Beyond the Spherical Sun:
a new era of helio- and asteroseismology

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ABSTRACTS

O1

Various dynamical puzzle pieces in the seismic Rubik's cube

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Abstract: Helioseismology and asteroseismology are both advancing rapidly, each in turn paced by the new observational tools that have recently become available, or are soon to begin functioning. Thus GONG+, SOHO/MDI, MOST and soon CoRoT and SDO/HMI will each contribute to expanding the data bases available for probing the interior of stars, joined by a range of individual observational projects, some embraced by HELAS. Although variable stars come in many forms, the sun and the solar-like stars share many aspects that challenge our understanding of the interior dynamics and structure attained within them. The intricate coupling of turbulent convection, rotation and magnetism plays a central role in these stars, and much of this can now be probed, especially with spatially-resolved observations of the sun. Thus the Rubik's Cube has many elements, both from local helioseismic probing and from theoretical modeling of these processes, that are likely to become aligned as we rotate the panels and attain a clearer picture of what may be going on within this star. We will review the dynamical issues that are likely to be a focus of the new observational and analysis efforts now under way and being planned. The structure of the solar near-surface shear layer with its multiple scales of motion, many interacting with magnetism, is beginning to be intensely studied. Yet its dynamic origin and potential variability as the solar cycle advances has yet to be clarified. The manner in which the solar differential rotation appears to be established within the bulk of the convection zone is now partly sorted out through simulations, placing significant constraints on the patterns of meridional circulations that are likely present. Since these are more complex than assumed in mean field flux-transport models that replicate some aspects of the solar cycle, it is essential to get guidance from helioseismic deductions about the deeper circulations. The tachocline of rotational shear at the base of the convection zone is the likely seat of the global dynamo, providing the means to build strong toroidal magnetic fields that eventually erupt. Devising helioseismic means to probe variations in this region should be a major effort as we try to devise and test self-consistent dynamical models for this subtle boundary layer. The sun continues to reveal itself as a remarkably complex magnetic star, a property likely shared by many other stars now being studied or contemplated.

O2

Local helioseismology, techniques and issues

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Abstract: I will describe the intuitive motivation for, as well as the practical application of, the various techniques of local helioseismology: ring diagrams, time-distance helioseismology, holography, and direct modeling. For each of these methods I will review the current understanding of forward modeling and inversion procedures. I will conclude with a discussion of outstanding issues and areas for future research.

O3

Farside helioseismic holography: recent advances

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Abstract: Both MDI and GONG have been calculating partial farside maps for some time, showing a high degree of agreement in detecting large active regions within approximately 45 degrees of the antipode of disk center. Recently, the full-hemisphere capability has been added to the farside pipelines of both instruments. We show here the capability of detecting large active regions and tracking them through out the full farside hemisphere by applying the technique to active region 10808. We also report on efforts underway to calibrate the farside signal in terms of equivalent magnetic field, including some preliminary maps obtained from artificial helioseismic data.

O4

Seismology of magnetic photospheres

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Abstract: Since the advent of local helioseismology, a variety of independently developed diagnostic techniques have converged to suggest the existence of relatively large-scale, near-surface flows associated with active regions. Plages, with their enhanced luminosity, generally appear to be the centers of large-scale inflows. Sunspots, which are much less luminous than the quiet Sun, appear to be the centers of somewhat more compact, but relatively rapid, near-surface outflows—according to some diagnostics, but in this case the evidence has been inconsistent. One of the major developments in local helioseismology of the late 1990s was the discovery by Duvall et al. that phase travel times for waves propagating into sunspot photospheres are significantly longer than for waves propagating away from them, a phenomenon to which we refer in this study as "the phase asymmetry." Duvall et al. proposed that the phase asymmetry is the signature of rapid downflows beneath sunspots, a thesis developed at length by other authors. However, outflows combined with downdrafts would evacuate the shallow subphotosphere of the sunspot, challenging basic requirements of mass conservation. In this study, we develop the hypothesis that the phase asymmetry is largely the result of phase perturbations induced by magnetic fields in the photospheres or shallow subphotospheres of active regions. Central to the hypothesis is partial conversion of arriving compression waves to Alfvén waves that disappear into the active region subphotosphere, thought to be a major contributor to absorption of p-modes by magnetic regions. If the entirety of the phase asymmetry can be attributed to magnetically-induced phase shifts, evidence for significant near-surface outflows from sunspots could be regarded as both considerable and consistent. This would support a general theory of flows in the convection zone driven by magnetically induced luminosity variations at the overlying solar surface. A careful re-examination of seismic flow diagnostics with a practical account of magnetically induced phase shifts would be particularly timely with the advent of the Helioseismic Magnetic Imager (HMI) aboard the Solar Dynamics Observatory.

O5

Comparisons between observed and simulated surface velocities in the presence of inclined magnetic fields.

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Abstract: The Dopplergram signal within sunspots, observed with SOHO-MDI, is used in helioseismic holography to calculate the phase change of incoming acoustic waves at the surface. We show that this, as well as the amplitude decrease, indicates that there is a directional dependence of the surface velocity on the direction and/or strength of the magnetic field. The directional dependence is consistent for two sunspots, AR9026 and AR9057. Using a realistic model of the near solar surface, with the addition of a uniform, inclined magnetic field, the magnetoacoustic interactions are analysed. The upcoming fast acoustic waves undergo conversion close to the $\beta \sim 1$ layer to slow magnetic waves and the degree of conversion is primarily dependent on the 'attack angle' between the ray path and the magnetic field. For conditions similar to those in a sunspot we have found considerable support for the wave conversion theory from the observations. Here we compare the results and the observations speculating on the cause of acoustic absorption, the directional dependence and discuss the implications for helioseismology.

O6

Imaging the interaction of solar waves with a sunspot

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Abstract: An original method to study the interaction of solar waves with a sunspot is presented. This method enables to see the deformation of a specific wave train as it passes through the sunspot. Local amplitude and phase shifts are measured using MDI/SOHO data.

O7

Seismic results on temporal variations of the solar interior

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Abstract: 2006 marks the 10th anniversary of the start of MDI observations and the 11th anniversary of GONG. These continuous medium-degree observations covering an 11-year solar cycle have revealed the deep-penetrating structure of the migrating zonal flow pattern known as the torsional oscillation, as well as giving hints of possible other periodicities in the rotation rate close to the tachocline. These results can now be compared with the predictions from dynamo modeling. Temporal changes in the structure of the solar interior are more challenging to measure, as the obvious solar-cycle effects are dominated by the surface. We will review the major results in the field, both historical and recent.

O8

Improving the seismic visibility of the solar tachocline

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Abstract: Using a new model for the oscillation l-*nu* power spectrum, that can reproduce the observed spectrum over a large dynamic range (~1000), we are able to determine oscillation frequencies that are minimally corrupted by systematic error. Inversion of the frequencies obtained by using this model to describe a high signal-to-noise m-averaged spectrum, based on 360 days of velocity observations from the MDI experiment on board the SOHO satellite, yields improved resolution for the mean internal seismic structure of the Sun over that previously obtained. In particular, the details in and around the tachocline, the region where the solar internal rotation changes rapidly from differential rotation to essentially solid-body rotation and which is believed to be the seat of the solar dynamo, are visible with unprecedented clarity. Here we show these results, highlight the details of the spectral model, and discuss its future application to individual l-m-*nu* spectra and the accurate determination of the internal rotation profile in this important region of the Sun.

O9

The seismic Sun over three activity cycles

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Abstract: The Birmingham Solar Oscillations Network has been observing low-degree p-modes for 30 years, covering almost three complete solar cycles. Each of these cycles has unique characteristics that may be observed in a number of different indicators of solar activity. Here, the global seismology is compared over the last three solar cycles and the links between activity and helioseismology are explored using proxies sensitive to a range of physical processes in the Sun.

O10

Cyclic variability of the seismic solar radius from SOHO/MDI and related physics

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Abstract: We report on the changes of the Sun's subsurface stratification inferred from helioseismic data. We have used SOHO/MDI f-mode frequencies and their temporal variation for the last 9 years to compute the variation of the subsurface layers of the Sun by applying helioseismic inversions. We have found a variability of the "helioseismic" radius in antiphase with the solar activity, with the strongest variations of the stratification being just below the surface around 0.995 Rs. On the contrary, the deeper layers of the Sun, between 0.975 Rs and 0.99 Rs seem to change in phase with the 11-year cycle. These results imply a non-homogeneous variation of the subsurface layers with depth and time. Then, we will discuss the physical processes which mainly act in this region as partial ionisation of the light elements, opacities, superadiabaticity and estimate the corresponding variation of pressure and temperature to deduce luminosity variations. We will associate also the possible varying magnetic pressure and rotation profiles extracted from global helioseismic observations. We shall finally conclude on how we may progress on this transition region between solar interior and external part with global seismology, in parallel to local seismology. (Ref : Lefebvre & Kosovichev, ApJ, 2005, 633, L149)

O11

Structure and flows under active regions

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Abstract: The subsurface structures and flow fields were derived by inverting time-distance helioseismology measurements based on ray approximations. Recent application of Born-approximation kernels into time-distance inversions reveals similar structures and flow fields, but with better details and into deeper interior. Additionally, how the masking effect, the inclined magnetic field and the showerglass effect change time-distance results is assessed. Some recent efforts of disentangling subsurface magnetic field from sound speed variations will also be presented.

O12

Twists and turns of subsurface flows

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Abstract: Locations with different magnetic activity have different types of subsurface flows associated with them. For example, locations of intermediate activity show on average downflows combined with cyclonic vorticity, while quiet regions are characterized by weak upflows and small anticyclonic vorticity. We derive several fluid-dynamics descriptors, such as divergence and vorticity, to characterize subsurface flows associated with different levels of magnetic activity. We measure the horizontal flow components with the ring-diagram technique analyzing Doppler images from the Global Oscillation Network Group (GONG) and the Michelson Doppler Imager (MDI) instrument on board the Solar and Heliospheric Observatory (SOHO). The large data sets available from both projects allow us to address a variety of questions from detailed studies of individual active regions to statistical surveys of data spanning a large fraction of the solar cycle. We will discuss some of the latest results.

O13

Subsurface convective flows within magnetic active regions measured through ring analysis

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Abstract: Through the recent development of high-resolution ring analysis (HRRA), we are now able to measure frequencies and frequency splittings for f modes and low-order p modes within regions on the solar surface as small as 20 Mm. We are now actively applying this novel technique to the measurement of flows within solar active regions. In this talk I will present preliminary measurements of the convective flow patterns that we observe within active regions and the correlation of these flows with the distribution of magnetic flux.

O14

Project update: SOHO

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Abstract:

O15

One solar cycle with GONG – Status and Prospects

Frank Hill and the GONG Team

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Abstract: The GONG program will complete its first solar cycle of operations in October 2006. In this talk I will review the status of the program, including the recent upgrade of the polarization modulation system, new developments in data processing, and plans for the future.

O16

The Helioseismic and Magnetic Imager

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Abstract: The Helioseismic and Magnetic Imager (HMI) instrument is scheduled to be launched in August 2008 as part of the Solar Dynamics Observatory. In this talk I will start with a brief overview of HMI followed by a more detailed discussion of the capabilities HMI will have in terms of making helioseismic observations. Finally I will describe the current status of the instrument and how we are planning to transition from MDI to HMI.

O17

HELAS - European Helio- and Asteroseismology Network

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

O18

Consequences of Large-Scale Flows Around Active Regions on the Dispersal of Magnetic Field Across the Solar Surface

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Abstract: Helioseismic analyses of near-surface modes recently revealed horizontal flows near the solar surface towards regions with enhanced magnetic activity. The magnitude of these flows appears to increase with the magnetic flux contained within them. Such flows help to confine magnetic flux to the activity belt and perhaps even to the active regions within which the field emerges, and will likely slow the random-walk dispersal of the field. We report on experiments with a surface flux dispersal model to study the consequences of such inflows towards strong-flux regions. We constrain the flow magnitude by comparing results of a flux assimilation model to solar observations over six-month intervals throughout the last solar cycle. The best-fit model is then used to quantify the effects of these flows on the Sun's global dipole and quadrupole fields on time scales of multiple centuries.

O19

Effect of the Subsurface Shear Layer on Solar Supergranulation

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Abstract: Supergranular convective cells on the Sun rotate faster than surface plasma or any other feature. Recent time-distance helioseismology results suggest that supergranulation also has properties of travelling waves. We suggest that these properties may be due to the steep gradient of the subsurface shear layer. We use a linear model to calculate phase speeds of the unstable convective modes. These phase speeds are greater than the speed of the surface plasma; however, they are significantly lower than the observed speed of the supergranular pattern. This suggests that the subsurface shear layer is a plausible explanation for the wave-like behaviour. We begin to model the non-linear effects, that may be the source of the higher observed speeds.

O20

Determination of sunspot structure from the p-modes observations

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Abstract: Early theoretical works show that scattering of p-modes by sunspots strongly depends on their subsurface structure. This gives an opportunity to deduce structure of sunspots using observed parameters of p-modes. We study the scattering of p-mode waves by sunspots with different radii, surface magnetic field strengths and magnetic field convergence rates. We discuss the implications of the theoretical results on the observations.

O21

Mode conversion and active region acoustics

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Abstract: Sunspots absorb energy from and shift the phase of f- and p-modes incident upon them. Understanding the mechanism causing each of these effects is vital to the local helioseismology of active regions. Because the beta-equals-unity layer typically lies in the near surface layers below the photospheres of sunspot umbrae, MHD mode conversion can occur. Mode conversion provides a promising absorption mechanism because the slow magnetoacoustic-gravity waves and Alfvén waves guide energy along the magnetic field away from the acoustic cavity. Our previous mode conversion calculations have shown that simple sunspot models with non-vertical magnetic fields can produce ample absorption to explain the Hankel analysis measurements, along with phase shift predictions that agree well with the observations. In this contribution we will discuss new results from models that extend from the solar interior into the atmosphere. In particular, we will examine the effect of the magnetic field inclination on the surface vector velocity and discuss the consequences for the local helioseismology of active regions.

O22

Seismic Emission from Solar Flares

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Abstract: Seismically active flares are the most interesting solar flares for helioseismologists. I will present properties of the recently detected seismic emissions which contribute towards understanding the amazing physics of solar quakes. Seismic emission from flares offers major new insight both into flare physics and helioseismology, ranging from a greatly improved understanding of basic flare MHD to an understanding of how seismic emission is generated in magnetic subphotospheres.

O23

Sunquake sources and wave propagation

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Abstract: Solar flares generate sunquakes observed as ripples on the solar surface. This helioseismic response to solar flares is caused by energetic particles penetrating into the lower atmosphere. The sunquake sources are observed directly in the MDI Dopplergrams as localized high-velocity impulses. The seismic sources are typically located in flare ribbons and correlate very well with sources of hard X-ray emission produced by high-energy electrons and observed from RHESSI. Detailed analysis of SOHO/MDI data showed that the structure of sunquake sources can be quite complicated in space and time. The analysis of several sunquake events in 2003-5 revealed new important features such as the strong anisotropy and ellipticity of the seismic wave fronts, and it also showed much smaller than expected distortion of the fronts when the waves propagate through sunspots. The helioseismic waves tend to have the greatest amplitude in the direction of expansion of the flare ribbons. This phenomenon is somewhat similar to the fault rupture effect in earthquakes, and can be explained by theoretical calculations of sunquake waves. In some cases, the wave anisotropy can be also caused by subsurface structures and organized flows. Investigation of sunquakes provides new insight into the physics of solar flares and new means for local helioseismic diagnostics.

O24

Magnetic Seismology of the Lower Solar Atmosphere

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Abstract: The dynamic interaction between solar photospheric motions and the magnetic structures in the lower solar atmosphere is a rather challenging problem. Coherent motions, e.g. acoustic or p-modes have important implications for the local dynamics of the solar atmosphere ranging from the low chromosphere deeply even into the corona. Coherent atmospheric fields, however, may interact with global oscillations, altering their properties measured at photospheric levels. Combined ground-based and satellite high spatial and time resolution observations (SOHO, TRACE, SVT in La Palma) supplemented with MHD modelling demonstrated the p-mode leakage into the chromosphere, transition region and low corona causing, among others, spicule formation, moss and loop oscillations. In my talk I review the latest results on how photospheric motions interact with the magnetic structures and waveguides of the transitional layer between the photosphere and the corona. A comprehensive study of this transitional layer, also called solar atmospheric boundary layer, allows us to perform lower atmospheric magneto-seismology. Theoretical and observational efforts on the coupling mechanism(s) of both coherent and random motions and magnetic fields to the low atmosphere are discussed. Key issues will be addressed, including what dynamic impact the photosphere has on the overlying magnetic atmosphere; what is the role of magnetic wave guides in the photosphere - chromosphere - transition region dynamics; what are the possible scenarios and physical details of the boundary layer coupling mechanism(s); how p/f-modes resonantly interact to lower atmospheric MHD slow and Alfvén waves; are the global oscillations influenced by the solar magnetic carpet; how the coupling could be used for atmospheric diagnostics, lower atmospheric magnetic seismology and connectivity studies.

O25

Low-frequency magneto-acoustic waves in the solar chromosphere

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Abstract: We demonstrate that low-frequency (< 5 mHz) propagating magneto-acoustic waves provide a larger source of energy for balancing the radiative losses of the solar chromosphere than their high-frequency (> 5 mHz) counterparts. The low-frequency waves, which are normally evanescent in the solar atmosphere, are able to propagate through 'acoustic portals' that exist in areas of strong, significantly inclined ($> 30°$ with respect to the vertical), magnetic field. Such conditions are found both in active regions and at the boundaries of supergranules. The latter implies that acoustic portals are omnipresent over the solar surface and throughout the magnetic activity cycle, an essential prerequisite for any baseline heating mechanism.

O26

Does the Sun have a sub-solar metallicity?

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Abstract: The inferred solar photospheric elemental abundances depend on the models used for the solar atmospheric structure and the line formation process as well as on the quality of the input atomic and molecular line data. In this review I describe our work aimed at improving all of these ingredients, including developing a realistic time-dependent 3D hydrodynamical model of the upper layers of the solar convection zone and atmosphere and taking into account departures from LTE in the line formation when necessary. The resulting C, N and O abundances are almost a factor of two lower than previously thought. For the first time there is excellent agreement between all the different atomic and molecular abundance indicators, in sharp contrast to the case with any 1D model atmosphere. I will describe some of the many observational tests we have carried out that supports the realism of our models and thus the low solar abundances. While the new solar chemical composition is in much better agreement with solar neighborhood measurements of hot stars and the interstellar medium, it does wreak havoc with the excellent agreement between standard solar models based on the old composition and helioseismology. I will briefly outline some of the proposed solutions to this problem.

O27

Reconciling the revised solar abundances with helioseismic constraints

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Abstract: In 2003-04, the solar photospheric abundances were revised downward after reanalysis of the solar spectrum using improved atomic physics and three-dimensional dynamical model atmospheres (Asplund et al.; Lodders). The revised photospheric Z/X is now 0.0165 ± 0.0017 ($Z \sim 0.0122$) compared to the previous determination of Grevesse & Sauval of 0.0230 ± 0.0023 ($Z \sim 0.018$). Adopting these new abundances results in solar models that have sound speed discrepancies of about 1.4%, as well as too-shallow convection zone, and too-low convection zone helium abundance as inferred from helioseismic data. Initial attempts to restore agreement considered enhanced diffusive settling, increased opacities below the convection zone, or adopting a larger solar neon abundance, but none of these resolutions are entirely satisfactory. In this talk I will review the work published to date, and discuss additional attempts to restore agreement, such as my own attempt considering lower-Z material at the sun's surface early in its lifetime, and including the hydrodynamic effects of gravity waves on the convection zone base as discussed by Arnett, Meakin, and Young.

O28

Non-kinematic flux-transport dynamos and torsional oscillations

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Abstract: We present non-kinematic flux-transport dynamo model for the sun that combines a meanfield model for differential rotation and meridional flow with the meanfield induction equation. The induced magnetic field is allowed to feed back on differential rotation and meridional flow through the macroscopic Lorentz force, leading to solar cycle variations of zonal and meridional flows. We show that the dynamo saturates through this feedback at a field strength of around 10-20 kG and that the equatorward transport of field by the meridional flow at base of the convection zone (essential for flux-transport dynamos) is not significantly reduced. The non-linear dynamo is capable of explaining the high latitude branch of torsional oscillations (with correct amplitude and phase relation with respect to the magnetic butterfly diagram), but cannot explain the low latitude branch through macroscopic Lorentz-force feedback. We present a compound model that includes a parameterization of enhanced radiative losses in the active region belt (following the idea of Spruit 2003, SolPhys 213,1) and show that this can provide the correct oscillation pattern in low latitudes close to the surface. Thermally driven inflows into the active region belt produced by this model are also consistent with observations.

O29

Solar evolution model with diffusion and new equation of state

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Abstract: Solar evolution model which includes baro-, thermo- and concentration-diffusion terms is presented. The barodiffusion is a dominating process which leads to settling of heavy elements to the core of the star. The effect of these terms on the chemical composition profile is studied in detail. Main attention has been paid to layers around the lower boundary of the convection zone whose structure is altered by diffusion processes. Gradient of chemical composition leads to discontinuity in the Brunt-Vaisala frequency and change the acoustic properties of these layers. The models were computed using two newest equations of state (OPAL 2005 and SAHA-S); acoustic properties of the models are discussed and preliminary conclusion about precision of equation of state in the adiabatic part of the convection zone is given.

O30

Molecular-dynamics simulations of hot dense Coulomb systems

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Abstract: In the deep solar and stellar interior, matter is mostly fully ionized. The Coulomb potentials are screened, resulting in effectively short-range interactions. This screening affects the nuclear reactions, because tunneling through a screened Coulomb barrier happens more easily than without screening. In a seminal paper, Salpeter (1954) discussed this enhancement. He based his study on the approximation of a static screening potential. There is the legitimate concern that dynamic effects could alter the result. Since 1996, Shaviv and Shaviv have been examining this question by numerical molecular-dynamics simulations. The calculation is essentially classical, although electrons are treated with effective potentials that mimic some quantum corrections. Shaviv and Shaviv have reported dynamical effects at the high end of the Maxwell distribution (where the nuclear reactions effectively take place). Given the importance of these effects for solar and stellar modeling, we have recently begun to develop our own molecular-dynamics tools to verify the results by Shaviv and Shaviv in an independent calculation. Although our analysis is still in progress, we can already show first results.

O31

Helioseismology with low-degree observations: where we stand, and what the future holds

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Abstract: In this talk, I will give a review of the current state of play of low-degree helioseismology, and demonstrate how the excellent quality of the data is opening up exciting opportunities for new investigation. This is at the same time raising fresh questions and problems for the field to confront, issues I will also seek to address.

O32

The internal structure of the Sun inferred from g modes and low-frequency p modes

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Abstract: Over the past decade, there has been several attempts at detecting g modes. None of these attempts provided indvidual frequencies which are keys for inferring the internal structure of the Sun. For doing so, we have used three different detection techniques: - asymptotic detection of g modes - collapsogram (rotation averaged spectra) - coincidence search in several data sets The first technique provides a global measure of the internal structure of the Sun, while the latters provides individual frequencies. The collapsogramme technique supported by coincidence constraints has been essentially used for detecting mixed modes in the range of 200 to 400 microHz. We will report on the results of inversions performed using the additional modes detected below 1000 microHz.

O33

Detection of asymptotic solar l=1 g-modes in GOLF data and consequences to our knowledge of the solar core

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Abstract: Solar acoustics (p) modes have provided detailed stratification of dynamical properties (density and sound speed) above the radiative zone (0.7 solar radius). At deeper layers and down to the core, large uncertainties still exist due to their lack of sensitivity. On the contrary, solar gravity (g) modes exclusively provide information from the core to the base of the convection zone, so they are required to obtain a complete picture of the interior of our Sun. Unfortunately, solar g modes have not yet been clearly detected although extensive and intensive searches have been developed along past decades. Here we show robust indications of their presence and existence using 10 years of GOLF data. The present analysis is based on the exploitation of the collective properties of the low-frequency (25 to 140 muHz) g-modes: their asymptotic nature, which implies a quasi equidistant separation of their periods for a given angular degree (l). The Fourier transform of the Power Density Spectrum (PDS), reveals a significant structure which is indicative of the presence of features (peaks) in the PDS with near equidistant periods corresponding to l=1 modes in the range n=-4 to n=-26. The statistical significance of this feature was fully undertaken and complemented with Monte Carlo simulations. This structure has more than 6.5 sigmas (of a χ^2 with 2 d.o.f) corresponding to a confidence level better than 99.5%. A detailed study of this structure induce a more complex structure of the gravity modes than initially expected (line-widths, magnetic splittings...). Comparing with the latest solar models, our results tend to favor a core rotating significantly faster than the rest of the radiative zone. In the framwork of the Phoebus group, we also apply the same methodology to other helioseismology instruments onboard SoHO and ground based networks.

O34

The DynaMICS project

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Abstract: A new project dedicated to the 3D magnetic vision of the Sun has been presented in 2005 in the framework of Cosmic Vision (Turck-Chièze et al. ESA SP-588,193 (2005). This project was pushed by 18 laboratories from Europe and United States. Its main scientific objectives were (1) a real understanding of the whole solar internal magnetism at the origin of the external cyclic magnetic fields, and also (2) the understanding of its global emergence up to the chromosphere. Today we propose a more complete project to ESA for the next decade in continuity of GOLF/SoHO, VIRGO/SoHO and PICARD for a long and continuous observation, about 10 years, around the L1 point. The DynaMICS project (Dynamics and Magnetism from the Inner Core of the Sun) must include at least three kinds of instruments: (1) a velocity resonant spectrometer to detect gravity modes and improve our knowledge of the solar core to layers between photosphere and chromosphere, the corresponding GOLFNG prototype is in construction, (2) radiometers for irradiance variabilities and (3) intensity local seismic measurements with a copy of the SODISM instrument (used in PICARD mission) which also follows the time variability of the solar radius and its deformation. These coupling instruments will measure the internal dynamics of the Sun from the core to the chromosphere and add new strong constraints on internal magnetic field in total complementarity with SDO. SDO and DynaMICS will allow the understanding of the magnetic field in the different regions of the Sun, and its emergence, measuring in parallel the different variabilities of irradiance and radius. Adding such mission to the ILWS program will give access to all the magnetic sources of the different solar cycles and predict them for the next century. This is an important information for the estimate of the real influence of the Sun on the earth climate.

O35

Observations of stellar oscillations

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Abstract: There has been tremendous progress in observing oscillations in solar-type stars. In a few short years we have moved from ambiguous detections to firm measurements. I will review the recent results, most of which have come from high-precision Doppler measurements. The best data have be obtained from two-site campaigns, although single-site observations are also being carried out. meanwhile, photometry from space gives a much better observing window than is usually achieved from the ground but the signal-to-noise is poorer. The WIRE and MOST missions have reported oscillations in several stars, although not without controversy, and we look forward to the upcoming launch of COROT.

O36

Rigorous analysis of dipolar oscillations of stars

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Abstract: We analytically discuss the equations of adiabatic dipolar oscillations of stars without the Cowling approximation. Using the first integral derived from the momentum conservation, and choosing the appropriate dependent variables, we show that the equations are formulated as the second-order equations, which are essentially the same in the form as those obtained in the Cowling approximation. These equations tell us that the expressions for the critical frequencies, the Lamb frequency and the Brunt-Vaisala frequency, should be modified. In addition, we obtain the exact scheme that classifies the dipolar eigenmodes.

O37

Frequency, splitting, linewidth and amplitude estimates of low-l p modes of alpha Cen A: analysis of WIRE photometry

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Abstract: We present results of fitting the 50-day time series of photometry of alpha Cen A taken by the WIRE satellite in 1999. Both power spectrum and autocovariance function (ACF) fitting techniques were used in an attempt to determine mode frequencies, rotational splittings, lifetimes and amplitudes of low-l p-modes. In all, using both techniques, we managed to to fit 18 modes (seven $l = 0$, eight $l = 1$ and three $l = 2$) with frequencies determined to within 1 - 2 micro-Hz. These estimates are shown to be about 0.8 + 0.3 micro-Hz lower, on average, than the frequencies determined from two other more recent studies (Bouchy & Carrier 2002; Bedding et al. 2004), which used data gathered about 19 months after the WIRE observations. This could be indicative of a activity cycle effect, although there may well be other contributions. Over a range of 1700 to 2650 micro-Hz we were also able to use the ACF fitting to determine an average lifetime of 3.9 +/- 1.4 days, and an average rotational splitting of 0.5 +/- 0.2 micro-Hz, which is the first ever reliable estimate of this parameter. In contrast to the ACF, the power spectrum fitting was shown to return significantly biased results for these parameters.

O38

Excitation and damping of solar-like oscillations

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Abstract: A review on acoustic mode damping and excitation in solar-type stars is presented. Current models for linear damping rates are discussed in the light of recent low-degree solar linewidth measurements with emphasis on the frequency-dependence of damping rates of low-order modes. Recent developments in stochastic excitation models are reviewed and tested against the latest high-quality data of solar-like oscillations, such as from alpha Cen A, and against results obtained from hydrodynamical simulations.

O39

Non-adiabatic effects in classical pulsators

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Abstract: It is known that adiabaticity can be reasonably assumed for the determination of the frequencies. However, the oscillations are always completely non-adiabatic in the superficial layers of a star, where the thermal relaxation time is smaller than the pulsation periods. These non-adiabatic effects are at the origin of the driving of the pulsation modes for classical pulsators: there is the well known kappa-mechanism and others associated for example with the flux blocking at the base of the convective envelope.A general review of these mechanisms will be presented, with special stress on the information they give us on the physics of stellar interiors. Another important field is the interpretation of the amplitudes and phases at the photosphere. The amplitude ratios and phase differences between different photometric passbands or between the light and velocity curves can be determined with non-adiabatic linear computations. The comparison with observations allows the mode identification and gives constraints on the description of the superficial layers of stars and thermal aspects of their oscillations. These additional constraints are complementary with those obtained by classical frequency fitting.

O40

Asteroseismology from the MOST space mission: one small satellite, so many light curves

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Abstract: After over three years in space, the Microvariability & Oscillations of STars (MOST) satellite has obtained over 500 light curves of high photometric precision, rapid time sampling, long time coverage and duty cycles approaching 100%. Photometry of bright solar-type stars has reached detection thresholds of a few ppm. MOST photometry has resulted in seismic models for red giants such as epsilon Ophiuchi and HD 20884 (a p-mode discovery), the beta Cephei star delta Ceti, SPB (Slowly Pulsating B) stars, and the magnetic pulsating roAp stars HR 1217 (HD 24712), gamma Equ and 10 Aql. MOST has discovered the new classes of SPBe and SPBsg pulsators, and revealed pulsational instability in late-type B stars, long thought to be stable. MOST has also discovered the richest oscillation spectrum observed for any star other than the Sun (about 90 frequencies), the delta Scuti star HD 209775, which we locate on the HR Diagram based on excitation models and eigenfrequency spacings. The sample of photometry of several hundred MOST guide stars is providing a unique perspective on the occurance of pulsational variability as a function of spectral type and luminosity class.

O41

Studying solar-like oscillations in red giants: MOST spacebased photometry of eps Ophiuchi

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Abstract: Oscillations similar to the p-modes observed with periods near 5 min in the Sun are expected to be excited in stars with an external convective envelope. Red giants are excellent candidates to search for such solar-like oscillations, and red giant asteroseismology offers a unique opportunity to probe the interiors of evolved stars. Detections of solar-like oscillations in red giants have been reported in a few stars. Recently, spectroscopy from two groundbased sites has revealed oscillations in eps Ophiuchi (De Ridder et al. 2006, A&A, 448, 689). Despite the bi-site data, daily aliases prevent a definite estimate of the large separation of the eigenfrequency comb, but point to two possible values. The large separation parameter is sensitive to the star's mass, which is not very well known for red giants. Motivated by the groundbased spectroscopic results and the remaining ambiguity in the eigenfrequency pattern, eps Oph was selected as a target for the MOST photometric space mission. It was monitored for 28 consecutive days in 2005, with an interruption during each 101-min orbit of the satellite but no long or daily gaps. A series of peaks in the Fourier spectrum of the photometry is detected, with amplitudes of about 80 - 100 ppm and frequencies consistent with one of the possible large spacings from the de Ridder et al. spectroscopic data. We present the MOST data and frequency identifications, how they compare with the spectroscopic results, the implications for models of eps Oph, and the prospects for future MOST photometry of red giants to search for solar-like oscillations.

O42

Modeling intermediate mass red giants

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Abstract: Observations have shown that solar-like oscillations can be excited in red giant stars, namely, in xi Hydrae. Red giants are very different from main sequence stars. For instance, they present a great density contrast between the dense core and the extended envelope, they have a hydrogen-burning shell, and they are brighter which implies they are expected to have greater amplitudes. Hence, they have proven to be worthy of asteroseismic investigation and, indeed, space missions as COROT have proposed to observe them. Therefore, being able to model red giants is important. When modeling red giants, one faces some extra difficulties which are not present or are not so prominent in main sequence stars modeling. We point out some of the difficulties we have found in our intermediate mass red giants models calculation. We conclude that if one plans to observe red giants and study in terms of asterosesimology some work will have to be done. Improvements in the treatment of the convection and semi-convection are necessary, since the red giant phase phase becomes very sensitive to it. A comparison between the available stellar evolution codes focus on red giant modeling would also be important.

O43

Pulsations and potential for seismology of main-sequence B stars

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Abstract: Large observational efforts concentrating on asteroseismology of massive main-sequence B stars, such as Beta Cephei stars, slowly pulsating B stars and pulsating Be stars, have been undertaken the past few years. In this talk, we give an overview of these efforts and discuss their impact in terms of our current understanding of the internal physics of these different types of B stars. We highlight problems in the theoretical interpretation of the observed frequency spectra, for both the pressure and gravity modes that have been detected. Finally, we mention some of the plans for future efforts to overcome these problems.

O44

Asteroseismology of sdB stars: successes and challenges

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Abstract: We review the recent progress made on the front of pulsating hot subdwarf B (sdB) stars, two families of which being now recognized. The first category was uncovered in 1997 and consists of short-period (100-200 s), low degree, low order p-mode pulsators commonly referred to as EC14026 stars. The second family, first reported in 2002 only, consists of long-period (1-2 h), low degree, high order g-mode pulsators sometimes known as PG1716 stars. Both families occupy two distinct domains in the effective temperature - surface gravity plane, the PG1716 stars being cooler and less compact, but the two domains actually touch. Despite their relatively recent discovery, the pulsating sdB stars (especially the EC14026 pulsators) have proved themselves surprisingly well suited and amenable to detailed asteroseismological analyses. Detailed studies have so far been carried out on a handful of EC14026 stars and have led to the successful determinations of the fundamental structural parameters of these stars through asteroseismological techniques. We discuss these results as well as current challenges and problems in the field. In particular, we summarize the apparently more difficult situation that we face for exploiting the pulsations of the long-period pulsators of the PG1716 type.

O45

Resolving the third dimension in roAp stars

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Abstract: The roAp stars pulsate in high radial overtone modes with vertical wavelengths that are short compared to optical depth 1. They also show the most extreme effects of atomic diffusion of any stars. We are now able to resolve pulsation radial velocity amplitude and phase as a function of atmospheric height from continuum optical depth $\tau_{5000} = 1$ up to $\tau_{5000} \sim 10^{-5}$, and possibly higher. These levels that are chromospheric in the sun are dominated by strong (up to 24 kG), global magnetic fields in the roAp stars. Hence we are able to observe radial pulsation nodes, standing waves, running waves, magneto-acoustic waves in more detail than for any star except the sun. These new observations put independent constraints on abundance distributions in the atmosphere, hence on atomic diffusion theory which is important in the sun, and in pulsation driving in β Cep stars and subdwarf B star, as well as other stellar astrophysical contexts. Results from our VLT high precision radial velocity survey of the roAp class of stars will be shown.

O46

Project update: CoRoT

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O47

Project update: CoRoT

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O48

Asteroseismology of planet-host stars in connection with planet searches

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Abstract: The internal structure of main sequence solar type stars strongly depends on their internal metallicities. This effect is particularly important for stars with masses around 1.1 Msun, which may or may not develop a convective core according to their internal chemical composition. Stellar models with the same external parameters (Teff, log g, L/ Lsun) may be quite different inside, and such differences can be tested with asteroseismological techniques. This is particularly important for planet-host stars: precise studies of their internal structure from asteroseismology are of great help for a better understanding of planetary systems and of their formation. I will discuss this subject using two particular examples : HD 160691 (mu Ara) and HD17051 (iota Hor). I will also show how looking for stellar p-modes may sometimes lead to new planets discoveries!

O49

Rotational transport: a dynamical description of stellar radiation zones

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Abstract: We briefly recall the physical background of the rotational transport occurring inside stellar radiation zones and its importance for stellar evolution. We describe its present modelling, its successes and its weaknesses. Next, we introduce the new theoretical results which allow us to treat the hydrodynamical processes simultaneously in the bulk of radiation zones and in the tachoclines. Then, we show how to introduce self-consistently the effect of a fossil magnetic field, which may be responsible, with internal waves, for the angular momentum transport in low-mass stars. Finally, we introduce the new developments that allow to treat in a coherent way the effect of the Coriolis force on the low-frequencies internal waves and its consequences for the transport and mixing processes. We present first results of numerical simulation of the hydrodynamical processes. This research is aimed at improving the modelling of stellar interiors in the context of present and future helio and asteroseismology missions such as SOHO, COROT and DYNAMICS.

O50

Internal gravity waves in the Sun

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Abstract: In this talk, I will explain how internal gravity waves generated at the base of the convection zone can lead to angular momentum extraction from the deep radiative interior through the effect of differential filtering. Such a physical process is indispensable to the understanding of the present day solar rotation. I will present results of the evolution of the internal rotation profile, and explain how such results are consistent with the surface evolution of lithium, which is burned not too far below the top of the radiative zone.

O51

Dynamical physical processes in the solar radiative interior

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Abstract: Recent seismic observations coming from acoustic (Couvidat et al. 2003) and gravity modes (Turck-Chièze et al. 2004, García et al. 2006 and related contributions in this meeting) show clearly that the Solar standard model has reached its limits and can no longer be used to interpret satisfactorily seismic observations. In this contribution, we take into account the role of rotation and of internal waves on the transport of angular momentum along time. We use the STAREVOL code, following the work of Charbonnel & Talon (2005), to show the consequences of the introduction of such processes on the rotation and sound speed profiles for the present solar model using recent abundance determination. We also discuss first results on the influence of the magnetic field via the Tayler-Spruit magneto-hydrodynamic instability.

O52

Numerical simulation of acoustic power distribution in sunspots

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Abstract: We make an attempt to explain the suppression of amplitude of 5-min. acoustic oscillations inside sunspot by modeling acoustic wavefields with non-uniform distribution of acoustic sources. We developed a program for 3D numerical simulation of propagation of acoustic waves in the upper convection zone. We used a realistic non-reflecting boundary condition at the top boundary. Nonreflecting boundary condition based on PML layer was established above the temperature minimum. This layer absorbs all waves not reflected by photosphere, simulating a realistic case when acoustic waves with frequency higher than acoustic cut-off frequency pass to chromosphere. Acoustic sources with random amplitudes, frequencies, and phases were distributed below the photosphere. Sources were masked in a central circle, simulating suppression of acoustic sources in sunspot umbra. Acoustic sources are supressed because strong magnetic field inhibits convective motions (downdrafts) which are the sources of the 5-min oscilaltions. Simulations were carried out for different radii of the masked region and different source distributions. Large scale simulations in rectangular box of size 120Mm x 120Mm x 50Mm showed that the amplitude of acoustic oscillations is approximately 4 times lower in the region without sources in comparison with the quiet Sun. This is in a good agreement with observations. Hence, the observed reduced oscillation power in sunspots can be explained almost entirely by the suppression of acoustic sources in sunspot areas due to the strong magnetic field inhibiting convective motions. These results challenge the theories of acoustic wave absorption in sunspots.

O53

Computational acoustics in spherical geometry: modeling and results

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Abstract: We will describe our efforts to simulate wave propagation within a spherical shell, which extends from $0.2R_{\odot}$ to about $1.0004R_{\odot}$ (where $R_{\odot}$ is the radius of the sun) and which possesses a solar-like stratification. We consider a model containing no flows or thermal perturbations that will serve as a reference model. We will present the results from helioseismic diagnostics that have been applied to simulation data. Obtaining reliable data of this kind opens up whole avenues of assessing signal-to-noise of various flow and thermal perturbations throughout the convection zone, including rising flux tubes, and the meridional return flow. To this end, I shall also discuss the computational model and techniques of validation.

O54

Artificial data for local helioseismology

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Abstract: The key to local helioseismology is the effective application of local seismic diagnostic techniques to determine the flows in and the structure of the solar interior with the finest possible spatial and temporal resolution. The extent and magnitude of the supergranular return flow and the nature of thermal anomalies, flows, and magnetic-field configurations in and near active regions are phenomena on which we hope local helioseismic analyes will shed clear light. In this paper we present progress we have made simulating local solar seismic data using magneto-acoustic-gravity (MAG) wave propagation simulations. Simulation results will be presented, along with details of code structure, accuracy, and efficiency.

O55

Prospects for helio- and asteroseismology

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Abstract: The conference will undoubtedly have demonstrated the great progress made in recent years in heliseismology, not least in moving beyond the spherical Sun, and in asteroseismology. The prospects for the coming years are, if anything, even brighter. The data from the upgraded GONG network, and even more from the Solar Dynamics Observatory, will provide detailed continuous views of the three-dimensional and time-dependent solar internal properties, challenging the tools for data analysis and modelling. Reliable data on high-degree modes should finally provide the possibility of probing in detail the thermodynamics of the hydrogen and helium ionization zones, as well as other near-surface aspects of stellar modelling which continue to affect helioseismic, and in particular asteroseismic, investigations. Observations from space with CoRoT and Kepler will provide extensive asteroseismic data on large numbers of stars; as a complement, the ultimate accuracy for selected stars will require a telescope network dedicated to radial-velocity observations, to reach also the deeper tones, of great diagnostic potential, of the stellar SONG.

P1

Optimal phase-speed filters in time-distance helioseismology

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Abstract: Gaussian phase-speed filters are used in time-distance helioseismology to increase the signal-to-noise ratio of the temporal cross-covariances that are fitted to derive travel times of solar oscillations. The central phase-speeds of these filters are prescribed by a solar model but their widths are chosen empirically. Here we show that there is actually an optimum value for the filter width that results in a maximum signal-to-noise ratio for the travel-time maps. This analysis is performed by simulating signal (forward problem with Born-approximation sensitivity kernels, Birch et al. 2004) and noise (noise model by Gizon & Birch 2004) travel-time maps.

P2

Sensitivity kernels for helioseismic travel times in spherical geometry

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Abstract: We present calculations of three-dimensional Frechet kernels in spherical geometry for use in time-distance helioseismology. These kernels give the linear sensitivity of travel times to localised flow perturbations.

P3

Validity of the Born approximation in the presence of magnetic fields

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Abstract: With the aim of studying the effects of magnetic fields in time-distance helioseismology, we test the validity of the first Born approximation by comparing the scattering coefficients of plane acoustic waves with those extracted from the corresponding exact solution. We show that the travel-time shifts obtained in the Born limit are everywhere accurate to first order in the ratio of magnetic to gas pressures. The Born approximation is not valid in the limit ofvanishingly smallflux tube radius for a fixed magnetic field. We also demonstrate the effects of wave-front healing by investigating the variation of travel-time shifts with distance from the flux tube. We will also report on the progress in computing the scattering matrix in the thin flux tube limit for a realistic near-surface polytrope.

P4

Tracking and remapping strategies for high-resolution ring analyses

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Abstract: High-resolution ring analyses have been performed to date by splintering large tracked regions into small subdomains. Here we test this procedure of tracking and remapping large tiles and subsequently subdividing them, by tracking and remapping each individual subdomain separately. We compare flow measurements obtained with these two different tracking strategies.

P5

The status of GONG's magnetogram processing pipeline

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Abstract: The GONG Program is developing a magetogram processing pipeline. It includes a zero-point correction and histogram equating. The goal is to produce an internally consistent set of site magnetograms which can be merged to produce high quality line-of-site magnetic field maps for other researchers to use (for example: to produce magnetic field extrapolations).

P6

High-degree p modes as surface waves: the group velocity

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Abstract: At high degree l, solar p modes can be considered as surface waves; this approach can have advantages in helioseismic inversions. Integral representation of the group velocity of surface waves is developed in terms of adiabatic eigenfunctions, and influence of uncertainties in the uppermost solar layers is briefly discussed.

P7

eSDO algorithms for local helioseismology: wave speed perturbation and subsurface flow analysis

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Abstract: We present provisional algorithm implementation, developed as part of the UK eSDO project, for estimating Subsurface Flows and Sound Speed perturbations from tracked Dopplergram data to be provided by Helioseismic and Magnetic Imager instrument. Starting with tracked and derotated Doppler datacube. the algorithms include modules implementing filtering (with optional low-pass and directional filters), computation of cross correlation functions, travel time extraction by Gabor wavelet fitting and reference cross-correlation function comparison (i.e. Gizon-Birch method) and inversion by Multi-Channel Deconvolution. Pre-defined sensitivity kernels are used in the inversion which can be chosen during run-time. The algorithms provide the following output: travel time differences and means, sound speed perturbations as function of depth and (horizontal) Subsurface Flows as function of depth and cross-correlation functions (optional).

P8

On the latitude-longitude distribution of travel times derived from GONG data

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Abstract: We present some preliminary results of travel time measurements of GONG data for 2001-2005. Our main interest is to see if there is any longitude-latitude dependence in travel time changes during the activity cycle. To isolate different wave packets propagating to different depths of the solar interior we apply a phase-velocity filter to spherical harmonic coefficients and reconstruct images in sin(latitude)-longitude coordinates. Separation distances between pairs of points in the cross-correlation computations range from 2 to 10 degrees.

P9

The effect of systematic errors on mode parameters

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Abstract: In spite of the unprecedented success of the MDI Medium-l program, the analysis pipeline is known to contain errors. Physical effects such as line assymmetry, horizontal displacement at the solar surface, and distortion of eigenfunctions have been ignored, as well as a wide array of instrumental effects. Perhaps unsurprisingly, some features of the results seem to be the effect of systematic errors. The most notable of these features are an annual variation in f-mode frequency changes, a bump in the normalized residuals of the a-coefficients around 3.4mHz, and polar jets in the inversions. In this poster we discuss the application of a variety of corrections to the analysis, the resulting changes in the mode parameters, and the effect on the magnitude of systematic errors.

P10

Correcting Dopplergrams of solar active regions: consequences for local helioseismology

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Abstract: MDI High-res Dopplergrams in solar active regions are corrected based on an algorithm which estimates the line broadening due to the Zeeman effect. The broadening is estimated directly from the data. The correction accounts for the average magnetic field configuration of a sunspot. The correction will have a substantial impact on acoustic power maps. We will also investigate the influence of the corrections on travel time maps and ring diagrams.

P11

Effects of horizontal magnetic fields on acoustic travel times

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Abstract: Local helioseismology techniques seek to probe the subsurface magnetic fields and flows by observing the properties of p-modes at the solar surface. The main feature of active regions such as sunspots is strong magnetic field and time-distance helioseismology can provide useful diagnostic for probing these structures. The effect of uniform horizontal magnetic field upon the travel time of acoustic waves is investigated. A purely vertical velocity is considered in a simple plane parallel adiabatically stratified polytrope. It is shown that such fields can lower the upper turning point of p-modes and hence ifluence their travel time. It is also found that these effects are frequency dependent.

P12

Dynamics study of solar oscillations and granulation with Themis oscillations

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Abstract: The GOLF-NG instrument is devoted to the search for solar gravity modes and low frequency p-modes. It is a 15 points resonant scattering spectrometer working on the D1 sodium line. Hence we will have the chance to observe solar oscillations as function of different heights in the atmsphere. The aim of this project is to reach extremely small signals, hence the need to reduce the impact of solar granulation in our measurements. Using Themis telescope, we made simultaneous observations of the quiet and active Sun with different helioseismological absorption lines: Fe, K, Na and Ni and by using the technique Inversion of Stokes profiles (SIR), we study the dynamics of solar oscillations and granulation.

P13

Inferring subsurface supergranular flow directly from helioseismic correlation data

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Abstract: Horizontally- and temporally-varying subsurface structures, e.g., flows and magnetic complexes, induce correlation between distinct Fourier components of photospheric wave motion. Woodard 2002, Astrophys. J. 565, 634 showed how raw correlation measurements can be used directly in an inversion for subsurface supergranular- scale flow. For this inversion, which used a SOHO/MDI high-resolution Doppler data cube covering an approximately 210 Mm x 210 Mm corotating field of view near the center of the solar disk, a time- and depth-independent flow was assumed. The inversion of correlation data is based on a physical model of randomly-driven solar oscillations in a plane-parallel, but otherwise realistic, stellar envelope with weak perturbing flows. The weakness of the perturbation implies a linear dependence of data on subsurface flow velocity. The linear sensitivity calculations have recently been extended to model the effect of depth- and time-dependent flow. I will describe a recent, SOLA inversion based on the more general sensitivity calculations, which shows supergranular flow to a depth of approximately 6 Mm beneath the photosphere. The vertical resolution and noise properties of the inversion will be presented.

P14

f-mode travel time kernels for velocity flows

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Abstract: We present a full forward analysis using f-modes to determine the near surface flows on the sun. A two-dimensional model is used that reproduces the observed power spectrum of f-modes. It also takes into account several systematic effects such as foreshortening and the projection of the velocity vector onto the line of sight. The sensitivity kernels are computed in the Born approximation, and examples of kernels are shown at different places on the solar disk where the above effects are important. We also calculate theoretical traveltimes from these kernels for a uniform flow in order to determine the limits of applicability for inversions.

P15

Subsurface flows measured with big rings

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Abstract: We measure horizontal flows at depths greater than accessible with the standard ring-diagram analysis. With the standard method, we are able to measure horizontal flows from the surface to a depth of about 16 Mm. By doubling the size of the dense-pack patches, we can roughly double the depth range and measure flows from the surface to a depth of about 30 Mm. Previous big-ring studies have focused on large-scale motions, such as the meridional flow. In the present work, we focus on subsurface flows associated with active regions. For this purpose, we analyze Doppler images from the Global Oscillation Network Group (GONG) with the big-ring technique and derive synoptic flow maps of several Carrington rotations. We will discuss some of the latest results.

P16

Subsurface flows from numerical simulations compared with flows from ring diagrams

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Abstract: Subsurface flows near the top of the solar convection zone provide a point of contact between small-scale simulations and helioseismic observations. Here, we focus on subsurface flows measured with ring-diagram analysis and results from numerical simulations of convection on supergranular and smaller scales. The fully compressible simulations extend from the surface to a depth of 18 Mm with a horizontal size of 30 Mm and consist of hydrodynamic as well as magnetohydrodynamic cases. We measure subsurface flows by analyzing Doppler images from the Global Oscillation Network Group (GONG). While the temporal and horizontal spatial scales are very different between simulations and observations, we can compare the average behavior and we can apply helioseismic techniques to the simulation results. First results are quite encouraging. For example, the relation between divergence or vorticity with magnetic flux is very similar in simulations and observations. We will discuss the latest results.

P17

Comparison of subsurface flows obtained with acoustic holography and ring analysis

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Abstract: We compare synoptic maps of subsurface flows obtained with acoustic holography and ring analysis. We measure the horizontal flows of Carrington rotation 1988 by analyzing Doppler images from the Michelson Doppler Imager (MDI) instrument onboard the Solar and Heliospheric Observatory (SOHO). For the comparison, we bin the holography maps to a spatial resolution similar to the one of the ring analysis. We find that horizontal flows derived from binned-holography maps are highly correlated with the ones from ring-analysis maps and that the average zonal and meridional flows are very similar. We will discuss the latest results.

P18

North-South asymmetry of zonal and meridional flows determined from ring diagram analysis of GONG data

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Abstract: We study the north-south asymmetry of zonal and meridional components of horizontal solar subsurface flows during the years 20012004 which covers the declining phase of solar cycle 23. We measure the horizontal flows from the near surface layers to 16 Mm in depth by analyzing 44 consecutive Carrington rotations of Global Oscillation Network Group (GONG) Doppler images with a ring-diagram analysis technique. The meridional flow and the errors of both flow components show an annual variation related to the B0 angle variation, while the zonal flow is less affected by the B0 angle variation. After correcting for this effect, the meridional flow is mainly poleward but it shows a counter cell close to the surface at high latitudes in both hemispheres. During the declining phase of the solar cycle, the meridional flow mainly increases with time at latitudes poleward of about 20°;, while it mainly decreases at more equatorward latitudes. The temporal variation of the zonal flow is significantly correlated between the hemispheres at latitudes less than about 20°;. The zonal flow is larger in the southern hemisphere compared to the northern one and this north-south asymmetry increases with depth. Details of the north-south asymmetry of zonal and meridional flow reflect the north-south asymmetry of the magnetic flux. The north-south asymmetries of the flows show hints of a variation with the solar cycle.

P19

Differences observed in the near-surface meridional flow using GONG and MDI: what is the source?

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Abstract: Ring-diagram analyses of GONG and MDI data reveal significant disparities in the meridional flows obtained from the two data sets using two somewhat different analysis techniques. In particular, meridional flows measured with MDI are always poleward at the surface at all latitudes; whereas GONG data show meridional flows with equatorward flows above 45 degrees in latitude within 1 Mm of the surface. We examine differences in the analysis techniques, including image merging, tracking, remapping, mode selection, and inversion procedures, in order to determine the source of these disparities.

P20

Helioseismic probing of giant-cell convection

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Abstract: The turbulent solar convection zone exhibits a range of scales of convection which are visible at the solar surface, ranging from granules (∼1 Mm) to supergranules (∼30 Mm). Numerical simulations of solar convection carried out in full spherical shells consistently reveal even larger scales of convection, termed giant cells, which may span a few hundreds of Mm in the horizontal and extend over much of the convection zone. Recent correlation tracking of supergranular motions has revealed the tendency of supergranules to align themselves in the north-south direction. This alignment is possibly due to organization by larger-scale giant cell motions and is generally weak, with the strongest alignment occurring at the equator. Using f-mode time-distance and specialized tracking techniques, we probe for the possible flow signals associated with the presence of these giant cells near the solar equator.

P21

The structure of the average supergranule

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Abstract: To determine the subsurface structure of supergranulation with helioseismology has proven to be a difficult problem. We have tried a new strategy that hopefully will lead to increased understanding. This strategy consists of measuring the travel times about the average supergranule and the subsequent modeling to determine the structure. As we can use a large number of features to create the average, the travel times can be determined to high accuracy. The location of the supergranules is determined from local maxima of the divergence signal, which is developed from the f mode. For each supergranule, the data is reinterpolated onto a cylindrical grid centered on the feature. Correlations are computed between pairs of points along radial lines and averaged in azimuth. The correlations for hundreds of features are averaged before travel times are estimated. By averaging the results from different time periods, thousands of features are used. Comparison with forward models and also RLS inversions will be used to estimate the subsurface supergranulation flows.

P22

Solar rotation and zonal flows from Mount Wilson 60 ft Tower data

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Abstract: Nine 108-day time series of data from the Mount Wilson 60ft tower, sampling the period between 1988 and 2001, have been analyzed for medium-degree p-mode frequencies and splittings, using the Stanford pipeline developed for MDI structure program data. We present preliminary results from global rotation inversions of the data, using MDI and GONG data for comparison. The rotation profiles from the Mount Wilson data in most cases agree quite well with the MDI and GONG results, at least at low latitudes, though the characteristic mid-convection-zone signature of single-site observations is evident, particularly in the data with very low duty cycle. The agreement is good enough to allow the detection of the migrating zonal flow pattern known as the torsional oscillation. The high-latitude subsurface 'jet' feature, seen in the MDI data analyzed with the Stanford pipeline but not in GONG data, is not seen in the Mount Wilson data.

P23

Meridional flow measurements with statistical waveform analysis

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Abstract: We use statistical waveform analysis (also called the direct-modelling approach) introduced by Woodard in 2002, analysing the cross power spectra coefficients, to investigate the meridional flow, using SOHO/MDI data. The meridional flow in the convection zone is a key ingredient of some solar dynamo models. The flow is poleward in the surface layers and must by mass conservation eventually turn equatorward. At what depth this occurs, and with what return velocities, and whether the vertical structure is single- or multi-celled, are important but challenging questions for helioseismology to address. In the past, meridional flow has been studied with a variety of techniques, including tracers on the surface, time-distance helioseismology, frequency shift measurements, and ring diagram analysis. A newly available improved treatment of statistical waveform analysis, which includes depth dependence of the flow velocity, provides us with an ideal tool to tackle meridional flow observations from a different angle.

P24

Examining possible errors in the inversion results of active regions

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Abstract: Helioseismic observations have demonstrated that the mode frequencies of the oscillations in the active regions are higher than those in the quiet regions. The frequency difference have been used to infer the structural differences between active and quiet regions. The inversions are done under the assumption that the entire frequency difference is due to changes in structure caused by magnetic fields. However, the magnetic fields can affect the oscillations directly through the Lorentz force. Thus the inversions will have systematic errors. In order to get a correct estimate of the structural differences we need to quantify the errors that may be introduced. To assess the magnitude of these errors, we perform inversions between models with and without magnetic fields. Our examinations will provide insight in interpreting the inversion results.

P25

Acoustic power and magnetic field orientation in a large sunspot

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Abstract: A large sunspot in NOAA 10756 was observed on 29 April 2005 using a solar vector magnetograph at Udaipur Solar Observatory. By combining co-temporal dopplergrams from SoHO-MDI and vector magnetic field information from the USO vector magnetograph, we studied the distribution of acoustic power as a function of magnetic field intensity as well as intrinsic field strength. The study does show that for regions of similar field strength and continuum intensity, the acoustic power is smaller for larger inclination. The ratio of high frequency power (frequencies between 5.5 mHz to 7.5 mHz) to low frequency power (frequencies < 5.2 mHz) is found to be well correlated with magnetic field strength B, for $B > 1500$ G. The ratio remains constant for $B < 1500$ G.

P26

On the cookie cutter test for time-distance tomography of active regions

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Abstract: Time-Distance holds the most promising potential for high resolution three dimensional tomography of active regions. Namely by analyzing time anomalies resulting from acoustic waves propagating through and interacting with an active region, we should obtain enough diagnostic information to map the flows and sound speed anisotropies below the solar surface as such a region develops. Initial inferences for time anomalies computed over and around active regions have shown tantalizing results - but guarded scepticism ought to be held as the formalism of the methodology is still in being developed and the nature of the interactions in the magnetized region - especially near the surface are poorly understood and thus not yet modeled. I present the results of a conceptual y simple test to validate the putative fast sound speed plume derived below the well studied active region of June 1998. The idea is to remove from the input set used in the inversion some of the time anomalies computed using observations taken at the surface inside the active regions, measurements that might have been affected by interactions not modeled in the kernels used in the inversion. To validate this test, I first computed a simulated data set based on a similar sound speed perturbation plume and resulting from a direct forward computation. The acoustic ray approximation was used to derive the kernels. I compare how well the underlying sound speed profile is recovered or not in this simulation as observables are removed over circular patches of various sizes centered on the active region (hence the so called cookie cutter test). I then present how the inversion behaves when the same tests is applied to actual data. Two distinct inversion techniques were used, one that allows me to compute the corresponding resolution kernels. The validity of the inferences are discussed in light of the results of these simulations and the resulting profile of the corresponding resolution kernels.

P27

Comparative study of isolated sunspots using time-distance helioseismology

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Abstract: We present a preliminary comparative seismic study of conditions around and beneath isolated sunspots. Using European Grid of Solar Observations' Solar Feature Catalogue of sunspots derived from SOHO/MDI continuum and magnetogram data, 1996-2005, we identify a set of isolated features by checking that within a Carrington rotation there were no other spots detected in the vicinity. We then use avaialable MDI level 2 tracked Dopplergrams to investigate such sunspots using the methods of time-distance helioseismology.

P28

Subsurface structure evolution associated with the emergence and decay of intensely active regions

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Abstract: In order to study the sub-surface structure variations associated with the formation and evolution of major active regions producing large, long-lived sunspot groups and intense flare activity, we have analyzed the localized power spectra at the sites of selected active regions from well before their emergence through their disappearance, comparing the helioseismic data with those for quiet regions of the same size and at the same latitude during similar time ranges. Because of the need for continuous data through disc passages of the selected regions over several Carrington rotations, we have analyzed GONG Doppler data, for which nearly continuous observations are always available, whereas continuous MDI data are usually limited to two rotations or less. The selected active regions were those that attained the greatest sunspot group area during the years for which there is reasonably complete GONG+ data coverage, from the middle of 2001 through 2005.

P29

Three-dimensional numerical simulation of wave propagation through a model sunspot

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Abstract: The interaction of solar waves with sunspots in being studied using numerical simulations. The code we have developed follows the linear evolution of wave perturbations (including magnetic perturbations) in a general three-dimensional background solar model. We used the model sunspot of Schuessler and Rempel (2005, A&A 441,337). Several possible applications, in the context of local helioseismology, will be briefly mentioned.

P30

Magnetic field inclination and atmospheric oscillations above solar active regions

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Abstract: We present the results of some simple numerical experiments exploring the transparency of active region photospheres to helioseismic waves incident from below. It is found that the expected signals at heights observed by MDI and similar instruments are extremely sensitive to magnetic field inclination. In particular, field inclined in the direction of propagation of the wave is far more transmissive than field inclined in the contrary direction. This is explained using ray theory and the concept of 'attack angle'.

P31

On the enhanced velocity signals observed during solar flares

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Abstract: Solar flares are known to release large amount of energy. It is believed that the flares can excite velocity oscillations in active regions. We report here the changes in velocity signals in two active regions which have produced large X-class flares. The enhanced velocity signals appeared during the rise time of the GOES soft X-ray flux. These signals are located close to the vicinity of the hard X-ray flux regions as observed with RHESSI. The power maps of the active region show enhancement in the frequency regime 5.0-6.5 mHz, while there is feeble or no enhancement of these signals in 2.0-4.0 mHz frequency band. The observed momentum in the flare core is found to be ranging between 10^{21} and 10^{23} gm cm/sec.

P32

On the relation between solar flares and solar p-modes excitation

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Abstract: Kosovichev & Zharkova (Nature, 1998) have shown the seismic consequences of a solar flare observed in 1996: they showed the propagation of waves in the photosphere. This kind of consequences has not been observed during the solar maximum but has been observed again during the very powerful flare observed in October 2003, by Donea & Lindsey (SOHO14, 2004 and ApJ, 2005) and Zharkova et al (SOHO17, 2006). Baudin & Finidori (SOHO14, 2004) have shown that the flare observed in 1996 had a signature visible in the amplitude of global p modes, and that could be also the case for the so called Bastille Day flare of July 2000. Refined and new analysis will be presented here about the possible signature in global mode amplitudes of the flares previously mentionned (July 1996, July 2000 and October 2003).

P33

The acoustically active solar flare of 2005 January 15. I. Seismic emission

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Abstract: We report the discovery of one of the most powerful sun quakes detected to date, produced by an X1.2-class solar flare in active region 10720 on 2005 January 15. We used helioseismic holography to image the source of seismic waves emitted into the solar interior from the site of the flare. Acoustic egression power maps at 3 and 6 mHz with a 2 mHz bandpass reveal a compact acoustic source strongly correlated with impulsive hard X-ray and visible-continuum emission along the penumbral neutral line separating the two major opposing umbrae in the δ-configuration sunspot that predominates AR10720. At 6 mHz the seismic source has two components, an intense, compact kernel located on the penumbral neutral line of the δ-configuration sunspot that predominates AR10720, and a significantly more diffuse signature distributed along the neutral line up to $\sim$15 Mm east and $\sim$30 Mm west of the kernel. The acoustic emission signatures were directly aligned with both hard X-ray and visible continuum emission that emanated during the flare. The visible continuum emission is estimated at 2.0×10^{23} J, approximately 500 times the seismic emission of $\sim 4 \times 10^{20}$ J. The close spatial alignment between sources of seismic emission and impulsive continuum emission in previousely published sun quakes has suggested heating of the low photosphere, with an attendant pressure transient as a major contributor to seismic emission into the active region subphotosphere. In these instances, the signature of protons suggested direct heating of the low photosphere by energetic protons, which can penetrate to the low photosphere and deposit heat there directly. The 2005 January 15 flare exhibits the same close spatial alignment between the sources of the seismic emission and impulsive visible continuum emission as previous flares, reinforcing the hypothesis that the acoustic emission is driven by heating of the low photosphere. However, it is a major exception in that there was no signature to indicate the inclusion of protons in the particle beams thought to supply the energy radiated by the flare. It is well established that electrons with energies consistent with the hard X-ray (HXR) signatures cannot penetrate into the low photosphere with sufficient energy to explain the seismic emission by

direct heating of the low photosphere. The continued strong coincidence between the sources of seismic emission and impulsive visible continuum emission in the case of a proton-deficient white-light flare lends substantial support to the "back-warming" hypothesis, that the low photosphere is significantly heated by intense Balmer and Paschen continuum-edge radiation from the overlying chromosphere in white-light flares.

P34

Seismic emission from M-class solar flares

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Abstract: The detection of significant seismic emission from solar flares is a major discovery with a broad range of diagnostic and control applications for helioseismologists and flare analysts. Donea and Lindsey (2005) suggested that significant seismic activity might possibly be excited by a relatively small flare (either a C- or a M-class flare) provided the energy is released suddenly into a relatively localised footpoint. We have applied computational seismic holography to helioseismic observations to image the seismic sources of solar flares. In this paper we report the detection of seismic emission from M-class flares. We will present properties of the recently detected seismic emissions from M-class solar flares.

P35

Mode parameter changes with magnetic activity, from large-aperture ring diagram analysis of GONG data

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Abstract: We study the peak parameters from large-aperture ring-diagram analysis of GONG data. This gives access to higher-order and hence higher-frequency peaks than the standard ring-diagram analysis. At and above the acoustic cut-off frequency, the sensitivity of peak frequency, amplitude and width to magnetic activity level changes rapidly as a function of frequency. We investigate these changes and relate them to previous studies of high-frequency modes at different degrees.

P36

Phenomenological simulation of total solar irradiance and its power spectrum

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Abstract: Far from being constant, the combined influence of the convective motions, the action of the magnetic fields, the temperature stratification, as well as the differential rotation, amongst other effects, make the modeling and the understanding of the time evolution of the total irradiance recieved from the Sun disk especially complex. The main goal of this work is to reconstruct the solar signal as if it came from a star (integrating every contribution to the total irradiance) and its time evolution, taking into account its most relevant sources and the properties for which detailed information is available. Such a simulation will improve the knowledge on the nature of the solar irradiance signal and will provide clues to manage the analogous stellar signal.

P37

Solar mean magnetic field near the surface and its variation during a cycle

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Abstract: The unsigned mean magnetic field characterizes the magnetic energy settled in the solar near surface region. It is one of the determinant ingredients that govern the turbulence in the photosphere, and the magnetic heating of upper layers. The acoustic eigenmodes are directly sensitive to this mean magnetic energy, via the magnetic pressure, and thanks to their trajectories sweeping entirely this region. We use the local-wave formalism to calculate the p-mode frequencies of the Saclay seismic solar model. Then, by comparing them to the LOWL observed frequencies, the order-independent differences (up to 40 microHz) can be attributed to the existence of a magnetic pressure that modifies the pressure, the density and the sound speed, taking also into account the additional alfven speed. A profile of unsigned mean magnetic field is deduced, increasing from zero at the surface to 25 kG, 5600 km deeper. Next, by applying the same method, the order-independent variations in frequency due the solar cycle (up to 0.4 microHz) is used to deduce the change of the magnetic profile, which amounts to only 2-3 G at the depth of 2100 km, but with a very narrow peak of 55 G, 220 km thick, right at the surface. Due to the non-linear effect of the magnetic field, the comparison alone of the frequencies between minimum and maximum activity is not sufficient to deduce the magnetic variation. The additional knowing of the magnetic field at minimum activity is necessary. If the latter is ignored, an extra variation of up to 130 G would be found. Finally, our results are compared to magnetic field estimates by other helioseismic methods and spectroscopic methods.

P38

High-degree mode parameters: changes with solar cycle.

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Abstract: We present a study of the variation of the amplitude, width, frequency and frequency splitting of high-degree ($100 < l < 1000$) solar acoustic modes over most of solar cycle 23 using global helioseismology analysis techniques on full-disk observations obtained with the Michelson Doppler Imager (MDI) on board the Solar and Heliospheric Observatory (SOHO) spacecraft. To infer unbiased estimates of high-degree mode parameters, the known instrumental and observational effects that affect specifically high-degree modes were removed as well as possible following the methodology described in detail in Korzennik et (2004).

P39

Spatial behaviour of f and p modes in atmospheric models

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Abstract: The pulsation of the solar surface is caused by acoustic waves travelling in the solar interior. These f and p oscillation modes are not bounced back completely at the surface, but are partially penetrate into the atmosphere. Atmospheric effects are investigated analytically in one-dimensional hydrodynamic (HD) and magnetohydrodynamic (MHD)models. The focus is on the spatial behaviour of the perturbations: how their amplitude of oscillation varies with height in the interior and in the atmosphere. The f and p modes can be coupled resonantly to local atmospheric MHD modes (such as Alfvén and slow waves). The spatial evolution of the f and p modes around the resonant layer is also studied.

P40

Hydrodynamical evolution of the solar tachocline

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Abstract: The thinness of the Solar tachocline still does not have a fully satisfactory explanation. The purely hydro solution, relying on the existence of anisotropic turbulence that mixes angular velocity has not been demonstrated from first principles, and the properties of turbulence need to be better understood. Here, we present preliminary results obtained with a purely hydro code to assess this problem.

P41

How magnetic is the solar tachocline

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Abstract: Models of solar activity are often coupled with the storage of strong magnetic fields of the order of 10^5 Gauss in the tachocline. Also the formation of the tachocline could be magnetic and leads to toroidal magnetic fields of about 200 Gauss. We investigate the stability of toroidal-field belts in the tachocline in computations of spherical shells. We find that the maximum stable field strengths are of the order of 100 Gauss being compatible with the tachocline formation, but not with the storage of 100 kG fields.

P42

The turbulent tachocline

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Abstract: One of the outstanding problem in the solar interior is to understand the dynamics of the tachocline, a thin layer linking the differentially rotating convection zone and the uniformly rotating radiative interior. In particular, turbulent transport in this stably stratified shear layer plays a crucial role in the transport of angular momentum (responsible for the transition to uniform rotation) and of chemical species (to account for the abundance anomaly of light elements on the surface of the sun). Here, we present a consistent theory of turbulence in presence of a large-scale radial shear by incorporating the important effects of rotation (inertial and Rossby waves), latitudinal shear and magnetic fields.

P43

Turbulent transport in magnetized tachocline and its implications

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Abstract: A theory of turbulent transport is presented in the magnetized tachocline by incorporating the crucial effects of a radial differential rotation and gravity waves. We provide theoretical predictions for the transport of magnetic flux, momentum, and particles and turbulent intensities, which show stronger reduction compared with hydrodynamic case, with different dependences on shearing rate, magnetic field, and Brunt-Vaisala frequency. In the limit where the strength of toroidal magnetic field is much larger than Brunt-Vaisala frequency, particle transport is more severely suppressed than momentum transport, effectively leading to a more efficient momentum transport. However, for reasonable values of parameter, typical of the tachocline, the eddy viscosity is found to be negative. Some of the interesting implications of these results in the angular momentum transport and surface depletion of light element as well as the long-term dynamics of the tachocline will be discussed. In particular, a consistent estimate on the thickness of the tachocline will be provided.

P44

Convection and non-axisymmetric large-scale flows at the base of the solar convection zone

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Abstract: We model penetrative convection and large-scale non-axisymmetric flows at the base of the solar convection zone. Physical parameters for this region are taken from the standard solar models. Transition from convective stability to instability is determined by change in the value of thermal conductivity. The flows are modeled in anelastic approximation. 3D numerical simulations show strong interactions between small-scale convection and large-scale flows that is attributed to deformability of the interface between convectively stable and unstable regions

P45

A non-local MLT treatment fitting 3D simulations

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Abstract: It is known that the mixing-length approach gives a very crude description of convection. First it is local and second it neglects the spectral nature of turbulence. However, it is still widely used in stellar evolutionary codes. Moreover, perturbative approaches of the MLT can be derived, allowing a non-adiabatic modelling of the convection-oscillations interaction. We propose here a generalisation of the mixing-length theory to the non-local case, introducing 2 non-local parameters and 2 free functions associated with the closure of the problem. The description of the convective envelope (including the overshooting region) as predicted by 3D hydrodynamic simulations (horizontal and time averages) can be reproduced with our treatment by adjusting these free parameters and functions. A perturbation of this treatment can be done as in the MLT, allowing the theoretical determination of the modes damping rates for structure models with 3D description of the convective zone top.

P46

Realistic supergranule-scale convection simulations

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Abstract: We report on the status of solar surface supergranulation scale simulations (48Mm x 48Mm x 20Mm (deep)). Effects of f-plane rotation at a latitude of 30 degrees are included. These simulations were bootstrapped from smaller width calculations which were relaxed for 3 turnover times (6 days) and have now relaxed for another turnover time at the full width. The size of dominant structures increases with depth, due to the halting of some downdrafts and the merging of others as they descend, to form the boundaries of the larger horizontal upflows. These large scale structures are also visible at the surface with a velocity amplitude that decreases linearly with increasing size. We thank NASA and NSF for their support of this work.

P47

A seismic estimate of solar heavy element abundances

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Abstract: The recent downward revision of solar photospheric abundances of Oxygen and other abundant heavy elements has caused a serious discrepancy between standard solar model and the seismically determined solar structure. In order to obtain an independent estimate of heavy element abundances in the Sun, we use the dimensionless sound-speed derivative in the solar convection zone to determine the heavy element abundance using helioseismic data. This technique is similar to that successfully used to determine the helium abundance in the solar envelope. We find a heavy element abundance of Z=0.0172 +/- 0.002.

P48

Seismic solar model with the updated elemental abundances

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Abstract: It has been stressed that the improved measurement of elemental abundances makes the discrepancies between the helioseismically determined sound speed profile and the evolutionary model of the sun larger. We construct a seismic solar model with constraints of the helioseismically determined sound speed and the new abundances so that the model is consistent with both helioseismology and the new abundances. We show that the neutrino flux estimated from this model is, however, about a half of that estimated from the standard solar model – that is, as small as the measured electron-neutrino fluxes without correction due to the neutrino oscillation.

P49

FLAGing up the rotation of the solar core

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Abstract: We report preliminary results on rotation inversions of artificial splitting data, data that came from fits to simulated time series made as part of the solarFLAG hare-and-hounds program (Chaplin et al., 2006, MNRAS). Implications of the results for inference on rotation in the core of the Sun are discussed.

P50

On the p-mode coupling by differential rotation

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Abstract: Coupling of solar p modes by differential rotation produces prominent observational signatures starting from degree l of about 100. This effect was first analysed by M. Woodard (1989 ApJ 347, 1176) using a high-degree asymptotic approximation. In this presentation, the effect is reconsidered within the framework of quasi-degenerate perturbation analysis.

P51

On the direct determination of sensitivity, resolution and information content of helioseismic data – application to the inversion of the solar rotation rate.

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Abstract: A Singular Value Decomposition (SVD) analysis was carried out on the kernel matrix for the solar rotation inverse problem. This SVD analysis effectively establishes a direct relationship between the mode set included in the inversion and the spatial resolution, sensitivity and information content of the resulting inferences. We show that such an approach allow us to determine the effect of adding low frequency and low degree p-modes, high frequency and low degree p-modes, and g-modes on the derived rotation rate in the solar radiative zone, without having to carry out a slew of inversions - as it is done usually.

P52

Evolutionary convective envelope in modern model of the Sun

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Abstract: The current model of the solar evolution includes diffusion redistribution of elements through all interior. Chemical evolution also involves the convection envelope, which is undergoing swift convective mixing. In the model, the convection zone is supposed to be homogeneous, but averaged abundances evolve slowly unlike to solar model without diffusion. Effect of deficiency of heavy elements in the Sun on depth of the convection zone is considered in comparison with model with fixed envelope composition. The stratification of the most convective zones, as in a classical model, is supposed to be nearly adiabatic. Moreover, plasma of the low half the convection zone is quite similar to perfect gas, and deviation from ideality arises basically owing to Coulomb interaction and the higher ionizations of heavy elements. Accuracy of these effects description in the modern equation of state (e.g. OPAL2005 and SAHA-S EOS) is studied. Abundances of heavy elements based on analysis of an isoentropic profile of adiabatic compressibility exponent are presented. Intermediate Coulomb nonideality occurs in the helium ionization layers. The structure and acoustic properties of these layers in new versions of the EOS are discussed.

P53

A new method to estimate the acoustic cut-off frequency of the Sun using the different properties between p-modes and pseudomodes of low degree

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Abstract: An important parameter for locating the upper boundary of p-modes cavities is the acoustic cut-off frequency which can also lead to a determination of the mean molecular weight provided the temperature is known (Isaak 1983). The acoustic cut-off frequency also represents the frequency boundary between p-modes and pseudomodes, that means, between trapped and traveling waves.The discovery of a solar signal well beyond the acoustic cut-off frequency (pseudomodes), could complicate its determination because, for example, looking for a sudden drop in the power density signal could no be longer used. Contrary to what might be thought at first sight, the existence of pseudomodes helps to provide a good estimation of the acoustic cut-off frequency because the frequency pattern of pseudomodes is shifted with respect to that of p-modes and also the phase difference between Intensity and velocity signals or between Intensity and Intensity signals at different depths, change significantly for trapped and traveling waves. In this study a new method is used to get a good determination of the acoustic cut-off frequency. It is based on a bivariate analysis (coherence and phase shift) between the intensity signals of VIRGO and the velocity signal of GOLF (both instruments on board the SOHO probe). This analysis is carried out over the frequency range of p-modes and pseudomodes. The results shows clear evidence that the acoustic cut-off frequency of the Sun is even lower to the theoretical value of 5300 μHz; specifically, a value around 5100 μHz is found in this research.

P54

The signature of chemical-composition effect and the adiabatic index

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Abstract: Recently, Asplund, Grevesse & Sauval (2004), using a refined model for the solar atmosphere, announced the new solar chemical composition with the heavy-element abundance (Z=0.0122) being about 30% lower than the previously determined value (Z=0.0171; Grevesse & Sauval 1998). The chemical composition affects solar models in a complicated manner and it is often difficult to determine whether the discrepancies between the Sun and a model result from the chemical composition or from other sources. In this study, we use the adiabatic index, $\gamma_1 \equiv (\partial \ln P / \partial \ln \rho)_s$, to examine and isolate the effects of different chemical compositions. The advantage is that γ_1 is independent of the macroscopic structural properties. Specifically, we exploited the fact that γ_1 deviates from the isentropic value of 5/3 in the element ionization zones, which are determined by the EOS formalism and the element abundance. The results of our study can provide an independent test of the newly determined solar composition.

P55

On the frequency signature of rapid variations in the background state

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Abstract: We present improved models for the seismic diagnostic that is contained in the frequency spacing of the observed acoustic modes. By modelling these signatures we are able to determine gross properties of the stellar interior. In particular we are interested in measuring properties that are related to the helium ionization zones and to the rapid variations in the background state associated with the lower boundary of the outer convection zone. The improved formulae for the seismic diagnostic are tested against a sequence of theoretical solar models.

P56

How GOLF sees the second helium ionization layer across the solar cycle

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Abstract: Previous works using intermediate-degree modes (Basu & Mandel 2004), but also recently low-degree modes (Verner et al 2006) have shown variations with magnetic activity in the adiabatic exponent Γ_1 in the second helium ionization region. Using ten years of low-l p-mode observations carried out by GOLF instrument, we propose a methodology to isolate the signal from the He-II zone using the second difference. Then, we look for possible variation of the parameters which characterize this layer near the solar surface across the solar cycle.

P57

Variations in p-mode frequencies and splittings with solar activity observed in LOWL data

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Abstract: We have analyzed independent 108-d timeseries of the spatially-resolved LOWL observations collected over $\sim$ 6 years, spanning the decreasing phase and the minimum of the solar cycle 22 and the rising of the solar cycle 23, to study the activity-related variations of the solar acoustic mode central frequencies. We present also the variations of the even a-coefficients of the frequency splittings, describing the solar asphericity, and of the odd a-coefficients, which sense the internal differential rotation. Their frequency and degree dependences with solar activity are both investigated.

P58

On the impact of the solar cycle on the shapes of resonant peaks

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Abstract: We assess the likely impact of the solar activity cycle on the underlying shapes of the resonant peaks seen in power spectra made from data spanning large fractions of the cycle period. We adopt a two-pronged approach: First, through the development of an analytical description of the expected profiles (subject to assumed constraints); and second, through the use of artificial seismic data to which temporal variations of the oscillator parameters are imposed. Implications of the results for the mode fitting procedures will be discussed.

P59

How does the change on solar abundances affect low frequency modes?

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Abstract: the most recent determination of the solar chemical composition has been done using Time-dependent, 3D hydrodynamical model of the solar atmosphere, instead of the classical 1D hydrostatic models. This new determination exhibits a significant decrease on oxygene and other heavy elements abundances comparing to their classical values. Its corresponding solar model is not consistent with helioseismological measurements. However, the increase on some bad determined elements abundances such as the neon abundance can minimize the inconsistency. Since the change on chemical abundances affectes essentially the opacity all along the interior of the star, low frequency modes are affected as weel. In this poster, we show the influence of abundances and opacity changing on the determination of g-modes and low degree p-modes frequencies. g-modes with frequencies around 250μHz are the less sensitive modes to these changes.

P60

The acoustic solar cycle: SPM and GOLF low-l p-mode variations

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Abstract: We present a detailed comparison of variations in the fundamental propierties of globally coherent, low-angular degree solar p modes as observed by SPM and GOLF instruments, both on board the ESA/NASA SOHO sattelite. Ten years of data, (1996-2006) were analyzed to extract estimates of changes in frequency, damping, power, acoustic forcing and peak asymmetry. The long and short term variation are analyzed and compared with the surface solar activity.

P61

Changes to global mode parameters from GONG and MDI over a solar cycle

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Abstract: We analyze GONG and MDI data for different lengths of observations to study p-mode parameters over the rising and falling phase of the current activity cycle 23. There has been some evidence that the p-mode frequencies derived from short term time series behave differently in rising and falling phases of the solar cycle. Thus, it would be interesting to study this behavior for other mode parameters. In this paper, we will concentrate on mode amplitudes, line widths, and energy parameters derived from time series of length varying from 9 days to 108 days. This may help us to understand the excitation and decay process of the oscillation modes of the Sun.

P62

The evolution of the solar velocity background from MDI and GOLF during cycle 23

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Abstract: We used SOHO/GOLF (GLobal Oscillation at Low Frequencies) and SOHO/MDI (Michelson Doppler Imager) data to perform a detailed analysis of the evolution of the solar background during cycle 23. We analysed and compared different sub-series of data and distinguished the different parts of the acoustic background solar spectrum linked to different aspects of solar activity, as granulation and supergranulation for example. We will then show the temporal evolution of the solar background within the past 10 years. Besides, as GOLF is able to measure the velocity at different heights in the sodium line, the variations with the altitude in the solar atmosphere will also be discussed.

P63

Sensitivity of the predicted frequencies of g-modes to different physical processes

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Abstract: More and more attention will be dedicated in the next years to the solar radiative zone in order to understand the discrepancy observed nowadays between standard model predictions including the new abundances and seismic observations. We already know that this internal region certainly requires to take into account more complex physical processes which may partly modify the deep layers. So we discuss here, as a first step, the sensitivity of the global gravity modes (n= -1 to n= -30) to the different physical inputs and we also compare gravity modes predictions produced by different teams for standard models.

P64

Needles in haystacks: how to use contemporaneous data in the search for g modes

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Abstract: Solar noise is a major problem, restricting success in the hunt for g modes. Contemporaneous datasets offer the possibility of reducing solar noise, but the statistical tests must take proper account of correlations. We explore the possible options, and present a formalism for the analysis.

P65

Theoretical damping rates and phase-lags for solar-like oscillations

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Abstract: We present the theoretical damping rates obtained for a solar model, using a new non-local time-dependent convection treatment. Our structure models fit the description of the convective zone top given by 3D hydrodynamic simulations. We compare our results with the observed line-widths and phase lags between intensity and velocity curves. The sensitivity of our results to the free parameters of our model is discussed.

P66

Solar-activity changes in the p-mode damping and excitation using LOWL observations

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Abstract: We have used the LOWL observations collected between beginning of 1994 and end of 1999 to study the temporal variations of the low- and intermediate-ℓ p-mode damping and excitation parameters with solar activity, as a function of the mode frequency and of the mode degree. We extracted the temporal variations in mode height, mode width, mode velocity power and mode energy supply rate by applying a multi-linear regression on the estimates of 16 108-d independent timeseries. This regression allowed us to correct the bias on the peak-finding estimates from the temporal fills and to obtain a measure of their fractional changes. We show that the p-mode damping and excitation parameters between $\ell = 0$ and $\ell = 60$ present different behaviours with solar activity. Our results confirm previous work made with the spatially-resolved GONG observations, and also with full-disk Sun-as-a-star instruments.

P67

Distribution of MDI p-mode power correlation coefficients

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Abstract: We have analysed a 72-day MDI spherical-harmonic time series to examine temporal variations of p-mode power and their correlation. The power variation is computed by a running-window method after the previous study by Roth (2001), and then distribution function of power correlation between mode pairs is produced. We have confirmed Roth's result that there is an excess of anti-correlated p-modes pairs with close frequencies. On the other hand, the amount of excess was somewhat smaller than the previous study. Moreover, the distribution function does not exhibit significant change when we paired modes with non-close frequencies, implying that the excess is not due to mode coupling. We discuss the possibility of statistical bias playing the central role in producing the excess.

P68

Status of the BiSON network

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Abstract: The Birmingham Group has been collecting data for thirty years, and are the only group to have been in operation over a complete magnetic solar cycle. What started out in the summer of 1976 as a single instrument in Tenerife developed rapidly, with a second instrument at Pic du Midi in 1978, and a third at Haleakala in 1981. Three years later in 1984 the group built the first semi-automatic station in Carnarvon, which was finally made fully automatic in 1985. The six station network of today was completed in 1992, and for the last thirteen years the group have been officially known as the Birmingham Solar-Oscillations Network (BiSON). We have nearly completed replacing the old computers with new Linux-based installations. These provide improved remote-control capabilities with better system monitoring and diagnostic facilities. We are also working on improving the guiding system, and other control hardware. Some of our stations have been recording global, longitudinal, solar magnetic fields since 1993. We are extending this capability to more stations and are continuing and expanding the analysis of these data. We are exploring novel techniques for widening the field of view of our KD*P retarders which should allow us to run with larger input apertures thus improving our signal-to-noise ratio. At present the network is producing a duty cycle of around 80% per year.

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Analysis of velocity-noise variations arising from photon-noise in data from the GOLF instrument.

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Abstract: Searches for low-amplitude p-modes and g-modes and studies of the solar velocity continuum all require a sound understanding of the noise characteristics of helioseismic data sets. In recent years both BiSON and GOLF teams have reported on meticulous studies of the noise behaviour of their full-disc instruments. This paper extends an analytical approach, originally developed to investigate noise variations in BiSON data, to recently published GOLF results. The new work confirms that observed annual noise variations in regions of the velocity power spectrum may be caused by photon-noise in intensity measurements, the effects of which alter as the operating point on the spectral line changes with the radial component of the orbital velocity. A brief discussion is given concerning the value of the present result for informing future simulations of full-disc data and for the design of new instruments.

P70

The p mode high excitation events: comparison between BiSON and GOLF observations

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Abstract: Recent observations have suggested that some flares excite waves on the solar surface and further solar activity like coronal mass ejections have been investigated as possible sources of excitation. This research has been motivated by the great interest in linkng the atmospheric events with the acoustic waves. Using 10 years of BiSON and GOLF observations, we studied the modes of oscillation at the tail of p mode power distribution in the frequency range 2.5-3.5mHz. We used for the first time the information content of the phase to the aim to help understand further the mechanisms responsible for their excitation and damping.

P71

Comparison of solar p-mode lifetimes from GONG, MDI and TON data

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Abstract: We present results of p-mode lifetime measurements obtained from GONG, MDI and TON (Taiwan Oscillation Network) data using the time-distance technique. Lifetimes of solar p-modes in the range $l = 100 - 600$ and $\nu = 2.5 - 4.5$ mHz were estimated from the decrease of the amplitude of the cross-correlation function of the surface oscillations with time. We also include the effect of dispersion of the wave packets in our measurements. The results from GONG, MDI and TON data are in good agreement taking into account the different spectral lines of the observations.

P72

A comparison of acoustic mode parameters using multi-spectal data

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Abstract: We analyze multi-spectral line observations to investigate the propogation behaviour of acoustic waves in solar atmosphere. We use simultaneous observations in several atmospheric layers to study relative changes in local mode parameters. The data sets include observations obtained with the Ni I 676.8 nm from Global Oscillation Network Group (GONG), K I 769.9 nm from Magneto Optical Filtters at Two Heights (MOTH) experiment and Na I D_2 589.0 nm from MOTH experiment and Mount Wilson Observatory (MWO) during Austral summer of 2002-03. The depth formation of these lines occurs about 200 km, 420 km and 780 km above the base of the photosphere, respectively. We generate power spectra using ring-diagram technique and the resulting power spectra are fitted to a Lorentzian profile to obtain the local mode parameters. Preliminary analysis of these parameters obtained from Ni I 676.8 nm and K I 769.9 nm spectral lines clearly show a significant increase in mode amplitude with increasing observing height, however, we do not see any significant change in mode width.

P73

Comparison of local frequency shifts between velocity and intensity data from MDI

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Abstract: There has been indication that the mode frequencies derived from velocity and intensity data are different. The frequencies derived from local ring diagrams also suggest a variation with the position on the solar disk. Since the apparent frequency shift can not be a property of the observables, it is expected that an simultaneous analysis of velocity and intensity data may provide important information about the driving and damping mechanism of local acoustic oscillations. It is known that the peaks in power spectra are not symmetric and the use of symmetric profiles may cause the fitted frequency to be shifted away from the true value. Thus, we analyze velocity and intensity data from MDI through ring diagram technique and fit the resultant power spectra with both symmetric and asymmetric profiles for comparison. We do this at several different positions on the solar disk to study the apparent shift between a single observable. We find that frequency differences between velocity and intensity are minimized when asymmetric fitting formula is used.

P74

On the amplitude of solar p modes

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Abstract: The convection in the outer layers of the Sun is still not well understood and modelled. Seismology can put constraints on the convection modelling through the observed amplitudes, width, and asymmetries of p modes as they are excited by convection. However, the measurements of these parameters is not an easy task, mainly because of the noise present in the data and of the influence of the observation and analysis methods. Previous comparisons of measurements from different instruments have shown that it is possible to obtain reliable estimates of the excitation rates of p modes (Baudin et al A&A, 2005). A better precision has been obtained using more data (Belkacem et al A&A, 2006). All of these measurements are now precise enough to look into details of the influence of the observational method through the height of formation in the solar atmosphere of the lines used for helioseismic observations. A proper calculation of eigen-functions of the observed modes is also important, in particular because of the non-adiabaticity of the oscillations in the solar atmosphere. We present here consistant calculations of the formation of the velocity signal in the spectral lines used in helioseismology, and non-adiabatic eigen-functions of the observed modes. Finally we compare the observed excitation rates measured by several helioseismic instruments.

P75

High resolution spectrum: towards a new observational strategy

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Abstract: In classical Fourier analysis, spectral resolution is inversely proportional to the length (duration) of the signal. Moreover, the observed signal should be regularly sampled at a rate satisfying Shannon's law. This means that if we need a high resolution spectrum we have to perform long continuous observations which implies in general huge amount of data and time. However by introducing an 'a priori' knowledge about the spectrum, such as 'narrow peaks spectrum' and using regularization methods, one can achieve a high resolution spectrum with shorter time and even with irregularly sampled data. Simulated data as well as GOLF data are used to illustrate this last technique. Therefore, we can expect developing a new strategy for sun or stars observation in order to achieve high resolution spectrum with shorter observation time. Elements of this strategy, such as oversampling and gaps distribution are presented and discussed.

P76

Study of the role of phase evolution in the amplitudes of low-l solar p modes

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Abstract: Previous studies have shown that the amplitude of the 'phase jitter' in solar p modes is strongly dependent on the lifetime. Here, we find that, in some cases, when the observed amplitude of the mode is many times the average expected for that mode, the phase variation is well below expectation. This information can be used to help to categorise large excitations seen in an extended, low-degree dataset. The hope is that we may be able to identify some large excitations as being driven by external means.

P77

Helio- and asteroseismology: the question of the conceptual framework

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Abstract: Star oscillations have been studied, understood, and the eigenfrequencies calculated by high precision codes, for more than 60 years. But, is the physical nature itself of the oscillations described by a clear concept? According to every general-public documents, as well as introductions to many theoretical articles, a star vibrates because of acoustic waves, and thus sounds like resonant cavities of musical instruments. This concept was indeed given by the very first papers to explain the 5-minute oscillations of the Sun. But since then, sometimes despite of their introductory words, theoretical works progressively adopt the language and the concepts of quantum physics, with notions of potential wells stretching to infinity. In parallel, numerical codes employ boundary conditions consisting in fitting to solutions coming from infinity. The concept of a cavity with finite limits is thus banished. One can wonder now if stars still oscillate because of acoustic waves, or if acoustic waves can have a quantic behavior. Is it possible to conciliate the contradictory points of view of classical waves in a cavity and quantum waves in an infinite space? How can the global physics of a huge gaseous sphere like a star can be described with quantum physics that has been untill now exclusively used for microscopic objects? These questions are debated in this paper.

P78

Effects of rotation on frequencies of rotating stars

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Abstract: The effects of rotation on the oscillation frequencies of stars present one of the greatest difficulties in the analysis of asteroseismic data. We have modified Christensen-Dalsgaard's 'adipack' adiabatic pulsations package to include the effects of rotation in a second-order perturbative approach. The code calculates stellar oscillations, accounting for the effect of the star's rotation to first order in the eigenfunctions and to second order in the eigenfrequencies. We present our initial results for main-sequence and near-main sequence stars of different ages and masses, for a range of different rotation rates.

P79

Effects of rotation on turbulent convection in young solar-like stars

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Abstract: Young stars are known to be faster rotator than their main sequence counterpart and to possess intense magnetic activity, subject of important research efforts. We have performed – as a first step – 3-D numerical simulations of turbulent convection of young solar-like stars in deep shperical shells using the anelastic spherical harmonic (ASH) code. These nonlinear models aim at understanding the complex interactions between convection and rotation. We discuss as the level of turbulence or the rotation rate is increased, how the redistribution of angular momentum by Reynolds stresses, meridional flows and viscous diffusion leads to the differential rotation profile seen in the models. In particular we focus our study on a regime where we find that the convection, when the rotation influence becomes strong, undergo a very pronounced spatial and temporal intermittency. In such thick shells, under some conditions, the convection can develop localized patterns and even a oscillating behaviour, with very interesting dynamical properties. Finally, we consider the influence of baroclinic effects associated to a tachocline at the base of the convective enveloppe of these young Suns, to see if the quasi cylindrical rotation profile obtained in most of the fastly rotating models can be broken to a more conical solar-like profile.

P80

Asteroseismic diagnostics of stellar convective cores

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Abstract: We present a detailed study of the small frequency separations as diagnostics of the mass of the convective core and stellar age in solar-type stars. We demonstrate how the small separations can be combined to provide sensitive tests for the presence of convective overshoot at the edge of the core. These studies are focused on low degree oscillation modes, the only modes expected to be detected in distant stars. Using simulated data with realistic errors, we find that the mass of the convective core can be estimated to within 5% if the total stellar mass is known. Systematic errors arising due to uncertainty in the mass, composition and overshoot could be up to 20%. Similar error estimates hold for stellar age determination using the new technique.

P81

Kepler telescope and solar-like pulsators

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Abstract: We present stars selected or a long-time monitoring for Kepler, a new NASA space telescope. The selected stars are primary asteroseismological targets for Kepler. They are mostly solar-like stars in which we expect detection solar-like pulsations. We determine fundamental astrophysical parameters of the selected stars. Then, we show estimations of pulsational properties of the targets. Finally, we show results of simulations of the Kepler capability of detection oscillations with frequencies and amplitudes typical for solar-like pulsators and the large separation determined from simulated data.

P82

Calibrating the solar dynamo: magnetic activity cycles of southern Sun-like stars

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Abstract: The solar magnetic activity cycle is responsible for periodic episodes of severe space weather, which can perturb satellite orbits, interfere with communications systems, and bring down power grids. Much progress has recently been made in forecasting the strength and timing of this 11-year cycle, using a predictive flux-transport dynamo model (Dikpati et al. 2005, 2006). We can strengthen the foundation of this model by extending it to match observations of similar magnetic activity cycles in other Sun-like stars, which exhibit variations in their CaII H and K emission on time scales from 2.5 to 25 years (Baliunas et al. 1995). This broad range of cycle periods is thought to reflect differences in the rotational properties and the depth of the surface convection zone for stars with various masses and ages. Asteroseismology is now yielding direct measurements of these quantities for individual stars, but the most promising asteroseismic targets are in the southern sky (alpha Cen A, alpha Cen B, beta Hyi), while the existing activity cycle survey is confined to the north. We are initiating a long-term survey of CaII H and K emission for a sample of 92 southern Sun-like stars to measure their magnetic activity cycles and rotational properties, which will ultimately provide independent tests of solar dynamo models.

P83

Stellar cycles and damping rates for Sun-like stars along the lower the Main Sequence

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Abstract: Through the use of observational and model data, we discuss trends in certain seismic parameters for stars on the lower Main Sequence, and the likely impact of these trends for inference on the stellar interiors. We concentrate in particular on general trends in acoustic mode damping, and trends in the stellar-cycle frequency shifts (inferred, to first order, from the Mount Wilson Ca II H & K survey data).

P84

Degree dependence of the p-mode excitation parameters in Sun-as-a-star data

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Abstract: In Chaplin et al. (2003; SOHO 12/GONG+ 2002, p. 119) we reported evidence for a degree dependence of the variation observed over the solar cycle of the widths of the low-degree modes. The data came from analysis of Sun-as-a-star observations made by the BiSON. Here, we report on attempts to validate the result using Monte Carlo simulations of the ∼10-yr dataset.

P85

Do we understand the relative importance of different observations? Case study: interferometry and asteroseismology

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Abstract: We use a minimization technique that combines the Levenberg-Marquardt algorithm with the Singular Value Decomposition (SVD) technique to fit physical parameters of a stellar system to observations. SVD also allows us to quantify the information that comes from each observable; we can use this knowledge to assess the relative importance of different kinds of measurements. We apply this technique to learn how interferometric measurements of stellar radii complement oscillation frequencies. We have done monte carlo simulations of particular Sun-like stars to see by how much an additional radius measurement is valuable in the determination of the system's parameters. We try to quantify this for representative measurement errors for radius and oscillation frequencies.

P86

12 Bootis: a test bed for extra-mixing processes in stars

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Abstract: 12 Bootis is a double-lined spectroscopic binary whose orbit has been clearly resolved by interferometry. We present a detailed analysis of the system and show that the evolutionary state of the components cannot be unambiguously determined, even when all available observational constraints are taken into account. The different evolutionary states that match the observations depend on the details of extra-mixing processes acting in the core (overshooting, diffusion etc). In order to discriminate among these theoretical scenarios, additional and independent observational constraints are needed. We show that these can be provided by solar-like oscillations, that are expected to be excited in both components of the system.

P87

Procyon-A and eta Bootis: observational frequencies analyzed by the local-wave formalism

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Abstract: Relatively consequent sets of p-mode frequencies are now available for the two solar-like stars Procyon-A and etaBootis, obtained after many years of effort from ground-based telescopes. Numerous theoretical interpretations of these observations have been done, but always following the same traditional numerical calculations. In spite of their very high precision, these calculations use boundary conditions that actually modify the star models by smoothing out their physical parameter profiles at the center and at the surface. The two stars considered here present steep variations toward the center due to the convective core stratification, and toward the surface due to the very thin convective zone. In order to analyse their eigenfrequencies, we use the local-wave formalism which, despite its lack of precision inherent to the fact that it is a semi-analytical calculation, uses directly the model profile without any modification. Based on other boundary conditions, the frequencies obtained with this formalism are different from that of the traditional numerical calculation. The first type of differences, up to some tens of microHz, already seen for the Sun, vary mainly with the degree l and not with the order n, expressing that they come from the use of different surface conditions. A second type can be seen for the two considered stars, concerning some very precise low-degree modes, whose internal turning points are across the steep variation of the core limit. Two main results can be pointed out: - The frequencies calculated with the local-wave formalism seem to fit better with observational ones. Furthermore, all the frequencies detected with confident levels equivalent to others but classified as 'noise' because too far from numerical results, find here their corresponding theoretical frequencies. - Some frequencies can be clearly identified here as indications of the core limit. These results must however be taken with caution because, as other authors, we have displaced the observational frequencies by + or - 11.57 microHz, the day-night alias of unique-site observations. A comparison with the very first data given by the MOST satellite leads again to the same results as above. But they still remain to be confirmed by more reliable observational data, coming from future multi site ground-based observations, or/and space observations.

P88

Modeling intermediate mass red giants: parameters constraints.

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Abstract: Because radial modes will be easiest to observe in red giants, we have studied the stellar parameters (stellar mass, mixing length parameter, metallicity and overshooting parameter) constraining the theoretical models using the large separation as the only asteroseismic observable available. We have calculated a grid of intermediate mass stellar models and we have considered a 2σ error box, with σ(Teff)=116 K and $\sigma(L/L_\odot)$=8, in the red giants region of the HR diagram. For the same mass, models of different age seem to have a very similar $l = 0$ oscillation signature. Statistical arguments were taken into account in order to choose the best fitting model.

P89

Analysis of line profile variations of pulsating red (sub)giants

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Abstract: So far, red (sub)giant oscillations have been studied using radial-velocity and/or light curve variations, which reveal frequencies of the oscillation modes. To characterise radial and non-radial oscillations, line profile variations are a valuable diagnostic. Here we present for the first time a line-profile analysis of pulsating red (sub)giants. The main difficulties encountered are the small line profile variations and the predicted short damping and re-excitation times in red (sub)giants. Two line diagnostics have been tested to see whether these are sensitive to the small line profile variations present in red (sub)giants. In addition, line profiles are simulated with short damping and re-excitation times and compared with the observations. The comparison between the observations and simulations reveals that non-radial modes are most likely to be visible in the line profile variations while theory predicts the occurrence of radial modes.

P90

Asteroseismology of K giants

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Abstract: Over a decade ago precise stellar radial velocity measurements established that K giant stars exhibit multi-periodic radial velocity variations on time scales ranging from days to hundreds of days with an amplitude which can be up to several hundreds m/s. Since their discovery, relatively little progress has been made in fully understanding the complex nature of K giant variability, but it seems clear that their short period variations are due to p-mode oscillations of solar-type nature. Here we consider the theoretical study of two K giants, HD32887 and HD81797, which have been proved to be suitable for ground observations and we will show how a pulsational analysis of the detected modes will enable us to draw important conclusions on the structural and pulsational properties of red giant stars.

P91

Pulsational properties of the beta Cep star SY Equ from simultaneous photometric and spectroscopic observations

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Abstract: We present the analysis of simultaneous multicolour uvyI photometry and low resolution spectroscopy for the fast rotating beta Cephei star SY Equ. The period search analysis was performed for all four passbands and for the first three moments of various line profiles. From the photometric data, we confirm the dominant pulsation frequency, f_1=6.029 c/d and we find an evidence for a few additional modes. In spectroscopy, the highest peak occurs at frequency f_a=0.195 c/d or its alias 0.805 c/d. It can be interpreted either in terms of a binary motion or as the g-mode pulsation. Such the low frequencies were already discovered in some beta Cep stars. We reveal also the main pulsation mode with the radial velocity amplitude of about 12 km/s and, in addition, a few possible frequencies. We made mode identification for the observed frequencies from combined photometric and spectroscopic data. In pulsation nonadiabatic calculations, the effects of rotation on the oscillation frequencies were taken into account up to the second order. Our study showed that the observed modes in SY Equ are consistent with the stellar models for much lower $T_{\rm eff}$ than derived from Geneva photometry. This effective temperature is in accordance with the determination from the IUE spectra.

P92

Chemical composition of the pulsating beta Cephei star gamma Peg

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Abstract: We present the determination of the detailed chemical composition of the pulsating beta Cephei star gamma Peg (HD 886, B2 IV). For this purpose we collected all currently available spectroscopic data and performed analysis by means of spectrum synthesis method. The majority of lines for hot B type stars are located in the ultraviolet part of the spectra. The high-resolution IUE (120 - 300 nm) and HST/GHRS observations (205.9 - 207.1, 134.3 - 138 nm) have been used to determine abundances of the iron group elements. The visual high-resolution, high S/N ratio spectra from UVES/VLT (300 - 1000 nm) were used to find the abundances of the other elements, for example C, N, O, Mg and Si. We also check the observations from ELODIE spectrograph (400 - 880 nm) as well as from Ondrejov Observatory (625 - 677, 438 - 460 and 750 - 802 nm).

P93

SIAMOIS: An asteroseismic network with one site... in Antarctica

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Abstract: SIAMOIS is a project devoted to ground-based asteroseismology, involving an instrument to be installed at the Dome C Concordia station in Antarctica. Dome C appears to be the ideal place for ground-based asteroseismic observations. The unequalled weather conditions yield a duty cycle as high as 90% over 3 months, as was observed during the 2005 wintering. This high duty cycle, a crucial point for asteroseismology, is comparable to the best space-based observations. Long time series (up to 3 months) will be possible, thanks to the long duration of the polar night. As a consequence, SIAMOIS is the only asteroseismic programme that can follow the way opened by the space project CoRoT: it will provide unique information on G and K type bright stars on the main sequence. In addition, spectrometric observations with SIAMOIS will be able to detect oscillation modes that cannot be analysed in photometry, and will be less affected by stellar activity noise, increasing the complementarity with space-based photometric observations. The SIAMOIS concept is based on Fourier Transform interferometry. Such a principle leads to a small instrument designed and developped for the harsh conditions in Antarctic. The instrument will be fully automatic, with no moving parts, and a very simple initial set up in Antarctic. The single dedicated scientific programme will avoid the complications related to a versatile instrument. Data reduction will be performed in real time, and the transfer of the asteroseismic data to Europe will require a modest bandpass. SIAMOIS will observe with a dedicated small 40-cm telescope.

P94

On the possible instrumental influence in MOST Procyon data analysis

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Abstract: The observation of p modes in the Fourier spectrum of MOST Procyon data has been claimed recently (Regulo & Roca Cortes A&A, 2005; García et al A&A, 2006). We present here some results on the influence of instrumental efects (temperature variations and window function for example) that could explain the features observed in the spectrum and interpreted as the signature of p modes.

P95

The spectral resolving power of irregularly sampled time series

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Abstract: A new method for investigating the frequencies of multiperiodic signals from an irregularly sampled time series is presented. The method is a time-frequency method and views the problem as an inverse problem. Using SOLA as a basis, the spectral resolving power of a given sampling can be investigated, also including weighting for the properties of the data errors.

P96

The autocorrelation function of stellar p-mode measurements and its diagnostic properties

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Abstract: The basic properties of acoustic wave propagation in stellar interiors can be analysed from the autocorrelation function (ACF) of intensity (or velocity) observations without measuring the resonant p-mode frequencies. We show how the strength of acoustic wave refraction in the stellar core, or forward acoustic amplitude, can be measured from a modulation in the ACF. This is the basic physical quantity which governs the so-called “small frequency separations”, and its measurement from the ACF can be used for determining the small frequency separations when the data is of insufficient quality for a reliable identification of the stellar p-mode frequencies.

P97

Time-distance helioseismology in steady sub-photospheric flows

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Abstract: Results of forward modelling of acoustic wave propagation in a realistic solar sub-photosphere with a steady horizontal flow are presented. The simulations are based on fully compressible ideal hydrodynamical modelling in a cartesian grid. The initial model is characterised by solar density and pressure stratifications taken from Model S of Christensen-Dalsgaard and is adjusted in order to suppress convective instability. Acoustic waves are excited by a non-harmonic source located close to and right below the depth corresponding to the visible surface of the Sun. A series of numerical experiments with coherent horizontal flows of various depths and speeds are carried out. The implemented flow field may mimick horizontal motions of plasma surrounding a sunspot (e.g. local analysis) or differential rotation (global analysis). The influence of steady state on the propagation of the sound waves through the solar interior is analyzed. Time-distance analysis technique is applied to compute the direct observational signatures of the background bulk motions on the travel times and phase shifts. This approach allows direct comparison with observational data.

P98

Three-dimensional numerical simulation of solar magnetoconvection with realistic physics

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

P99

Intensity and velocity oscillations in magnetic concentrations

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Abstract: We analyzed intensity and velocity oscillations in magnetic network using high-resolution 2D spectral scan images from Interferometric Bidimensional Spectrometer (IBIS). In photosphere, oscillations in intensity and velocity in 2-5.2 mHz band shows reduced amplitude while at higher frequencies 5.2-7.0 mHz and 7.3-25.8 mHz band oscillations amplitude inhance in line core intensity and shows reduced amplitude in line core velocity however in chromosphere the oscillations have different character, we found higher power in 2-5.2 mHz, 5.2-7.0 mHz and 7.3-25.8 mHz band in core velocity compared to core intensity. Amplitude variation with height is also inferred from our analysis. These findings are manifestation of high frequencies halos around strong flux concentrations (pores) in intermediate field strength network and mode conversion of solar p-modes in magnetic fields.

P100

An acoustic showerglass originating in the helioseismic Doppler measurements over active regions

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Abstract: By use of a Stokes profile synthesizing radative transfer code ("STOPRO", Frutiger et al. 2000), a study of helioseismic Doppler measurements is made focussing on the effects of line shape changes caused by the Zeeman effect as well as by broadening due to large velocity amplitudes. The spectral lines used are Ni I (6768 A), Fe II (6173 A) and magnetically insensitive Fe I (5576 A). A 2-d MHD simulation of waves over a spreading magnetic geometry (Hasan et al. 2005) is used as input. The output returned by MDI-like Doppler measurement algorithms, as well as by the center of gravity (COG) method, are compared with an appropriately height averaged (by use spectral response functions) input simulations. We show that the Zeeman split and broadened line profiles could cause the Doppler measurement algorithms to introduce shifts in the phase evolution of (magneto)-acoustic waves. These phase shifts show a dependence on the field strength, and also on the inclination of the field vector to the line of sight. Consequently, the phase shifts depend on the polarization states (linear or circular) used for measurements. We also show results from calculations based on oscillations superposed on a Maltby model of sunspot atmosphere with a simplified construction of spreading field geometry and field strengths: pressure balance with a quiet Sun atmosphere and and an empirically known run of Wilson depression across a sunspot. We discuss the possible connections between the present source of acoustic showerglass and that has been studied in the context of wave propagation in inclined magnetic fields using helioseismic holographic measurements. We discuss the implications of these results to the local helioseismic study of sunspots.

P101

Forward modeling of atmospheric magneto-acoustic-gravity waves

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Abstract: Measurements of travel times of atmospheric magneto-acoustic-gravity waves are a new tool to understanding the solar atmosphere. Using this tool requires an understanding of how the parameters in the model used to describe the observations, in particular phase and group travel time, as well as fit frequency width and amplitudes, are sensitive to different wave conditions in the atmosphere. We present the results from forward models and compare these results with those from the analysis of the Magneto Optical Filter at Two Heights (MOTH) data obtained at the South Pole in 2003.

P102

Solar quakes associated with the flare 28 October 2003

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Abstract: Recently, during the decline of solar cycle 23, new quakes were observed in association with solar flares on 2003 October 28 and 29 in active region NOAA 10486 using helioseismic holography (Donea and Lindsey, 2005). 5 seismic sources were found in these flares that are well co-aligned with hard X-ray emission. The observations suggest a direct link between energetic particles accelerated in these three flares and the acoustic waves generated by them. The fact that all the seismic flares occur near solar minimum suggests that the lack of seismic waves during solar maximum may be explained by obscuration of the seismic signals by a 'boiling' solar atmosphere. We investigate the new seismic sources using the time-distance method developed by Kosovichev and Zharkova (1998) and report recognisable ridges of 3 seismic waves in the flare 28 October 2003. The extracted start times and momenta are compared with the accelerated electron and proton parameters extracted from the hard X-ray and gamma-ray observations from the INTEGRAL, CORONAS and RHESSI satellites.

P103

g-modes and the solar cycle

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

P104

Does the inference of solar subsurface flow change with choice of the spectral line?

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Abstract: Local helioseismic analysis of Dopplergrams allows investigation of the subsurface flows of the Sun with depth. However, the determination of flows and the interpretation would be more reliable if results from independent sets of contemporaneous data agree with one another.To test the reliability of results, we compare subsurface flows obtained from data sets of Global Oscillation Network Group (GONG) and Magneto Optical Filters at Two Heights (MOTH) experiment. The GONG data is obtained through observations of Ni I 676.8 nm line while the MOTH experiment consists of observations of two spectral lines, K I 769.9 nm and Na I D_2 589.0 nm and thus corresponds to different heights in the solar atmosphere. In this analysis, we use ring-diagram and inversion techniques to determine sensitivity of solar subsurface flow to the choice of the spectral Line.