Coronal mass ejections (CMEs) originate from closed magnetic field regions on the Sun and constitute the most energetic phenomenon in the heliosphere. The daily rate of CMEs is known to be well correlated with SSN, but the correlation is less than perfect. The solar-cycle variations of the two quantities also significantly differ, especially during the solar maximum phase. This paper explores the reasons for the reduced correlation and the change in level of correlation with the phase of the solar cycle. The primary reason seems to be the bimodal nature of the CME sources on the Sun. While the vast majority of CMEs originate from solar active regions (where sunspots reside), a significant number of CMEs come from non-active region sources, viz., quiescent filament regions. During a three-year period around the maximum phase of a solar cycle, one observes a high rate of CMEs from the polar crown filament region, where there are no sunspots. Energetic CMEs also originate from quiescent filament regions in sunspot latitudes. Making use of the extensive and uniform CME data that became available in cycle 23, I separate CMEs from sunspot and non-spot regions to explain the observed relationship between SSN and the daily CME rate.

Recent Developments in the Modeling of CMEs and Flares

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The existence of eruptions in the solar atmosphere has been known for more than 150 years, yet the underlying mechanism that triggers those remains uncertain. Most present-day models for these eruptions are based on the principle that the energy that drives them comes from the free magnetic energy associated with electrical current flows in the solar corona. However, there is no general agreement as to what causes the rapid release of this energy at the onset of an eruption. One possibility is that the energy release is caused by a combination of ideal (loss of a stable equilibrium) and nonideal (magnetic reconnection) processes. The first process can explain the rapid onset of the eruption, but the second is needed to explain the large scale of the energy release. Several research groups around the world are currently developing three-dimensional models based on these two processes.

Energetics of CMEs

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We examine the energetics of 39 flux-rope like coronal mass ejections (CMEs) from the Sun using data in the distance range ~ 2-20 R_s from the Large Angle Spectroscopic Coronograph (LASCO) aboard the Solar and Heliospheric Observatory (SOHO). This comprises a complete sample of the best examples of flux-rope CMEs observed by LASCO in 1996-2001. We find that 69% of the CMEs in our sample experience a clearly identifiable driving power in the LASCO field of view. For these CMEs which are driven, we examine if they might be deriving most of their driving power by coupling to the solar wind. We do not find conclusive evidence in favor of this hypothesis. On the other hand, we find that their internal magnetic energy is a viable source of the required driving power. We have estimated upper and lower limits on the power that can possibly be provided by the internal magnetic field of a CME. We find that, on the average, the lower limit on the available magnetic power is around 74 % of what is required to drive the CMEs, while the upper limit can be as much as an order of magnitude larger. We also present a method for measuring electrical currents enclosed by the CMEs in this sample. Such currents are responsible for providing the Lorentz self-force that propels the CMEs. Our estimates for the driving current are based on measurements of the propelling force obtained using the methods outlined above. We find that the CMEs typically enclose currents of a few times 10^{11} Amperes.

Coronal mass ejection as a result of magnetic helicity accumulation

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In this talk, we present our understandings that coronal mass ejections (CMEs) are unavoidable products of magnetic helicity accumulation in the corona. We show that in an open atmosphere such as the solar corona the total magnetic helicity of a force-free field must be bounded and the accumulation of magnetic helicity in excess of its upper bound would initiate a non-equilibrium situation resulting in an expulsion such as a coronal mass ejection. We also show that the magnitude of the helicity upper bound of the force-free fields is non-trivially dependent on the boundary condition. Fields with a multipolar boundary condition can have a helicity upper bound ten times smaller than those with a dipolar boundary condition when helicity values are normalized by the square of their respective surface poloidal fluxes. This suggests that a coronal magnetic field may erupt into a CME when the applicable helicity bound falls below the already accumulated helicity as the result of a slowly changing boundary condition. Our calculation also shows that a monotonic accumulation of magnetic helicity can lead to the formation of a magnetic flux rope applicable to kink instability. This suggests that CME initiations by exceeding helicity bound and by kink instability can both be the consequences of helicity accumulation in the corona. Our study gives insights into the observed associations of CMEs with the magnetic features at their solar surface origins.

Session V B: 11:30 – 13:15

Three-dimensional Magnetic Reconnection

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Three-dimensional reconnection is much more diverse than two-dimensional reconnection and can occur both in the vicinity of null points, as well as in the absence of null points. It occurs continuously and continually throughout a diffusion region, as opposed to at a single point as it does in two dimensions. This means that in three-dimensions field lines do not reconnect in pairs of lines or even in sets of surfaces making understanding three-dimensional reconnection difficult. One important location for three-dimensional reconnection is at separators, special field lines that connect pairs of null points and lie along the intersection of the two separatrix surfaces emanating from the null points. By focussing on a series of three-dimensional resistive MHD experiments involving separator reconnection I reveal the local requirements and nature of reconnection along separators, as well as describing some of the global consequences of reconnection at multiple separators. Futhermore, I discuss the similarities and difference between separator reconnection in different atmospheric regions.

Statistical studies on CMEs

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Coronal mass ejections are spectacular ejection of material seen in the coronal field of view. Regular observations of these are possible either by ground-based or space-based coronagraphs. In this talk, I will present an overview of our current understanding of coronal mass ejections. I will describe observations of CMEs based on data from the space missions such as SoHO. Based on these data, the physical properties of CMEs, the mechanism of their initiation, their propagation in the interplanetary medium, and their geo-consequences will be discussed. Further, I will highlight the recent observations of CMEs recorded by internally occulted white-light inner coronagraph, namely, COR1, aboard the twin STEREO spacecrafts. The applications of these observations to 3-D reconstructions of the leading edge of CMEs will be presented. New observations from STEREO surpass the achievements of previous missions by providing an improved view of the 3-D structure of CMEs from two vantage points, specifically, in respect of their origin and evolution in the interplanetary medium. Finally, the implications of the new results for statistical modeling for forecasting space weather will also be briefly discussed.

Theoretical models of flares

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Recent space solar observations have revealed the key role of magnetic reconnection in solar flares and unified view of various types of flares, ranging from CME related flares at largest scale to nanoflares associated with tiny chromospheric jets at smallest scale. Here we review theoretical models of flares and discuss unified model of flares based on magnetic reconnection mechanism. We will also discuss the possibility of unification of solar and stellar flares with the same physical mechanism, i.e., magnetic reconnection.

Session VI: 14:30 – 15:55 Solar-Stellar connections

The Sun as a Star

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Solar Physics (usually) deals only with the Sun. Stellar Astrophysics can reach out to many thousands of stars in the Galaxy and allows us to place the Sun in a more general stellar context. In particular, we can address the question what solar properties are typical for stars at large and what kind of behavior is known only for the Sun or only for stars. A fundamental basic result of the last decades of cool star research is that magnetic activity is found for all stars with outer convection zones, at levels often exceeding the solar activity level significantly. In my talk I plan to concentrate on the following issues: (a) X-ray emission from the Sun and the stars (b) Sun spots and star spots (c) Solar and stellar flares (d) Solar and stellar cycles

Monitoring Solar Wind in the Near-Earth Environment with SWIM of the SARA Experiment aboard the Indian lunar Mission Chandrayaan-1

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The SARA experiment aboard the Indian lunar mission Chandrayaan-1 mission consists of two instruments: Chandrayaan-1 Energetic Neutral Analyzer (CENA) and the Solar Wind Monitor (SWIM). CENA will provide measurements of low energy neutral atoms sputtered from lunar surface in the 10 eV–3.3 keV energy range by the impact of solar wind ions. SWIM will monitor the solar wind flux precipitating onto the lunar surface and in the vicinity of moon. SWIM is basically an ion-mass analyzer providing energy-per-charge and number density of solar wind ions in the energy range 10 eV–15 keV. It has sufficient mass resolution to resolve H, He, O, Na/Al-group, K/Ca-group and Mn/Fe, with energy resolution of 7%, and angular resolution 9 deg (elevation) x 22.5 deg (azimuth). The viewing angle of the instrument is 17 deg x 160 deg. Mechanically SWIM consists of a sensor and an electronic board that includes high voltage supply and sensor electronics. The sensor part consists of an electrostatic deflector to analyze the arrival angle of the ions, cylindrical electrostatic analyzer for energy analysis and the time-of-

flight system for particle velocity determination. The total size of SWIM is slightly greater than a credit card and has a mass of 500 g. The moon's orbit provides a unique location to observe solar wind continuously over 27 days period around the Earth. The measurement with SWIM will provide a unique data base for near-Earth solar wind conditions over a 2 year period of the Chandrayaan-1 nominal mission life time. With solar wind measurements being made at L1 point (240 Re; Re = Earth's radius) and at around 6-10 Re, the SWIM will not only help to study lunar-solar wind interactions, but will also be of great importance to study changes in solar wind as it propagate from L1 point to Moon's orbit (60 Re) to Geostationary orbits.

Coronal activity in non solar-like stars

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Recent X-ray studies of intermediate-mass and massive stars outside their main sequence phase indicate that some of these stars show coronal type X-ray spectra. I will discuss evidence of coronal activity in this class of sources using Chandra high spectral resolution observations, focusing in particular on the case of G-type sources such as Theta-1 Ori E (a binary system of nearly identical G0 stars of sim 3.5 M_odot in their pre-main sequence phase), and post-main sequence G-type giants like HR 9024 (M sim 3 M_odot). I will present spectra and analysis of some of these stars, including line-based spectral characterization of spectra and dynamics. The high quality X-ray spectra suggest that these stars present solar-like X-ray activity in some phases of their lives possibly sustained by a transient solar-like dynamo mechanism.

FIP effect: stellar-solar connection

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First Ionisation potential or the so called FIP effect in the solar corona is a well known phenomenon. Abundances in the solar corona are correlated with the FIP of an element in that abundances of elements that have lower FIP (e.g; Na, K ..) are found to be higher compared to elements that have higher FIP (e.g; O, Ne ..). The cause for such anamolous abundances in the corona is not well known. However, such an effect is observed in the photospheres of some pulsating evolved RV Tauri stars. There are now atleast three stars which show FIP effect but in the reverse i.e elements that have lower FIP are much more depleted compared to elements that have higher FIP. Results from high resolution spectroscopic analysis of some of these stars and future plans to understand the connection between stellar photospheres and solar corona will be discussed.

Posters: Session I

P1: Long-term variations in the solar meridional flow determined by sunspot groups

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Using Greenwich and Solar Optical Observation Network sunspot group data during the period 1879-2006, we have looked for variations of the order of the length of a solar cycle in the mean meridional motion of the sunspot groups. We have analysed the data by binning it into the 4-years moving time intervals (4-years MTI) successively shifted by 1 year, because the data are found to be inadequate in an interval of the size smaller than 4 years. We find that the pattern of variation in the mean meridional motion of the spot groups differs considerably from one cycle to another, particularly between an even numbered cycle and its following odd numbered cycle. The FFT and a wavelet analysis of the 4-years MTI data suggest that there exists a 20-30 year periodicity in the solar meridional motion. Maximum amplitude of the variation in the mean meridional motion determined from the whole northern or southern hemisphere 4-years MTI data is found to be about 5 meter per second. Maximum amplitude of the corresponding variation determined from the data in 20-30 deg latitude interval of the northern or southern hemisphere is found to be about 10 meter per second. During the current cycle~23 (1997-2006, beyond 2006 the data are not available), which is anomalous in the sense that the cycles pair 22,23 violated the Gnevyshev and Ohl rule, the mean meridional motion of spot groups is substantially different from that during the last 10-11 cycles. That is, the motion is relatively strong around the maximum years of the current cycle (the average over a whole hemisphere is about 10 meter per second around the year 2000) and its direction is northward in both the northern and the southern hemispheres. Implications of this result for understanding the aforementioned abnormal behavior of the cycles pair 22,23 and the north-south asymmetry of solar cycle~23 will be briefly discussed.

P2: Low-Frequency Solar p Modes in Spatially Resolved Observations using m-Averaged Spectra

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We use more than 11 years of GONG and SOHO/MDI data to detect low- and medium-degree, low-order modes by constructing m-averaged, rotation-corrected spectra ("collapsograms") in which we have varied the rotational splitting to find the narrowest average profile, or the maximum likelihood, of a resonant mode peak to determine the rotation splitting, as well as the mode's average frequency, amplitude, and lifetime. The technique works well even when none of the individual- spectra are strong enough to be fit. This range of angular degrees corresponds to modes that are sensitive to the structure of the solar core and the radiative interior. Moreover, the low-frequency modes have deeper upper turning points, and thus should be less sensitive to the turbulence and magnetic fields of the outer layers, as well as uncertainties in the nature of the external boundary condition. In addition, as a result of their longer lifetimes, the determination of the frequencies of lower-frequency modes is more accurate.

P3: The Advanced Technology Solar Telescope (ATST)

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The 4m Advance Technology Solar Telescope (ATST) has as its highest priority science driver high resolution and high sensitivity observations of the highly dynamic solar magnetic fields throughout the solar atmosphere, including the corona. With its 4 m aperture, ATST will resolve features at 0.03" (20km on the Sun) at visible wavelengths. The science requirement for polarimetric 10-4 relative sensitivity (10-5 relative to intensity) and accuracy (5 x 10^{-4} to intensity) place strong constraints on the polarization analysis and calibration units. A high-order adaptive optics system delivers a corrected beam to the initial set of state-of-the-art, facility class instrumentation located in the Coude lab facility. The prospect of highly sensitive polarimetric observations in the near-infrared (and at longer infrared wavelengths) at high spatial resolution (0.08" @ 1.6 micron), that can be achieved from the ground in a consistent manner over long periods of time is particularly exciting. Instruments can also be mounted at the Nasmyth focus. For example, instruments for observing the faint corona preferably will be mounted at Nasmyth where maximum throughput and minimum stray light is achieved. The initial set of first generation instruments includes: the Visible-Light Broadband Imager (VLBI), the Visible Spectro-Polarimeter (ViSP), the Near-IR Spectro-Polarimeter (NIRSP), which includes a coronal module, and the Visible Tunable Filter.

P4: Improving our knowledge on the dynamics of the solar core: low-degree high-frequency p modes and g modes

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Solar gravity modes being modes that propagate mainly in the radiative zone, they represent the best tool to extract information on the solar core. Many attempts have been led to look for these modes. The latest detection, based on the asymptotic properties of g modes, was claimed by Garcia et al. 2007. It is interesting to study how low-degree high-frequency p modes are important to recover the rotation profile between 0.1 and 0.2R. We will use different simulated rotation profiles. Then, we will introduce a several tens of g modes in artificial inversions to see how they bring information on the solar core rotation.

P5: Are the Magnetic Fields of the Polar Faculae Generated by a Local Dynamo ?

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Polar Faculae (abbreviated as PF) are bright small – scale structures of dimensions of a few seconds of arc that populate the polar zones (> ±60 deg latitudes) on the Sun. They possess magnetic fields ranging from 150 to 1700 Gauss and constitute the magnetic fields at the poles. However, the question as to where and how the magnetic fields of the PF are generated in the solar interior remains open. Using measurements of the rotation rates of the PF, we show that the anchor depths of the magnetic flux tubes of the polar faculae lie in the sub-surface layers located at depths between r = 0.96 to 0.98 R_o. If so, it might be possible that the polar faculae are generated by a local dynamo located in the sub – surface shear layers at these depths.

P6: Meridional Motions on the Sun during the period 1906 – 1987
1. Evidence for the return meridional flow in the convection zone

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We have derived the meridional motions on the Sun using spot groups divided into 3 area classes (small, medium and large) as tracers, with the aim to detect the return meridional flow in the convection zone. This is based on the concept that spot groups of small and large areas have their flux tubes anchored at shallower and deeper depths respectively within the convection zone and that the meridional motions of the spot groups of different areas reflect those of the plasma layers at the respective anchor depths. Spot groups of the three area classes show mainly an equator ward flow. We interpret this as evidence of the return flow in the interior at the three depths that correspond to the anchor depths of flux tubes of spot groups of the three area classes. The sun spot data we have used are from our measurements of the Kodaikanal White light images for the period 1906 – 1987.

P7: Propagation and generation of waves in solar and stellar atmospheres

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The fact that the temperature increases with height in the solar atmosphere and in atmospheres of late-type stars has been known for many years. To maintain this temperature increase, sources of heating must be present in these atmospheres. One of the most important, and still unsolved, problems in stellar astrophysics is to identify the basic physical processes responsible for the heating, and explain stellar activities caused by this heating. It has been shown that acoustic and magnetic waves generated in stellar convection zones are prominent sources of the heating. Recent studies also demonstrated that the wave energy may excite atmospheric oscillations, which can be used as indicators of stellar activity. In this dissertation, new theoretical tools to study the propagation and generation of acoustic and magnetic waves in non-isothermal stellar atmospheres are developed. The tools are used to determine the rate of wave generation and the conditions for wave propagation. Specific applications include the generation of acoustic waves in non-isothermal and magnetic-free regions and torsional waves inside isothermal and non-isothermal magnetic flux tubes, calculations of cutoff frequencies for different waves for vertical and inclined flux tubes.

P8: Are active regions responsible for modifying oscillation frequencies?

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The oscillation frequencies are known to vary in phase with the solar activity cycle; however the basic mechanism that causes this change is not yet understood. Detailed analysis of improved and continuous measurements of intermediate-degree mode frequencies for solar cycle 23 have pointed out a complex relationship between them. Our recent work suggests that the frequencies do not correlate well with the solar activity at all phases of the solar cycle. A strong correlation is seen during the rising and declining phases whereas at high-activity phase a significantly lower correlation is found. In particular, the proxies sensitive to strong magnetic field have much lower correlation at high-activity phase. Thus, the argument that the frequency variation depends on the magnetic field associated with the active regions on the solar surface is questionable. In this context, we investigate the variation of high-degree mode frequencies as a local response to the active regions. We also attempt to suppress the effect of localized magnetic field and study the response of the frequencies. Detailed analysis procedure and consequences of suppressing active regions on the results will be presented.

P9: Alpha Effect on the Solar Atmosphere

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The upper solar atmosphere is a region of partially ionized plasma. In such plasma the magnetic induction is subjected to the ambipolar diffusion and the Hall effect in addition to the usual resistive dissipation. In this paper we initiate the study of the alpha dynamo in partially ionized turbulent plasma. The Hall effect arises from the treatment of the electrons and the ions as two separate fluids and the ambipolar diffusion due to the inclusion of neutrals as the third fluid. It is shown that these nonideal effects modify the so called alpha effect and the turbulent diffusion coefficient beta in a rather substantial way. The Hall effect may enhance or quench the dynamo action altogether. The ambipolar diffusion brings in an alpha which depends on the mean magnetic field. The new correlations embodying the coupling of the charged fluids and the neutral fluid appear in a decisive manner. The turbulence is necessarily magnetohydrodynamic with new spatial and time scales. The nature of the new correlations is demonstrated by taking the Alfv'enic turbulence as an example.

Posters: Session II

P10: Hanle effect as a diagnostic of photospheric turbulent magnetic fields

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The solar surface magnetism manifests itself in the form of mixed polarity field (99%), with the remaining 1% being well directed in solar active regions. Despite a large filling factor, the inherent nature of the random field is not yet fully understood (see Stenflo 2004; and Trujillo Bueno et al. 2004). The theoretical framework required for its exploration are magneto-convection simulation, and radiative transfer modeling. Unresolved mixed polarity fields are invisible to the Zeeman effect but leave polarimetric signals for the Hanle effect. It is not yet clear whether the random component is weak, or spread over a wide a spectrum (milli to kG) of field strengths; the spectrum of the correlation length of the fluctuations is also largely unknown. A basic theory of polarized line formation in weak random fields has been developed recently (Frisch 2006). It is applicable to random magnetic fields with a finite correlation length of fluctuations and an arbitrary magnetic field vector distribution (PDF). Up to now, only the simplified case of micro-turbulence (zero correlation length) was considered. We have developed a powerful numerical method to solve the Hanle scattering transfer problem for random magnetic fields with finite correlation length, under solar atmospheric conditions. The sensitivity of the Hanle effect, to the magnetic field correlation length and to the shape of its PDF, is presented for various types of spectral lines. We use PDFs which can simulate the random component of the solar weak magnetic fields. References: Frisch, H.: 2006, A&A 446, 403 Stenflo, J.O.: 2004, NATURE, 430, 304 Trujillo Bueno, J., Shchukina, N., and Asensio Ramos, A.: 2004, NATURE, 430, 326.

P11: Magnetic Feature Tracking and the Small Scale Dynamo

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Magnetic feature tracking (MFT) allows unprecedented views into the ensemble behavior of the smallest scale magnetic flux concentrations visible on the Sun. We have used MFT to probe the nature of the small scale dynamo. The statistical behavior of small flux features indicates that the solar network may be thought of primarily as a stochastic phenomenon produced by the random interaction of myriad unresolved magnetic flux tubes. There are some parallels between the behavior of the small scale magnetic field and the behavior of exciton pseudo-particles in a semiconductor.

P12: SST/CRISP magnetometry with Fe I 630.2 nm

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We present recent full Stokes observations in the Fe I 630.2 nm line with CRISP, an imaging spectropolarimeter at the Swedish 1-m Solar Telescope (SST). The observations reach a spatial resolution of 0".16, close to the diffraction limit of the SST, representing a major improvement over any past ground based or space based spectropolarimetric data. We describe the data acquisition and reduction methods and present results of Milne-Eddington(ME) inversions applied on observations of plage.

P13: A Power-law Distribution of Solar Magnetic Fields Over Six Decades in Flux

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Using SOT, MDI (high-resolution and full disk) magnetograms magnetic flux features are identified in the photosphere. It is found that by using a `clumping' algorithm, which counts a contiguous group of pixels above a g iven cutoff as one feature, all feature fluxes, regardless of flux strength, follow the same distribution – a power-law of slope -1.85\pm0.15 – between 2\times $10^{\{16\}}$ and a few times $10^{\{22\}}$ Mx. This result suggests that the mechanism producing magnetic features on all currently observable scales appears to be the same. The implications of this result for the solar dynamo and surface processes is discussed.

P14: On a possible method for measuring magnetic field strength in the outer corona

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Magnetic field strength in the outer corona at heights > 0.2 solar radii is generally derived indirectly from the properties of meter wavelength radio bursts and by extrapolation of the optical measurements of the photospheric field using the potential source surface model. It is pointed out that the thermal radiation of the quiet sun and active regions will be polarized due to the anisotropy arising out of the existence of magnetic fields in the corona. Circular polarization characteristics of the low radio frequency thermal radiation can therefore, be used to estimate the magnetic field strength directly.

P15: An estimation of the coronal magnetic field using multiple type II radio bursts

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Multiple type II solar radio bursts observed on January 23, 2003 in the band 30 – 130 MHz were used to estimate the strength of the magnetic field simultaneously at two different heights in the solar corona. The strength of the magnetic field was estimated using 1 to 5 times the Newkirk's density. The magnetic field varied from about 1.47 to 2.16 Gauss for the first type II burst and from 1.13 to 1.76 Gauss for the second type II burst for the above densities. The coronal magnetic field strength was found to vary with height according to power law with the power index varying from -3 to -2 for densities 1 to 5 times the Newkirk's density. For coronal temperature of 1 X 10^6 K and 2 X 10^6 K, the derived value of plasma beta was in the range of 0.07 to 0.7 in the solar heights of 1.2 to 1.7 solar radii.

Posters: Session III

P16: Properties of the outer penumbra

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Penumbrae of sunspots remain intriguing and partly enigmatic objects that for many years have escaped a consistent and complete description. Our understanding of the structure and physical processes acting in the inner and the central parts of penumbrae have recently been significantly advanced by advanced instruments including the Hinode spacecraft and numerical simulations. In particular, there is now strong evidence for the existence of convective-roll-like processes in the inner and mid penumbra (i.e. overturning convection in the presence of a horizontal magnetic field). However, it is unclear if the same process also dominates the energy transport in the outer penumbra. In this presentation we discuss properties of the outer penumbra as revealed by broad-band time series and spectropolarimetric observations recorded by the Solar Optical Telescope on Hinode.

P17: On the observation of flare driven oscillation modes in the Sun

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The study of the effect of flares on the oscillations of the Sun has been in focus since the advent of helioseismology. There has been significant progress in this field in the last solar cycle with the inflow of continuous data from the instruments onboard SOHO spacecraft and ground based network of telescopes, GONG. Here, we have used disk integrated velocity signals at the solar surface obtained from SOHO/MDI and GONG+ full-disk Dopplergrams to study the flare induced velocity oscillations during the major solar flare (X17.6/4B) of 2003 October 28. We observe that these velocity oscillations are enhanced significantly during the flare in the higher frequency band (5-6.5 mHz) while there is feeble or no enhancement of these oscillations in lower frequency band (2-4 mHz). We also observe the presence of high frequency power in these velocity oscillations of the Sun comparable to granulation power even in non-flaring condition. Thus, does the local tremors in the Sun account for the enhancements in the global high-frequency oscillations of the Sun?

P18: The subsurface magnetic structure of solar active regions

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Helioseismologists have been successfully using acoustic waves to probe the structure of solar interior. There has been less success in probing magnetic fields because the pure acoustic waves become magneto-acoustic waves when they propagate through the solar active regions. While the sound-speed difference between two regions of the Sun is directly related to the temperature difference between those two regions, the wave-speed difference of magneto-acoustic waves does not have a simple relation with either the thermal structure or the magnetic structure. The aim of this work is to derive a simple way to correctly infer differences in the magnetic and thermal structures below pairs of active and quiet regions. While we cannot determine differences in the magnetic field, B, we can determine differences in beta, the ratio of magnetic to gas pressure. Our results show that the effect of magnetic fields is strongest in a shallow region above $0.985R_o$ and that the strengths of magnetic-field effects at the surface and in the deeper ($r < 0.98R_o$) layers are inversely related, that is, the stronger the surface magnetic fields the smaller the magnetic effects in the deeper layers, and vice versa. Our study also indicates that there are indeed non-negligible β in the quiet regions and that the profile of β varies from region to region, but is more uniform and stable than that in the active regions.

P19: Vector magnetic field inversions of high cadence SOLIS-VSM Flare data

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We examine full Stokes observations by SOLIS-VSM in the photospheric lines Fe I 6301.5 and 6302.5. The data have high spectral and temporal resolution, moderate spatial resolution and large polarimetric sensitivity and accuracy. Datasets are processed with the inversion code LILIA, an LTE code written by Hector Soccas-Navarro. This results in photospheric maps of the full magnetic field vector. We analyze an active region during an X-class flare recorded in September 2005. Making use of additional available data on this particular active region, we hope to obtain a more complete picture of the magnetodynamics governing a flare.

P20: Spectral Analysis of Sunspot Penumbrae Observed with HINODE

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The nature of the energy transport in the penumbrae of sunspots is a controversially discussed aspect at the moment. Is it convection in magnetic field free gaps that exist in the space separating areas of strong magnetic field which is more or less static? Is it a convective flow that is channeled by magnetic flux tubes? Or is it by means of dissipative turbulent magneto-convection? To investigate the plasma flow on a small scale we used spectropolarimetric data of sunspots at different heliocentric angles recorded by HINODE. We created maps of apparent Doppler velocities by taking advantage of the line shift of Fe 630.15 nm with respect to an averaged Fe 630.15 line core of the quiet Sun. Since we deduced the line shifts in the wing of Fe 630.15, that is, between 85 % and 95 % continuum intensity, we were able to visualize the flow pattern in the low photosphere. In sunspot penumbrae close to disk center, the flow pattern along the line of sight, which we interpret as the vertical component of the Evershed flow, consists of a series of elongated 'pearl chain' like structures, extending radially through the entire center side penumbra. The up-flow appears not as a single elongated filament, but is concentrated in patches of strong up-flow separated by weaker up-flow or even down-flow. Due to projection effects the down-flow appears stronger on the limb side penumbra, but it is dislocated and spread out over a wide area in the outer penumbra. For sunspot penumbrae at large heliocentric angles these patterns are obscured by a combination of the horizontal Evershed flow and projection effects, but they are still ascertainable.

P21: Temperature structure from Ca II H using filtergrams

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A method in development to extract temperature at different depths from the Ca II H&K lines using filtergrams is presented along with preliminary inversion results. The inversions give information up to a height of 200–300 km. We make use of the Swedish 1-m Solar Telescope (SST) blue filter setup which allows for simultaneous observations in four filter positions including a 1-Å tunable filter that scans through the Ca H blue wing.

P22: Observations of the Evershed flow velocity of the sunspots during 100 years

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Right from the discovery of Evershed effect, observations of Evershed flow velocity of the sunspots is surveyed from the literature. Aim of the present study is to examine whether Evershed flow velocity of the sunspots is dependent on the strength of the solar activity cycle or not. Preliminary analysis of the extensive survey of the literature shows that the magnitude of the velocity of the Evershed flow of the sunspots is independent of the strength of the solar activity cycle. In the light of these results, Gokhale and Hiremath's model (1986) on the Evershed flow of the sunspots is discussed and compared with other theoretical models.

P23: Average thermal structure of the sunspots during their initial appearance

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During their life spans, the sunspots immensely contribute to the solar irradiance variations and influence on the Earth's environment and climate. Understanding of sunspots' contribution to the solar irradiance variations will also be useful in understanding and delineating the contribution due to stellar spots for the stellar irradiance variations and hence without ambiguity signal due to extra-solar planets can be detected. As the spot groups with different life spans have distributed anchoring depths (Hiremath, K. M., A & A, 386, 674, 2002 and references there in), observations of the sunspots' dynamics, magnetic field and thermal structures during their initial appearance on the surface can be used for inferring these physical variables in the convective envelope. Ultimate aim of the present study is to estimate thermal structure of the convective envelope. Keeping in mind these crucial views, for different sizes and life spans during their initial appearance on the surface and by using SOHO/MDI continuum images, we measure the average intensity of the umbra and the whole spot and, compute the intensity of penumbra and, umbra penumbra intensity ratio. We also compute average temperature of the umbra, penumbra and the whole spot. Important findings of this preliminary study are: (i) smaller spots are brighter than the larger spots, (ii) depth of the penumbra may be shallower compared to the depth of the umbra, (iii) brighter umbrae have brighter penumbrae and vice versa and, (iv) umbra penumbra ratio-a measure of thermal structure of the convective envelope-is different for different life spans indicating different temperature structure of the sunspots at their anchoring depths.

P24: Dynamics of Small-scale Features seen in Sunspots

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We present the investigation carried out on the large decaying sunspot region NOAA 8350 observed during 05-14 October 1998 at National Solar Observatory (NSO), Sunspot, USA, using Dunn Solar Telescope. High-resolution observations were taken on 1kX1k CCDs with the application of UBF in 557.1, 557.6, 630.2 and 656.28 nm on one side, and parallel in G-band on other side with a plate scale ~0.118”/pixel. Our analysis of higher quality observations on 08 October 1998 with superb seeing conditions (~0.25”) revealed m any interesting results: (i) umbral dots inside the sunspot showed upward velocity of ~400 m/s surrounded by downward velocity of ~300 m/s suggesting clear evidence for a convective origin of the umbral dots. (ii) the light-bridge crossing over the umbra of the sunspot showed opposite polarity with respect to the umbra, and the plasma ejection followed by the Ellerman bombs. We discuss our results in context to currently existing theories of monolithic and cluster flux-tubes, and conclude that monolithic model suits better to explain magnetoconvection in umbral dots. The opposite polarity of the light-bridge with parent umbra and the plasma ejection seen in H-alpha suggest possibility of low-altitude reconnection near upper chromosphere. We propose a model to interpret our observations and results.

P25: Atmospheric Stratification of Sunspot Light Bridge from inversion of Strokes profiles as recorded by Hinode

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We present here the height stratification of sunspot light bridges. We have used here the 04/07/07 Hinode spectropolarimetric data to reval the vertical structure of sunspot light bridge. We find here the temperature decrement in middle of sunspot light bridge and a canopy structure. The gas density is also studied over the light bridge structure and is found to vary from middle to outwards.

P26: Correlation between the torsional oscillations and the sunspot cycles

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The most well-established periodic temporal variations in the solar differential rotation are torsional oscillations, which have been systematically measured since 1986. The torsional oscillations of a cycle begin around two years before the sunspots of that cycle appear and at a latitude higher than where the first sunspots are subsequently seen. Analyzing these two cycle data, we shall explore whether there is any correlation between the strength of the solar cycles and that of the torsional oscillations. Also a methodology for a theoretical investigation of this correlation based on a dynamo model will be outlined.

P27: Magnetic Structure of a Sunspot Light Bridge as Revealed by Hinode

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High resolution spectropolarimetric observations of a sunspot light bridge in NOAA AR 10953 were made on 2007, May 01 by the Japanese Space Satellite, *Hinode*. The observed Stokes profiles were inverted using the inversion code MELANIE, which assumes a Milne-Eddington atmosphere to retrieve the magnetic field. Inversions of the Stokes profiles were also carried out using SIR at 3 slit positions across the light bridge which yielded the thermal and magnetic parameters as a function of optical depth. It is observed that the light bridge, which is an extension of the penumbra, comprises of relatively weak, inclined magnetic fields with localised regions of strong downflows exceeding 3 km/s. The field azimuth is rotated by more than 70^{circ} on the light bridge where strong asymmetric linear polarisation signals are seen, which have not been previously observed. This indicates an inhomogeneous transverse magnetic field along LOS. In addition we also find double-lobed Stokes V profiles at localised regions on the light bridge. The weak horizontal fields on the light bridge are blanketed by the umbral field that essentially forms a "canopy". The line center image reveals the presence of a dark lane which is absent in the continuum image. The presence of the same is seen in the 2D temperature maps provided by the inversions using SIR. The 2D magnetic field structure indicates that a light bridge is field-free only in a localised region. We provide a scenario for the magnetic topology of the light bridge that explains the azimuth rotation and the observed, non-ideal Stokes profiles. These anomalous, linear and circular polarisation profiles are possibly a result of 2 magnetic components separated in height along LOS, within the line forming region of the Fe sc i lines. These 2 components correspond to the relatively weak, inclined fields on the light bridge and the over lying umbral field that bends across the light bridge respectively.

P28: 3D Velocity Flows in Flare Productive and Dormant Active Regions

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In solar cycle 23 some active regions, such as, NOAA 9704, 10486, 10656 etc., produced extremely energetic flares and CMEs. It is expected that characteristically these active regions should be distinct as compared to other less flare-productive active regions. In order to identify any distinguishing features in the internal structure and dynamics related to the level of flaring activity, we have have studied velocity flows in several active regions and their correlation with magnetic and energetic transient activities. To investigate these characteristic properties, we have also derived the vorticity vector and the kinetic helicity density of subsurface flows using ring diagram analysis. Some recent results are presented.

P29: Numerical Models of Travel Time Inhomogeneities in Sunspots

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We investigate the direct contribution of strong, sunspot-like magnetic fields to helioseismic wave travel time shifts via two numerical forward models, a 3D ideal MHD solver and MHD ray theory. Two measurement geometries are employed in estimating the travel-time inhomogeneities, namely single-skip centre-to-annulus and common mid-point deep-focusing, the latter chosen so as to avoid oscillation signals inside strong field regions. We confirm some existing ideas and bring forth new ones: i) that the observed travel time shifts in the vicinity of sunspots are overwhelmingly governed by MHD physics and not reflective of the underlying thermal structure (sound-speed decrease at all depths), ii) the travel time shifts are sensitively dependent on frequency and phase speed filter parameters and the background power below the p_1 mode, and iii) despite its seeming limitations, ray theory succeeds in capturing the essence of the travel-time variations as derived from the MHD simulations.

P30: A new look at the sunspot numbers in relation to coronal background X-ray emission

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The solar soft X-ray background flux derived from GOES 1-8 A measurements for the period 1974 to 2006, spanning a period of three solar cycles, is studied. Wagner (1988) determined the daily 1-8 A X-ray background flux (XBF) in the form of monthly averages and annually smoothed values for the years 1974 to 1988 (solar cycle 21). We analyze this data in conjunction with Kodaikanal photoheliogram data and the Greenwich sunspot data to find that the sunspot areas represent well the 1-8 A background X-ray flux on the time scales of a solar cycle. We further demonstrate the tight relationship of background X-ray flux with sunspots using Greenwich sunspot area data for solar cycles 22 and 23 also. Consistent correlations over three solar cycles suggest a strong relationship between the flux emergence at the locations of strong field regions, sunspots, and the coronal heating processes that ultimately result in coronal X-ray emission. We further find that the pattern of variation of sunspot numbers [R=k (10g + n)] derived from the white light images show noticeable deviations from the pattern depicted by the sunspot areas when compared to XBF. A weightage factor, such as W_i, assigned to individual spot groups in R=k ($W_i g_i$ + n) may provide better estimation of the true strength of solar cycles. References: Wagner, W. J., 1988, Adv. Space Res., 8, 67.

P31: USO Solar Vector Magnetograph (Phase-III) :: Upgradation to high-cadence spectro-polarimetry

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The Solar Vector Magnetograph is a modern imaging spectro-polarimeter installed at USO, Udaipur. Earlier phases saw the development of the instrument using off-the-shelf components with in-house software development. Subsequently improvements were done in the opto-mechanical design of the sub-systems and the telescope tracking system. The third phase of the instrument development saw three major improvements, these include: (i) installation of a web-camera based telescope guiding system, developed in-house, (ii) high-cadence spectro-polarimetry using Liquid Crystal Variable Retarders and fast CCD camera and (iii) inclusion of Na 589.6 nm line for chromospheric observations. In this contribution we will present the performance characteristics of the instrument and its characterization using HINODE/SP observations.

P32: Observations of the Evolution of a Primitive Penumbra

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Sunspots are the manifestation of strong magnetic fields that emerge in the solar photosphere. Although sunspots are stable configurations when compared to the dynamical time scale of ~1 hour, the observed umbral and penumbral fine-structure is very dynamic and subjected to constant change and transformation on small spatial scales. Our understanding of these processes and the nature of the fine structure improved significantly in the last decade, but we still lack detailed knowledge about particularly the key process of penumbral formation and decay. Observations of this process are very rare and in many cases limited to imaging information only. It is known that sunspot penumbrae form relatively fast and hence catching them at the right time is not easy to accomplish. We report about high-spatial resolution observations that witness the transformation of a primitive penumbra into a penumbral segment in the decaying follower of active region NOAA 10837 on December 22, 2005 obtained at the Dunn Solar Telescope (DST), Sunspot, NM, USA. The Universal Birefringent Filter (UBF) and the Diffraction Limited Spectropolarimeter (DLSP) were used in conjunction with the high-order AO system to acquire sequences of line scans of Halpha and Fe I 543.4 nm and spectropolarimetric maps in the Fe I 630.15 nm and Fe I 630.25 nm lines. The observations are also supported by Gband and CaK imaging. We determine the LOS velocities and proper motions and how they vary in time and the growth rate of the penumbral areas. The spectroplarimetric observations are used to determine the magnetic field geometry. In this paper, we will present preliminary results and discuss the implication on the current understanding of the formation of sunspot penumbrae.

P33: On the high frequency oscillations in the chromosphere above sunspots

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Using high spatial resolution (2 arcsec), and temporally unevenly sampled H-alpha observations from the 15 cm Solar Tower Telescope at ARIES, we investigate the intensity oscillations in the chromosphere above the sunspots, with a view to tracing the existence of high-frequency oscillations there. Using classical periodogram method, we find rare signature of high-frequency oscillations with periods between ~ 20 s and ~ 30 s in the chromosphere above the sunspots with the significance level between ~95 – 100 %. These oscillations may represent the fast MHD waves generated either by chromospheric shocks or by small-scale magnetic reconnection. The new observations may shed new light on the lower solar atmosphere dynamics.

P34: Dynamics of active regions revealed by tracking of Doppler features

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We investigate the large-scale horizontal dynamics of active regions in the 23rd solar cycle. The large-scale horizontal velocity fields were measured applying the local correlation tracking (LCT) algorithm to the processed high-cadence full-resolution full-disc MDI Dopplergrams. This method was developed recently using synthetic data and tested by comparison with results of the time-distance helioseismology. We performed the selection of NOAA active regions in the available dataset and followed their individual evolution in time. Our dataset consists of 1004 full-disc flow maps, in which we identified 568 active regions of various types, 503 of which were recorded in more than one flow map. The statistical study of this sample gives us a unique opportunity to study the dynamics of active regions in various stages of their evolution. In few cases, we found behaviour that is consistent with the dynamical disconnection of sunspots from the magnetic roots recently proposed by Schuessler & Rempel (2005, A&A 441, 337).

P35: The Butterfly Diagram Resolved

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This work originates from the need to get a picture of the spot zone so sharp that it may efficiently help us to place tighter and more realistic constraints than we usually do on dynamo models. The suitability of Maunder's butterfly diagram (BD) to serve, in its original version, for such a purpose is criticized, since it merely registers the presence of spot groups, ignoring by design any difference among them. Using sunspot data obtained at INAF – Osservatorio Astrofisico di Catania, during cycles 20 through 23, I have constructed a new version of the BD, representing the distribution of spotted area in a latitude-time diagram. Visualizing it by a set of level lines, the internal structure of Maunder's "butterfly wings'' becomes visible for the first time. The outermost contour lines show, confirming previous results found by this author (Ternullo; 2007, Solar Phys. 240, 153; 2007, Astron. Nach., 328, 1023), that the spot zone interrupts its over-all equatorward drift several times per cycle, shifting back toward higher latitudes. Higher and higher level contour lines form concave arcs which more and more deeply penetrate the "butterfly wings'', and eventually split into close lines, embracing small portions of the time-latitude diagram; they correspond to photopheric sites whose extension does not exceed ~5 or 6° in latitude; there, the spot production rate is higher than in the neighbourhood, for time intervals not longer than one year. The BD reveals, therefore, a markedly discrete structure: the solar activity splits into "knots'' of activity, involving different photospheric regions at different epochs, throughout the whole cycle. Spots are not scattered about one latitude continuously drifting equatorward as usually believed, but about as many latitudes as the knots are, at as many epochs in the cycle. The cycle history is but the history of a sequence of knots activations and extinctions. The latitude of a given knot may be either higher or lower than that of the previous one; it is constant throughout the knot lifetime. As a knot forms, the role of “active latitude’’ passes from a latitude to another, so as to account for the zigzagging poleward/equatorward drift of the spot zone centroid, described by this author. Looking for some kinds of regularity governing the knots activation throughout the cycle is the new challenge this work brings to the attention of the scientific comunity.

P36: Evolution of Helicity and Energy in active region NOAA 10930

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A X3.4 class solar flare was observed from the active region NOAA 10930 (S06W35), which started at 02:14 UT on 13^{th} December 2006. We study the energy and helicity budgets for the eruption. HINODE (SOT/SP) data for 12, 13 and 14 December is used for the study of pre and post eruption cases. Also the critical threshold for twist in the active region is calculated. It is known that the magnetic tension is reduced in highly sheared magnetic field regions e.g., polarity inversion lines. We study the evolution of magnetic tension near the polarity inversion line of NOAA 10930 to check if the loss of magnetic tension was the possible cause of its eruption. We try to establish a relation between the global twist and the average tension of bipolar active region. This is an effort to decide a critical value for these parameters to forecast the flares.

P37: Does coronal rotation period depend on the sunspot number?

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The solar rotation is known for very long time, but still there unsolved issues of its variability of both type; spatial and temporal. There were two approaches used for the estimation of rotation (i) tracer method – based on visual tracing of solar features in consecutive images and (2) the spectroscopic method. The feature tracing method was largely used for the estimation of rotation of photosphere and chromosphere. Recently this method has been successfully used for the X-ray bright points to determine coronal rotation. For the coronal rotation is there are three observational approach e.g. Fe XIV and X lines, soft X-rays, and radio waves. The multi-frequency radio measurements of Sun revealed that there is differential rotation in corona as a function of altitude. The comparison of rotation period estimates from optical and radio method show both the similarities and disagreements. The disagreements are in excess of 2 days. The long term variability of the coronal rota tion period show that there are three components in this variability; irregular component, 11 year variation which is related to the sunspot number and 22 year component which may be related to solar magnetic field reversal or Hale effect. The radio images at 17 and 34 GHz are also used for the determination of coronal rotation at the height of their emission, the estimates show differential rotation as a function of latitude. Thus corona has differential rotation both as a function of latitude and altitude. Here radio measurements of coronal rotation will be presented and compared with the optical and X-ray.

Posters: Session IV

P38: Influence of magnetic fluctuations and solar plasma density on the solar wind-magnetosphere coupling efficiency

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Field orientation within the transient and the corotating structures, ejected from the sun and later evolved in the interplanetary space, are considered to be crucial for the reconnection between the solar wind and the magnetosphere. However, fluctuations in the magnetic field and/or enhancements in plasma density might influence the coupling between the solar, interplanetary and magnetospheric fields. Consequently, the geoeffectiveness of the solar wind structures with enhanced field variance and density are likely to increase. We study the effects of both the enhanced field fluctuation and the plasma density on the magnetic reconnection/coupling efficiency. We consider solar plasma/field properties, particularly the field fluctuation and plasma density before, during and after interplanetary events of geospace consequences. Considering geoeffectiveness of different magnitude as a measure of coupling efficiency/reconnection rate, we study the influence of the enhancements in solar plasma density and field fluctuations on the solar wind-magnetosphere coupling efficiency, during southward field orientation within the interplanetary structures.

P39: Spatial & temporal correlation between the fine scale features in Gband and Ca II Hline images from Hinode/SOT Observations

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A 1hour long time sequence of the Gband and Ca II H line images obtained on April 14, 2007 from 17:00 hrs to 18:00 hrs taken simultaneously by Solar Optical Telescope onboard the Hinode Mission have been analyzed. The Solar SoftWare (SSW) in IDL has been used to analyze these images. In each sequence, we selected 20 BPs and derived the light curves. A power spectrum analysis on GBPs and CaBPs data has been performed to determine the periods of intensity oscillations. The simultaneous frames of Gband and Ca II H line are compared for spatial correlation and found that there is onetoone spatial correspondence between the GBPs and CaBPs. This suggests that the CaBPs are magnetic in origin. The power spectrum of GBPs and CaBPs reveal that they are associated with 2-5 min and 3-4 min period of intensity oscillations respectively. The correlation factor is determined for the corresponding light curves of GBPs and CaBPs to find the time period of progressive waves from photosphere to chromosphere region. We found that there is a phase lag between the two light curves and it is suggesting for propagating waves.

P40: Viscous damping of Alfven surface waves at a tangential discontinuity with steady flows in the solar atmosphere

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The dispersion relation for Alfvén Surface waves propagating along the moving viscous plasma-vacuum interface has been derived and solved numerically. The plasma region above the interface is assumed to be moving parallel to the direction o f the background magnetic field. This interface supports two modes of viscous-damped Alfvén surface waves when the upper layer is static. However, when the flow is introduced, new modes start evolving in addition to the existing modes and the damping due to viscosity increases. The damping length of Alfvén surface waves due to viscosity in the solar atmosphere has been estimated.

P41: Spectroscopic Diagnostics of Polar Coronal Plumes Observed from Space

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Polar coronal plumes are ray-like structures aligned along open magnetic field lines in polar coronal holes. A total eclipse of the Sun in white light shows up structured rays, depicting the magnetic nature of the Sun. Many studies have been carried out to map these rays with coronal magnetic field inferred from the current-free photospheric magnetic field extrapolations. These rays, known as ‘polar coronal plumes’, seem to play a role in the acceleration mechanism of the fast solar wind. They have been extensively observed from space across the electromagnetic spectrum. Extensive investigations have been made in unraveling the appearance and disappearance of these polar coronal plumes. The fact remains that we know little about them, probably because we have little direct knowledge of coronal magnetic field. In this paper, we briefly discuss the observations of polar coronal plumes from space with a view to understanding their three-dimensional structure. Using these observations, especially from SUMER/SOHO, we will deduce density, temperature, flows, and abundance anomaly (if any) in plumes and discuss their implications in further understanding of these structures in the Sun’s atmosphere.

P42: Long-period Transversal Waves in the Chromosphere as seen by EIS/Hinode

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We detect, for the first time, the long-period oscillations (~ 10 min) in high-resolution chromospheric He II 256.32 Å spectral line observed by EIS/Hinode. These oscillations are transverse to the magnetic field and can be caused either by incompressible Alfvén waves or by transverse tube kink waves. In the first model, Alfvén waves can be parametrically excited by well known photospheric ~ 5 min oscillations. In the second model, the transverse oscillations are interpreted as the wake behind the propagating kink pulse, oscillating at natural frequency of the medium. The kink pulse can be excited by granular buffeting on the anchored magnetic tube. Temporal damping of these observed oscillations supports the model of kink pulse propagation. We discuss the wave-linkage from the Sun's sub-surface energy reservoir to its outer layers with a view to resolving the long-sought energy transport and heating mechanism (s) in the solar atmosphere. Exploring the role of transversal waves in heating the solar corona and accelerating the wind, we report that the estimated observed waves' energy flux of ~ 5·106 erg cm-2 s-1 is sufficient to feed the quiet Sun chromospheric and coronal energy losses.

P43: On the Role of Acoustic-gravity Waves in the Energetics of the Solar Atmosphere

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We revisit the dynamics and energetics of the solar atmosphere, using a combination of high-quality observations and 3D numerical simulations of the overshoot region of compressible convection into the stable photosphere. We discuss the contribution of acoustic-gravity waves to the energy balance of the photosphere and low chromosphere. We demonstrate the presence of propagating internal gravity waves at low frequencies (<5mHz). Surprisingly, these waves are found to be the dominant phenomenon in the quiet middle/upper photosphere and to transport a significant amount of mechanical energy into the atmosphere outweighing the contribution of high-frequency (>5mHz) acoustic waves by more than an order of magnitude. We compare the properties of high-frequency waves in the simulations with results of recent high cadence, high resolution Doppler velocity measurements obtained with SOT/SP and SOT/NFI on Hinode. Our results seem to be in conflict with the simple picture of upward propagating sound waves. We discuss the implications of our findings on the energy flux estimate at high-frequencies.

P44: On the statistical detection of propagating waves in polar coronal

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Waves are important to the study of dynamical processes in coronal holes and the acceleration of the fast solar wind. Spectral time series was taken with the SUMER spectrometer on-board SoHO on the 20th October 1996. The observations were obtained in the transition region line, N iv 765 Å, and the low coronal line, Ne viii 770 Å. To detect the presence of waves and to study their characteristic properties in terms of their propagation speeds and direction. Previous statistical studies, undertaken with data from the CDS spectrometer, report the presence of waves in these regions. We extend this analysis using SUMER observations. Using Fourier techniques, we measure the phase delays between intensity oscillations, as well as between velocity oscillations, in our two lines over the full range of available frequencies. From this, we are able to measure the travel time of the propagating oscillations and, hence, the propagation speeds of the waves that produce the oscillations. We detect the presence of long period oscillations in polar coronal holes on the disk. Our results indicate the presence of compressional waves with a dominant period of ~25 min. However, we also find power at many other different frequencies and so we are able to study oscillations over a full range of frequencies. We find evidence for propagating waves with a fixed time delay in the coronal hole. We find, moreover, that there is a difference in the nature of the wave propagation in the bright ('network'), as opposed to the dark ('internetwork') regions, with the latter sometimes showing evidence for downwardly propagating waves which are not seen in the former. From a measurement of propagation speeds, we find that all measured waves are subsonic in nature. Waves with different characteristics are found to be present at different locations in the observed coronal hole. The measured propagation speeds are subsonic, indicating that the majority of them are slow magneto-acoustic in nature. These waves, measured at lower atmosphere, could accelerate further at higher altitudes and may be important for the acceleration of the fast solar wind.

P45: Dynamical Evolution of Solar Coronal X-ray Bright Points from Hinode/XRT Observations

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To understand and clarify the origin of the footpoints of X-ray Bright Points (XBPs) and heating of the quiet solar corona, the study of the spatial and temporal relationship between the solar coronal XBPs and the photospheric and chromospheric magnetic features is an important issue in physics of the Sun. The Hinode/XRT observations provide an opportunity to investigate and understand more deeply the dynamical evolution and nature of the XBP than has been possible to date and to determine their connection to the magnetic features. Such high resolution observations and investigations would be helpful in understanding the role of oscillations and nature of the waves associated with XBPs to heat the corona. A long-time sequence of the soft X-ray images, obtained on April 14, 2007 in a quiet region at high temporal resolution using X-Ray Telescope (XRT) on-board the Hinode mission, have been analysed. The aim is to observe the intensity oscillatory phenomena in coronal XBPs of different brightness levels and to bring out the differences, if any, in the period of intensity variations and heating mechanism during their dynamical evolution. We have also compared the XRT images with GONG magnetograms using Coronal Modeling Software (CMS) to determine the spatial relationship between the different classes of XBPs and strength of the magnetic field. The important results of these analysis of XBPs in relation to magnetic field are discussed in this paper.

P46: A Numerical Investigation of Cancellation of Unsheared Flux

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Cancellation of magnetic flux in the solar photosphere and chromosphere has been linked observationally and theoretically to a broad range of solar activity, from filament channel formation to CME initiation. Because this phenomenon is typically measured at only a single layer in the atmosphere, in the radial (line of sight) component of the magnetic field, the actual processes behind this observational signature are ambiguous. We have used numerical modeling to investigate the physics of flux cancellation, beginning with the simplest possible configuration: a subphotospheric Lundquist flux tube surrounded by a potential field, in a gravitationally stratified atmosphere. Cancellation is driven by a two-cell circulation pattern imposed in the convection zone, in which the flows converge and form a downdraft at the polarity inversion line (PIL). Here we present and compare the results of 2D and 3D simulations of cancellation of initially unsheared flux --- to our knowledge, the first such calculations iI which the computational domain extends below the photosphere. Our calculations show that 3D cancellation in an arcade geometry does not produce a fully disconnected flux tube in the corona, in contrast to the simplest picture of flux cancellation consistent with the 2D results. Rather, most of the reconnected field stays rooted in the photosphere and is gradually submerged by the downdraft at the PIL. A Rayleigh-Taylor-like instability develops due to the strong density pileup overlying the region where the converging flows decelerate, breaking the horizontal symmetry along the PIL. This generates an alternating pattern of magnetic shear (magnetic field component aligned with the

PIL), which ultimately produces systematic footpoint shuffling through reconnection across the ``folds" of the convoluted PIL. When the forcing region is finite along the polarity inversion line, the added complexity yields a coronal field that largely resembles an inhomogeneous sheared arcade well-rooted in the photosphere. These simulations demonstrate the importance of considering both the effects of submergence and the full 3D configuration of the magnetic field and subsurface flows, in determining the physical processes behind flux cancellation on the Sun.

P47: The study flows in solar atmosphere and its relation to the magnetic configuration

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To study the kinematics of the magnetic structures in the Solar atmosphere, the basic equations of M.H.D are solved, by incorporating the following approximation. The fluid is assumed to be infinitely conducting, the Cartesian coordinate system is used, with the symmetry along the length of the structure. The acceleration due to gravity is assumed to be a constant and the system is in a steady state. With these approximation, the basic equations of M.H.D are solved analytically. From the condition for the existence of solutions the magnetic configurations capable of various type of flow is derived. In This work not only the general solution is discussed but also the special solutions like the flow along the length of the structure, the maintenances of study flow and the flows of the order of Alfvanic velocity is also discussed. These study will have wide ranging application in understanding the various phenomena specially in the context solar flares and prominences.

P48: High Frequency Surface and Body Waves in Coronal Loops with Steady Flow

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The effect of anisotropic viscosity and plasma flow are examined for high frequency surface and body waves in low – beta straight magnetic slab configuration. The slab is considered to have a one dimensional inhomogeneity of Alfvén speed in the direction perpendicular to the axis of the slab which coincides with the equilibrium magnetic field. We approximate the coronal loop by above model and examine the damping of waves for the loop parameters similar to those observed Tomczyk et al. (2007). We also present the effects of the flow within such loops.

P49: Variation of network contrast in the solar atmosphere

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Intensities of EUV emission lines in a coronal hole and the neighbouring quiet Sun region have been obtained from Solar and Heliospheric Observatory (SOHO)/Coronal Diagnostic Spectrometer (CDS) observations. The formation temperatures of the observed lines vary from 0.083 MK to 1.10 MK and hence they represent increasing heights in the solar atmosphere from the upper chromosphere and transition region to the low corona. The intensity contrast of the network has been estimated for each line. Variation of this in the solar atmosphere as well as the differences in the quiet Sun region and the coronal hole will be discussed.

P50: Observing and interpreting the Halpha chromosphere

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I will present new data from the IBIS bi-dimensional spectrometer at the NSO Dunn Solar Telescope with simultaneous spectral sampling of Halpha and Ca II 8542 that show striking similarities and dissimilarities in different diagnostics measured from these lines. Comparison demonstrates that network heating affects Halpha mostly in its line width and that chromospheric fibrils appear very different in the two lines. Recent MHD simulations suggest why this is so, and why so many fibrils are visible in Halpha anyhow.

P51: Jet Induced Mini Solar Quakes at the Transition Region

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It is suggested that the origins of the coronal heating and the fast solar wind problems lie within the fine structures that appear in the corona and transition region. EUV spicules appear as small jets and can reach heights of approx. 10’’ above the solar limb (Popescu et al., 2005). It has been estimated that there are up to 60,000 spicule events in the lower solar atmosphere at any given time (Sterling A., 2000.- Review). Macro-spicules are large jets and have been observed to extend anywhere from 10 to 60 arcsec (7000 – 40000 km) i.e. escaping beyond the transition region to outer corona, have rise velocities of 10-150 km/sec., lifetimes of 3-45 mins. (Dere et al. 1989) and are thought to be a contributor in the role of mass and energy transport between the chromosphere, transition region and upper atmosphere. Macro-spicules originate from either erupting loop or spiked jet events due to magnetic reconnection between open and closed field lines (Yamauchi et al., 2004, Axford & McKenzie 1992, 1997). Here we show 2.5D ideal MHD numerical simulations (VAC) along with recent observational evidence (Hinode EIS/SOT-FG, SoHO/MDI, TRACE – 5th March 2007), for the first time, that jets which form as a result of p-mode leakage (De Pontieu, Erdélyi & James, Nature, 2004; Malins & Erdélyi, 2007; Erdélyi et al. 2007) in the region of a current sheet, puncture the transition region and generate ‘mini’ solarquakes with measurable surface wave velocities. With further analysis of the TRACE 171 large field of view and after applying wavelet denoising techniques, we reveal an abundance of such mini solarquake-like features, suggesting that these mini solarquakes present the signatures of large jets on-disk, which in turn could enable the tunneling of waves to be dumped in the upper atmosphere.

P52: If the coronal loops are magnetically shielded ?

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We have made spectroscopic observational in four strong coronal emission lines, namely FeX, FeXI, FeXIII and FeXIV on large number of days during the 1997 – 2007 choosing two emission line simultaneously. We have studied the variation of line-widths of these lines along the coronal loops of all sizes, shapes and orientations. We have also investigated the variation of intensity ratios along the loops and correlation between the line-widths of different emission lines. We find that line width of FeX line increases with height and that of FeXIV line decreases with height along the loops. The intensity ratio of FeXI/FeX line increases with height whereas that of FeXIV/FeX decreases with height along the loops. There is good correlation between the line-widths of FeX and FeXIV emission lines. From these results we conclude that the coronal loops are not magnetically shielded.

P53: Waves in weakly ionized solar atmosphere

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The solar plasma, from photosphere to chromosphere, is partially ionized. As a result, the collision of charged particles with neutrals becomes important which greatly affects the excitation, propagation and damping of waves, solar dynamo, flux emergences and magnetic reconnection. We start with the three-fluid MHD approximation for the weakly ionized solar atmosphere and end up with a single fluid description that includes nonideal effects such as Hall-effect and ambipolar diffusion. Hall and ambipolar effects play a very important role in the wave propagation in the solar atmosphere. These waves have altogether different wave characteristics compared to the canonical waves namely, slow, fast and Alfvén waves and therefore become important from the observational viewpoint. We will briefly discuss the wave propagation scenario in the weakly ionized solar atmosphere, solar prominences and solar spicules.

P54: Effect of steady flow on damping of small-amplitude prominence oscillations

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Recent high-resolution observations, both from ground and space, show the clear evidence of field aligned steady flow in solar prominences. We have investigated the effect of steady flow, for the first time, on spatial damping of small-amplitude prominence oscillations. The non-adiabaticity has been invoked through thermal conduction, radiation and heating in the energy equation. In this paper, we will discuss how steady flow changes the propagation and damping of MHD wave modes. The steady flow can improve our understanding on the non-adiabatic mechanism that operates in the wave damping of small-amplitude of prominence oscillations. The strong effect of steady flow, on small-amplitude prominence oscillations, also likely to play an important role in both wave detection and prominence seismology.

P55: Small-scale Loop in the Magnetic Network and its Magnetoacoustic Oscillations as seen by EIS/Hinode

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We analyze the temporal series He II 256.32 image data obtained from EIS/Hinode. Our analysis shows the presence of a small-scale magnetic loop of length ~ 3450 km in the magnetic network. Using standard wavelet tool, we find a periodicity of ~ 11 min close to the loop apex, which is interpreted as the fundamental mode (m = 1) of magnetoacoustic oscillations. Using MHD model of magnetoacoustic oscillations in the underlying field-free cavity, and observed period ~ 11 min, we estimate theoretically the length of loop as ~ 3500 km, which is in agreement with the observationally estimated loop length. In our previous study (Srivastava et al. 2008), we have shown that these modes could leak into the upper atmosphere through magnetic network core and cause intensity oscillations from the chromosphere to the corona. In this paper, we investigate the field-free cavity regions below the small-scale magnetic loops with appropriate sound speed and granular dimensions. Our results show that this can also serve as a resonator for the excitation of long-period oscillations in these overlying small-scale loops in the magnetic network. We also discuss the importance of new result to understanding the dynamics of the lower solar atmosphere which is extremely complex in its magnetic structuring.

P56: Sign of helicity at different heights on the Sun

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In Solar atmosphere, the twist parameter alpha has the same sign as magnetic helicity. It has been observed using photospheric vector magnetograms that negative/positive helicity is dominant in the northern/southern hemisphere of the Sun. Chromospheric features show dextral/sinistral dominance in northern/southern hemisphere and sigmoids observed in the X-rays also have dominant sense of reverse-S/forward-S in northern/southern hemispheres. It is important to investigate whether the individual features have one-to-one correspondence in terms of helicity at different atmospheric heights. We use data taken from HINODE : SOT/SP and XRT, YOHKOH : SXT and H-alpha data of Udaipur Solar Observatory, Dunn Solar Telescope: ASP/DLSP and UBF H-alpha images, H-alpha images from Big Bear Solar Observatory, Observatorie de Paris , Meudon and Kodaikanal Solar Observatory to statistically find one-to-one correspondence among their helicity signs at different heights (photosphere, chromosphere and corona) in the solar atmosphere.

Posters: Session V

P57: Magnetic relaxation in an incompressible viscous fluid

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We demonstrate spontaneous current sheet formation during the relaxation of a three dimensional magnetic field in a viscous, perfectly conducting incompressible magneto fluid. The current sheet manifests itself in the form of magnetic tangential discontinuity created when different parts of the fluid press each other as it relaxes to the lowest magnetic energy state. One novel feature of the numerical scheme used for this purpose is the description of the magnetic field in terms of evolving flux surfaces which are possible sites of tangential discontinuity formation. The computation follows initial global flux surfaces of simple geometry as they evolve in time to more complex forms creating magnetic tangential discontinuities in the process. This work illustrates the physics of spontaneous current sheet formation as described in the Parker theory.

P58: Twisted Emerging Flux Region and M1.6 Flare on 27 May, 2003

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We present here the multi-wavelength analysis of M1.6 flare occurring in the decaying active region NOAA 10365 on 27 May, 2003 using the Meudon solar tower MSDP H-alpha spectrograph data, MDI magnetograms, TRACE 1600 A, RHESSI and SOHO/EIT data. New bipole emerges in this active region. The diverging flow pattern and the tongue shape of magnetic pattern in the photosphere with elongated polarities of highly suggestive to the emergence of a twisted flux tube as it was first discussed by lopez-Fuentes et al (2000). These tongues indicate the emergence of flux tube with right hand twist, i.e. positive magnetic helicity. The flare signatures in the chromosphere are four ribbons observed in H-alpha (MSDP, Meudon) and in 1600 A by TRACE. Their shifted forward "J" shape ribbons indicate that the flare was triggered by coronal reconnection below a twisted flux tube of positive helicity. It is the first time that such a consistency between the signatures of the emerging flux observed in the photosphere and flare ribbons is found. Secondary ribbons observed at the periphery of the active region by the MSDP and SOHO/EIT are related to the existence of a null point detected high in the corona by a linear force-free-field extrapolation. We discuss on the possibility of such secondary brightenings in terms of "breakout" model or in terms of plasma compression above separatrices.

P59: The kinematics of a coronal mass ejection and long duration event

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The long duration event (LDE) and coronal mass ejection (CME) of December 17, 2006 were observed by a number of instruments, including EIT, LASCO, TRACE, and RHESSI. Due to the wide range of energies and fields-of-view covered, the event provided an ideal opportunity to simultaneously study the kinematic evolution of both a CME and its associated post-eruption arcade over a period of nearly ten hours. The CME reached a peak velocity of ~797~km~s^{-1}, while the post-eruption X-ray sources located above the post-eruption arcade were observed to rise with a velocity of ≤1.2~km~s^{-1} in RHESSI 3-6, 6-9 and 9-12 keV images. These observations will be discussed in light of theoretical models which predict a coupling between a CMEs kinematics at many solar radii from the Sun, and the dynamic behavior of the on-disk post-eruption arcade.

P60: Polar flaring filament

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A special case of huge polar filament giving CMEs 'en raffales' is analyzed. This filament was registered on the solar disk between 11 and 19 August 2001. It appeared as two parallel filaments, but on 13 August a double S-shape linked these two filaments forming a single huge feature. On 14 August 2001 a special feature was observed surrounding the filament – a two-ribbon flare, flare that produced a CME. Parts of the double S filament disappeared after few CMEs occurred on 15 August 2001. After the last CME occurred on 15 August 2001, part of the filament still exists on the solar disk but gets a simple shape in S its self. This complex feature is a long-lived one: a previous rotation was observed the part of the filament that gave the flare. The double S polar filament could be observed also the next solar rotation. The 3D coronal extrapolated magnetic field before and after the flare, in the region of the flaring filament was computed. We could observe strong magnetic reconnections in zone and a total reconfiguration of the magnetic topology after the flare and the CME associated. We investigated the evolution and possible causes for the CMEs given by this filament.

P61: Kinematics of the solar erruptive event of Jan 20, 2005 at Decameter wavelengths and its association with Flare & CME

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During the decending phase of the solar cycle 23, an extreme solar eruptive event occured on 20 January 2005. It has fascinated the attention of solar and solar-terrestrial community since it ranked among the largest in the past fifty years. The multi spectral data shows it as one of the strongest emissions from 200 MeV gamma rays to very low radio frequency range observed by WIND/WAVES experiment. In this presentation, the dynamic spectra of the Type IV and Type II burst on January 20, 2005 obtained with the Gauribidanur Radio Array Solar Spectrograph (GRASS) is analysed in conjunction with WIND/WAVES and LASCO data to obtain the kinematics of this eruptive event.

P62: Morphological study of the Halloween CME events using wavalet analysis

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In this work, we present a morphological study of the Halloween events (28 Oct. – 7 Nov. 2003) in which several flares and coronal mass ejections were observed. For this study, we use data from SOHO – EIT, LASCO and TRACE. This event is famous for the strong interaction observed with the earth's magnetosphere. This caused strong geomagnetic storms. This event involved several fast CMEs in a very short lapse of time. In this study, we use the wavelet analysis technique to separate the different spatial scales of CMEs.

P63: Energy-dependent Timing of Thermal Emission in Solar Flares

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We investigate the energy-dependent timing of thermal emission in solar flares, using high-resolution spectra and demodulated time profiles from the SOXS instrument. We model the spectral-temporal hard X-ray flux f (ε, t) in terms of multi-temperature plasma governed by thermal conduction cooling. In this quantitative model we characterize the multi-temperature differential emission measure distribution (DEM) and nonthermal spectra with power-law functions. We fit this model to the spectra and energy-dependent time delays of a representative dataset of 11 solar flares observed with SOXS during 2003-2006. We find all flare events are suitable for fitting and obtain a satisfactory fit that is consistent with the theoretical model. The best-fit results yield a thermal-nonthermal cross-over energy of $\varepsilon_{th} = 12.0 \pm 3$ keV, nonthermal spectral indices of $\gamma_{nth} = 4.0 \pm 1.5$ (at ≈15- 50 keV), thermal multi-spectral indices of $\gamma_{th} = 5.0 \pm 2.5$ (at ≈10-20 keV), thermal conduction cooling times of $\tau_{co} = 101.8 \pm .0.8$ s. We also present the tests carried out for the scaling laws with temperature and density of the flare plasma and show that they are consistent with the theoretically expected scaling laws. Our modeling of energy-dependent time delays provides an alternative method to separate multi-thermal from nonthermal spectral components based on information in the time domain, in contrast to spectral fitting methods.

P64: Acceleration of CMEs associated with erupting prominences

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The association of coronal mass ejections (CMEs) with erupting prominences is known for a long time. However, most studies focus exclusively on CMEs, which cannot be observed close to the solar surface. Here, we present results of a study of a few CMEs which were associated with eruptive prominences. Data from STEREO and SOHO space missions have been used to study these events. The velocity of rise of the filaments temporally preceding CMEs is compared with the velocity of CMEs. Primary aims of this study are to measure the velocity of slow rise of filaments, and to locate the region of maximum acceleration of CMEs. Chen and Krall, (2003), theoretically proposed a relationship between the critical height for maximum acceleration of a CME and its footpoint separation. Our study aims to validate their universal scaling law of acceleration based on the improved data from STEREO.

P65: Power Law and Hydrodynamical Approach of Nanoflare Heating

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The concept of coronal heating by nanoflare are showed turn to the characteristics of active regions which results presumably from a large number of more or less random heating agents. The flare associated small impulsive events of magnetic energy dissipation from 5 x 10^{23} to 10^{26} ergs called nanoflares and it is treated as heating agents. The analysis of these agents is represented by a power law distribution as a function of their energies with a negative slope of 1.5 and it may be more. We discuss the physical characteristics and features of nanoflare heating process in respect of power law distribution and formulate the coronal luminosity. We estimate the radiation energy and generation rate of nanoflares. We also discussed the hydrodynamic simulation results of nanoflare with the variation of power law index α.

P66: X-radiation processes at the Sun: recombination emission and Inverse Compton scattering

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We have shown that recombination emission can exceed the bremsstrahlung Hard X-ray (HXR) flux for certain flare conditions (A&A 481, 507–518 (2008)). Here we will show that particular spectral features may suggest non-thermal recombination plays a significant part in the flare HXR continuum, something that has been ignored in the past. It is important to note that these results could demand a reconsideration of the numbers of accelerated electrons since recombination can be much more efficient in producing HXR photons than bremsstrahlung. In related work on diagnosing flare ion and relativistic electron acceleration, we have also been reconsidering the role of Inverse Compton (IC) scattering of photospheric photons. Gamma-ray observations clearly show the presence of ~100 MeV electrons and positrons in the solar corona, by-products of GeV energy ions. Here we will present results of IC scattering of such photons taking proper account of radiation field geometry near the surface. If observed, such radiation would let us determine the number of secondary positrons produced in large flares, contributing to a full picture of ion acceleration and to predicting neutron fluxes to be encountered by future inner heliosphere space missions.

P67: Interplanetary Consequences of Intense Flare Events between Sun and 5 AU

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In this paper, we analyse the interplanetary consequences of intense solar events occurred during November 2 – 4, 2003, at the active region #486. We find that the record solar event of the cycle 23 (X-ray intensity >X28) has been influenced by the interaction of a proceeding slow CME. The interaction characteristics have been obtained using white light images from LASCO/SoHO coronagraphs, radio waves signatures recorded by WAVES/Wind instrument and URAP/Ulysses system. The interplanetary scintillation measurements at 327 MHz using the Ooty Radio Telescope provide the three-dimensional images of CMEs in the inner heliosphere. These images show the structural evolution of CMEs and provide evidences of interaction of CMEs with other slow CMEs as well as background solar wind. The scintillation images have also been employed to obtain the radial profiles of CME speed. We also infer the effects of the propagating structures of CMEs and their associated phenomena in the inner heliosphere as well as at Ulysses spacecraft at a location ~5AU from the Sun. This study provides evidence that the internal energy (i.e., magnetic energy) possessed by the CME is utilized to support the propagation.

P68: Quiet-Sun mini-CMEs

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Observations of eruptions, with characteristics of small coronal mass ejections (CMEs), seen in quiet Sun images taken with the Extreme UltraViolet Imager (EUVI) on STEREO, are described. They occur at the junctions of supergranular cells and appear to be ac tivated by converging and rotating supergranular flows, near small concentrations of opposite polarity magnetic field. The eruptions produce strong brightening at the onset site, faint waves moving with plane-of-sky speeds up to 150 km/s, and surge-like ejections. An estimate of the occurrence rate is about 1400 events per day over the whole Sun.

P69: Magnetic and Velocity Field Changes Related to Solar Fare on October 28 and 29, 2003

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Magnetic and velocity field measurements of solar active regions are known to suffer from ambiguities caused by the changes in spectral line profile during the course of a major flare, which creates difficulties in the interpretation of flare-related changes. We have detected rapidly “moving” features, apart from the abrupt and persistent changes in the magnetic and velocity fields in the pre- and post-flare phases related to the X17/4B flare observed on October 28, 2003 and the X10/2B flare observed on October 29, 2003 in super active region NOAA 10486. These features were located near the compact acoustic sources reported earlier by Donea and Lindsey (2005) and seismic sources reported by Zharkova and Zharkov (2007). We find the moving magnetic feature to be spatially associated with the flare ribbon separation observed in the upper atmosphere: chromospheric H-alpha, temperature minimum (1600Å) and transition region (284Å). The detailed results will be presented in this paper.

P70: On the structure and origin of a magnetic cloud from multi-spacecraft observations

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Magnetic clouds are believed to be magnetic flux ropes in the core of Coronal Mass Ejections (CMEs) observed in-situ in the solar wind. Their origin is closely connected to the question of how CMEs are initiated. Two theories on the onset of CMEs are the sheared arcade models and erupting flux rope models, where flux ropes are produced during the eruption or pre-exist prior to their expulsion, respectively. By comparing properties of the magnetic cloud with its solar counterparts we intend to find observational constraints on these theories. To this end, we reconstruct t he magnetic cloud on May 22, 2007 from multi-point in-situ observations by STEREO/WIND to obtain a robust local axis orientation and magnetic fluxes. From observations of its associated two-ribbon flare on May 19, 2007 the reconnected flux during the eruption is calculated. The magnetic fluxes in the cloud agree well with expectations from a sheared arcade model, but leaves the possibility of a pre-existing structure triggering the eruption. We also find indications for a rotation of the flux ropes axis through the helical kink instability. Thus it seems that to explain the solar and interplanetary observations elements from both sheared-arcade as well as erupting-flux-rope models are needed.

P71: Evidence of magnetic reconnection outflow in the flare as seen by EIS/Hinode on 13 December 2006

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We analyse the raster data of the flare which occurred in active region NOAA 10930 on 13 December 2006, and observed with EUV imaging spectrometer (EIS) onboard Hinode. The intensity, Doppler velocity and Full width at half maximum (FWHM) maps of strongest coronal line Fe XII 195.12 A has been obtained. We find a blue-shift in the Doppler velocity map, which is associated with the rare signature of magnetic reconnection outflow in the corona. We discuss our observational results in the light of existing theoretical models.

P72: Evolution of Solar Magnetic Field and Associated Multi-wavelength Phenomena – Flare events on 20 November 2003

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The period October-November 2003 is well known for its extreme level of solar activities. Three active regions (i.e., 484, 486, and 488) produced several intense flares and large coronal mass ejections. In particular, AR 484 remained active for two or more consecutive solar rotations. We analyze two flare events (1N/M1.4 and 2B/M9.6) from the remnant of the above active region, occurred on November 20, 2003. In this study, the primary H-alpha observations from the Solar Tower Telescope, ARIES, Nainital, have been supplemented with X-ray data, EUV images, and radio measurements at a range of frequency bands. The evolution of large-scale magnetic structure at the event site, in association with the first flare, was rather gradual. The interaction between two filaments produced a slow-rising flare event, which showed two stages of magnetic reconnection. As one of the filament systems got destabilized, the bright arcade formation confirmed the ongoing re connection corresponding to the moving filament and the merging of the moving filament with the other at the center of the active region resulted in a twisted and heavily curved magnetic topology. The relative clockwise rotation between two sunspot systems has caused the destabilization of the filaments. The second flare, although showed similar stages, but the flare onset was quick and the initial and final magnetic configurations were different. The cusp-shaped magnetic field at the main phase of the flare and its evolution in correlation with the ribbon separation provides the initial stages of the CME eruption. The radio intensity profiles, in the frequency range 245-15000 MHz, suggest the crucial heights at which the CME is launched. Additionally, the radio measurements are discussed in terms of particle accelerations and their corresponding magnetic configurations.

P73: Disappearance of g-band fibrils in Flaring Region Near the Moat Boundary

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Detecting photospheric changes in relation to flares are important as they provide a link between the photospheric and coronal activities. Such changes have been detected earlier using SoHO/MDI observations associated with large X-class flares. The changes were found in the form of photometric decay of a penumbra close to the flaring site. With the advent of HINODE era, we have begun to explore the photometric and magnetometric changes in relation to smaller flares also. In this poster, we present observations of a g-band fibril structure disappearing in a B-class flaring region near the moat boundary.

P74: Major surge activity from superactive region NOAA 10484 on 25 October 2003

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The active region NOAA 10484 produced many eruptive events during October-November 2003. Using our 15 cm Solar Tower Telescope at ARIES, we observed a major surge in H-alpha from superactive region NOAA 10484. The surge was associated with SF/C3.9 class flare. This surge was also observed with SOHO/EIT 195 Å and NoRh in 17 GHz which shows the similar evolution in these wavelengths. The SOHO/MDI magnetograms show that the surge occurred where the photospheric longitudinal fluxes of opposite magnetic polarities emerged, converged and were cancelled by each other. The surge shows ejective funnel shaped structure with fast expansion in linear (~1.2x10^5 km) and angular size (~65 deg.) during maximum phase. The mass motion of the surge was along the open magnetic field lines with average velocity ~100 km/sec. The de-twisting motion of the surge reveals the relaxation of sheared and twisted magnetic flux. The MSFC magnetogram shows highest shear 80-90 deg. at the surge location. Our observations support the magnetic reconnection models of the Surges and Jets.

Poster: Session VI

P75: Relationship between Soft X-rays and EUV Emissions during Solar Flares: A Case Study for October-November 2003

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Temporal variation in the intensity of X, M, and C class flares in soft X-rays (1-8 Å, from GOES) and in EUV (26-34 nm, from SOHO/SEM) are studied for the solar active period of October-November 2003. Although EUV is known to have impulsive and gradual emission peaks during flare, we found that the impulsive and gradual emission peaks manifest in several ways. Both the impulsive and gradual EUV peaks were found to be shifted in time with respect to the 1-8 Å soft X-ray peak. The relationship of these time delays with the strength of flare (1-8 Å peak X-ray flux) is investigated. It is found that the time delay for the EUV 26-34 nm impulsive and gradual peak shows a linear correlation with the strength of flare; however, the trend need not be similar for the flares within a single class of the flare. The relative enhancement for both impulsive and gradual EUV emission shows a linear trend with the peak X-ray flux. These results have implications on the radiation emission mechanism during the flare and the existing standard solar flare model.

P76: How resonances on time scales of light travel could have got "built-in" in the solar system's gravitational dynamics just before the Sun's arrival on the main sequence

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It was pointed out earlier (Gokhale, 2005, 2007) that it is possible to construct a hydrodynamic solar model ("HDSM") according to which the acoustic waves and the strong toroidal magnetic fields (needed for producing the solar variability phenomena) could be powered by a spectrum of normal mode oscillations of solar mass elements that could be maintained by resonant power-input from gravitational interactions between solar mass elements and planets on time scales of light travel. Such resonances, (suggested by the observed matching of the frequency ranges of the Sun's normal modes with reciprocals of light travel times between the Sun and the planets), were shown to be possible under a hypothesis which is consistent with (i) the general relativity theory of gravitation and (ii) the observed motions of the solar system bodies on time scales > day. Here I present a scenario (based on the commonly accepted scenario of the Sun's formation) showing how such "resonances on light travel time scales" could have got built-in in the solar system's gravitational dynamics just before the Sun's arrival on the main sequence (and could continue to exist during the Sun's subsequent slow evolution on the main sequence). These resonances could have ensured fastest disposal of the system's gravitational energy before the Sun's arrival on the main sequence, and could have maximized the pre-Sun's central heating through decay of g-modes at the inner boundaries of their propagation ranges. This could have led to the "rapid" onset of nuclear ignition (on time scales of dynamical evolution of the solar system at that time).

P77: Evolution of Coronal Helicity in A Twisted Emerging Active Region

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Active region magnetic fields are believed to be generated near the shear layer of the convection zone by the dynamo processes. These magnetic fields are concentrated into flux tubes which rise, due to buoyancy, through the convection zone to appear in the form of bipoles at the photosphere. Thin fluxtube simulation show that all the active regions emerge with some twist and some of them show larger twist than the others. A Theoretical model (Longcope and Welsch, 2000) predicted that an emerging flux tube injects helicity into the corona after its initial emergence, through a rotation of its footpoints driven by magnetic torque. The model also predicted that the rotation rate of the bipoles will depend on the rate of flux emergence, and will follow a characteristic time evolution over one or two days. There have been very few observational studies of helicity injection into the corona by emerging flux. This poster presents the results of our study on the injection of helicity into the corona by the emerging active region NOAA 8578. We use spin helicity to quantify the rotation speed of the emerging bipoles. Adding this to the braiding helicity gives the time history of the total helicity injected into the corona during the emergence of this active region.

P78: Direct or indirect manifestations of internal magnetic field: open issues and possible solutions

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The whole dynamics of the stellar radiative zones could appear like a crucial ingredient for understanding th e stellar magnetism and its surface variability but unfortunately direct indicators are still largely missing today. After a short summary on the present solar observational constraints coming from seismic and neutrino detections and their open issues, we present some recent numerical computations which illustrate the complexity of the internal layers (in the radiative zones and in the subsurface layers). Then, in some specific cases we show the magnetic impact on the surface layers through solar quadrupole moment and oblatness. The space PICARD mission (scheduled launch 2009) will deliver new information on some of these related questions.

P79: New Space Instrumental Development for an improved investigation of the solar variability

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In this poster we describe the instruments ready for the space PICARD mission (scheduled launch June 2009) which focus on the surface layers and the irradiance variability. We show also the development of the GOLF-NG instrument dedicated to the deep interior dynamics and the temporal solar atmosphere evolution along the solar cycle. These instrumental efforts must be pursued during the coming decades through a large space mission.

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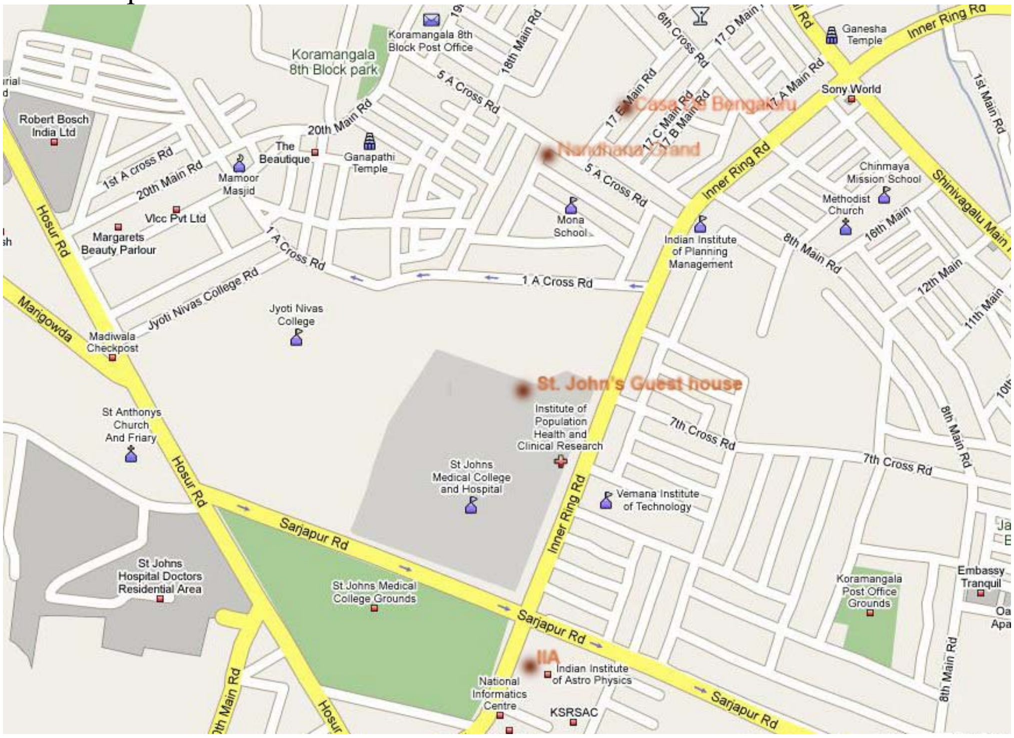

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