Program & Abstract Book

17th August 2007

http://www.mps.mpg.de/meetings/seismo/helas2/

Göttingen

August 20-24, 2007

Program and Abstract Book
17th August 2007
Andreas Lagg (lagg@mps.mpg.de)

Program

08:00 - 08:15 Welcome addresses and LOC announcements
Laurent Gizon, Oskar von der Lühe, Stefan Dreizler

Monday, 08:15 - 12:00 Session 1

Chair: Stefan Dreizler

Outstanding Problems and Key Observations in Solar and Stellar Physics

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09:40 - 10:40 Coffee & Posters

12:00 - 13:30 Lunch

Monday, 13:30 - 18:30 Session 2

Chair: Conny Aerts

Asteroseismology: Observations

15:10 - 16:10 Coffee & Posters

18:30 Poster session with dinner buffet

Tuesday, 08:00 - 12:00 Session 3 **Chair:** Mario Monteiro

Asteroseismology: Theory and Modelling

Tuesday, 13:30 - 17:30 Session 4 **Chair:** Michael Thompson

Global Helioseismology and Solar Models

Wednesday, 08:30 - 12:00 Session 5

Chair: Laurent Gizon

Waves, Waves & Waves

08:00 Buses to Göttingen University

08:30 - 09:00 **Mathias Fink** (invited)

09:00 - 09:30 **Bruce Cornuelle** (invited)

09:30 - 10:00 **Guust Nolet** (invited)

10:00 - 10:30 Refreshments

10:30 - 11:00 **Robert Wagoner** (invited)

11:00 - 11:30 **Bernard Schutz** (invited)

11:30 - 12:00 **Edward Wright** (invited)

12:00 Packed Lunch
13:15 Excursion to the city of Goslar
20:00 Conference dinner at Rathskeller, Göttingen

Thursday, 08:00 - 12:00 Session 6 **Chair:** Markus Roth

Local Helioseismology

09:30 - 10:30 Coffee

12:00 - 13:30 Lunch

Thursday, 13:30 - 17:30 Session 7 **Chair:** Jørgen Christensen-Dalsgaard

Magnetoconvection, Coronal Helioseismology and Concluding Talks

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Friday, 08:30 - 15:00 Session 8

Splinter Meetings

Poster Session: Asteroseismology and Stellar Physics

Poster Session: Helioseismology and Solar Physics (PH)

Outstanding Problems and Key Observations in Solar and Stellar Physics

Monday, 08:15 - 12:00 **Chair: Stefan Dreizler**

Stellar structure and evolution: unsolved problems

N. Langer[1]

(1) Sterrekundig Instituut, Universiteit Utrecht

The role of rotation, magnetic fields and convection in stars in general, and massive stars in particular, will be discussed. Evidence for three different modes of magnetic fields in massive stars will be shown, and their observational signatures will be highlighted. A connection to the distribution of rotational velocities for main sequence stars will be drawn. We then explore the consequences for stellar evolution, with relevance for supernovae and gamma-ray bursts, and the spins and B-fields of white dwarfs and neutron stars.

Presentation:	Invited talk
Time:	08:15 - 09:00

Contact:
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Variable stars across the observational HR diagram

L. Eyer[1], N. Mowlavi[1]

(1) Observatoire de Genève

An overview of variable objects across the observational Hertzsprung-Russell (HR) diagram will be presented, together with a summary of their global properties such as fraction of variables, amplitudes and periods for different types of pulsating stars. Some striking discoveries performed in the last decade in the observational HR-diagram will be summarised, and future projects that will improve our knowledge of variable stars mentioned.

Presentation:	Invited talk
Time:	09:00 - 09:40

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Solar and stellar activity cycles

M. Rempel[1]

(1) HAO/NCAR

A variety of different dynamo models have been proposed for the sun. While there is an agreement regarding the basic processes of the solar dynamo, there is no general agreement about the combination and the relative importance of these basic processes. Unfortunately observational constraints are not strong enough to clearly distinguish between different dynamo models in the case of the sun. Studying stellar magnetism of the lower main-sequence allows to impose additional constraints on the fundamental dynamo process, since it allows to investigate how the properties of dynamos change when rotation and convection zone depth are different from the solar values, which is model specific. In this talk I will start with a summary of the open key questions regarding the solar dynamo, such as the role of the tachocline, the role of a meridional flow and the saturation amplitude. I will then outline how these questions can be addressed by studying stellar dynamos through observations and theory.

Presentation:	Invited talk
Time:	10:40 - 11:20

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Magnetic active regions and sunspots

S.K. Solanki[1]

(1) MPI for Solar System Research

Active regions are the most readily visible manifestation of the solar magnetic field, being the sites of magnetic field-induced heating of the plasma (e.g. in plage regions and in coronal loops), as well as its cooling (sunspots and pores). All the remarkable and often energetic phenomena associated with active regions are driven by events in the Sun's sub-surface layers, which will be discussed later in the conference. In this talk, however, I will concentrate on the directly visible atmospheric layers of active regions and sunspots.

Presentation: Invited talk
Time: 11:20 - 12:00

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Asteroseismology: Observations

Monday, 13:30 - 18:30 **Chair: Conny Aerts**

Asteroseismology with ground-based photometric observations: abilities, limitations and achievements

A. Pigulski[1]

(1) Instytut Astronomiczny U. Wr.

Ground-based photometric observations are still the primary source of our knowledge of frequencies of modes excited in different types of pulsating stars. A typical set of photometric observations, accomplished usually by means of a multi-site campaign, allows to detect modes with amplitudes down to ∼0.1 mmag. The current abilities and limitations of this method of data collection will be discussed in view of the requirements of the mode identification methods and asteroseismology. We will also present some newest results of the multi-site campaigns on stars in open clusters and Galactic field.

Presentation:	Invited talk
Time:	13:30 - 13:50

Contact:
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A new level of photometric precision from space: binary stars with the WIRE satellite

H. Bruntt[1], J. Southworth[2]

(1) School of Physics, University of Sydney, Australia

(2) University of Warwick, United Kingdom

The WIRE satellite was launched in March 1999 with the aim to study starburst galaxies in the infrared. However, the main instrument was never used because the coolant for the camera was lost. For two epochs during the period 1999-2006 the 52-mm star tracker was used to produce high-precision light curves of some of the brightest stars in the sky (V¡6).
WIRE measured the pulsation in a few hundred stars across the Hertzsprung-Russell diagram in many types of variable stars: Beta Cepheids, Delta Scuti stars, classical Cepheids, and solar-like oscillations in both giant stars and main sequence stars.
We will present new results for five detached eclipsing binaries observed with WIRE. The photometric precision in the light curves is unprecedented and when the data is combined with ground-based radial velocity measurements, we can determine absolute masses and radii to better than a per cent. This allows us to place firm constraints on the theoretical models of the component stars, the sample spanning a spectral range from B4V to F5V. In some of the eclipsing systems we find strong evidence for pulsation in one of the components stars.
The failure of the main experiment was the cause of much grief for the cosmologists, but the ingenious idea of Derek Buzasi to use the star tracker to monitor bright stars made WIRE a very successful asteroseismology mission. The sad news is that communication with WIRE failed in October 2006 after almost eight years in space.

Presentation: Invited talk
Time: 13:50 - 14:10

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Recent MOST space photometry

Gordon Walker[1]

(1) UBC

The Microvariability and Oscillations of STars satellite has a 15 cm aperture photometric telescope and was launched in 2003 June. To date, it has undertaken more than 64 primary campaigns including some clusters and obtained observations of >850 secondary stars of which some 180 are variable. More than half of the latter pulsate with the majority being B-type. Since 2006 January, MOST has operated with only a single CCD for both guiding and science. The resulting increase in read-out cadence has improved precision for the brightest stars. The 2007 light curve for Procyon confirms the lack of p-modes with photometric amplitudes exceeding 8 ppm found in 2004 and 2005. p-modes have been detected in other solar-type stars as well as pre-main sequence objects, roAp and delta Scuti variables. g-modes have been detected in a range of slowly pulsating B stars, Be stars and beta Cephei variables. Differential rotation has been defined for several spotted solar-type stars and limits set to the albedo of certain transiting planets and the presence of other purturbing planets. As long as the experiment operates, we expect the mission to continue.

Presentation:	Invited talk
Time:	14:10 - 14:30

Contact:
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First assessment of CoRoT data

E. Michel[1]

(1) Observatoire de Paris

After a successfull launch by the end of december 2006, CoRoT has started its scientific observation programme by early february. Since then, it has been continuously harvesting light-curves of unprecedent quality. Thirty objects have been observed already in the field dedicated to stellar seismology. Over the next three years, more than 100 objects will be observed in this field (and a few tens of thousand fainter ones in the exoplanet field), half of them during 150days. These data are expected to shed a new light on the pulsationnal behavior of various type of stars. They are also intended to bring new very strong constraints for stellar modelling and tackling key physical processes at work in stars. We use here the first CoRoT data to illustrate their quality and show how these results compare with specifications.

Presentation:	Invited talk
Time:	14:30 - 15:10

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Spectroscopic observations

W. Zima[1]

(1) Instituut voor Sterrenkunde, K.U. Leuven, Belgium

Successful asteroseismology depends on the identification of the observed pulsation frequencies. Due to the complexity of the observed frequency spectra we need to assign the degree, ℓ, and the azimuthal order, m, to as many pulsation frequencies as possible in order to allow for a meaningful comparison with asteroseismic models. Whereas photometry is an important tool to detect and identify ℓ of low-degree pulsation modes, the study of absorption line profile variations can reveal and identify ℓ **and** m of pulsation modes with degrees as high as $\ell = 14$, completing our picture of the stellar pulsation spectra. The investigation of line profile variations requires spectroscopic time-series of high signal-to-noise ratio and high resolution. In my talk I will provide an overview of spectroscopic studies that have been carried out for different kinds of pulsators. I will also present the different existing spectroscopic mode identification methods and present challenges for interpreting the observed line profile variations.

Presentation:	Invited talk
Time:	16:10 - 16:30

Contact:
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Spectroscopic mode identification for the β Cephei star 12 Lacertae

M. Desmet[1], M. Briquet[1], P. De Cat[2], W. Zima[1], G. Handler[3], J. Krzesinski[4], H. Lehmann[5], S. Masuda[6], P. Mathias[7], D. E. Mkrtichian[8], J. Telting[9], K. Uytterhoeven[10], S. L. S. Yang[11], C. Aerts[1]

(1) Institute of Astronomy - Catholic University of Leuven - Belgium

(2) Royal Observatory of Belgium

(3) Institut für Astronomie, University of Vienna - Austria

(4) Mt. Suhora Observatory, Cracow Pedagogical University - Poland

(5) Karl-Schwarzschild-Observatorium - Germany

(6) Okayama Astrophysical Observatory - Japan

(7) Observatoire de la Côte d'Azur - France

(8) Astronomical Observatory of Odessa National University - Ukraine

(9) Nordic Optical Telescope, La Palma - Spain

(10) Brera Astronomical Observatory - Italy

(11) Department of Physics and Astronomy, Universtity of Victoria - Canada

We present the results of an extensive multisite spectroscopic study of the β Cephei star 12 (DD) Lacertae. This star is one of the best observed β Cephei stars. It has 10 known oscillation frequencies from a recent multisite photometric campaign, but a lack of identified m-values for its detected modes. A spectroscopic multisite campaign was carried out and almost a thousand high-resolution spectra were gathered in a time span of 11 months, taken with 8 different telescopes. To this we added the numerous archival spectra of the star. The Si III line profiles centered on 4560 Å were subjected to a detailed line profile analysis. We searched for oscillation frequencies in the first three velocity moments. We also performed a frequency search across the line profile. In our data set we find at least seven independent frequencies, together with combination frequencies. One of these frequencies is a low-frequency signal, most likely originating from a g-mode and also detected in the photometric campaign. By means of two state-of-the-art methods: the Fourier parameter fit method and the moment method, we identified the (ℓ, m)-values of the five modes with the highest amplitudes. This constitutes indispensable information for our in-depth seismic modelling of 12 Lacertae of which we will report briefly.

Presentation:	Contributed talk
Time:	16:30 - 16:45

Contact:
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Observations of hot compact pulsators: the subdwarf B variables

S. Schuh[1]

(1) Institut für Astrophysik, Universität Göttingen

Following the successes of white dwarf asteroseismology made possible through the instigation of appropriate infrastructure for multi-site observational campaigns, novel kinds of multiperiodic nonradial pulsators among compact evolved objects recently have received a lot of attention.
Since the discovery of the first prototype a decade ago, these subdwarf B variables have developped into a major new focus due to two reasons:

- Although their current evolutionary status appears to be solved (subdwarf B stars can be identified with extreme horizontal branch models), the corresponding proposed formations scenarios still await validation or falsification through decisive evidence, and in the meantime continue to raise fundamental questions related to late stellar evolution. Probing the internal structure of these objects with asteroseismological methods therefore represents a valuable potential resource, for which the observational basis must be provided.

- In an almost amusing reversal of the normal course of matters, the theoretical interpretation of the pulsational behaviour of the variety of pulsational properties found in subdwarf B stars seems to grow more and more difficult: From an initial simultaneous prediction of the p-mode pulsations by theory at the time of discovery of the first variables, to a current inability of theory to reproduce the complex behaviour observed especially in the g-mode domain. The observed overlap area (hybrid objects with both p- and g-modes) in particular seems to constitute a major challenge to theory and has triggered vivid activity with some surprising first results.

This obviously has significant impact on how to best exploit the wealth of observational data that is currently available, which spans time-resolved photometric and spectroscopic data from the optical (ground-based) to the FUV (space-based) domain. In the course of briefly reviewing the most important observational campaigns on subdwarf B pulsators conducted world-wide in the last years, as well as a subjective selection of specific targeted observations, I will give an overview of some key objects.
The objective of this contribution is to summarize the observational properties of pulsating subdwarf B stars, which provide the constraints to be taken into account by any modelling approach.

Presentation:	Contributed talk
Time:	16:45 - 17:00

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Stellar oscillations of planet hosting K Giant stars

A. Hatzes[1], M. Zechmeister[1]

(1) Thüringer Landessternwarte

Recently a number of giant extrasolar planets have been discovered around K giant stars using precise stellar radial velocities (RV). These discoveries are important because many of these giant stars have intermediate masses in the range 1-3 solar masses. Early-type main sequence stars in this mass range have been avoided by radial velocity planet search surveys due the difficulty of getting the requisite RV precision for planet discoveries. K giant stars can thus tell us about planet formation for stars more massive than the sun. However, the problem for planet searches around K giant stars is an accurate determination of the stellar mass. This is due to the fact that evolutionary tracks for stars spanning a wide range of masses all converge to the same region of the H-R diagram.
We report on the discovery of stellar oscillations around several planet hosting giant stars. In particularly, we present radial velocity measurements for Beta Gem that show at least 6 pulsation modes centered on a frequency of 89 micro Hz. The mode frequencies and amplitudes are consistent with p-mode oscillations for a giant star having a mass of 1.7 solar masses. An investigation of stellar oscillations in planet hosting K giant stars offers us the possiblity of getting an independent and more accurate determination of the stellar mass for these objects. This is of central importance for extrasolar planet studies

Presentation:	Contributed talk
Time:	17:00 - 17:15

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Asteroseismology of Przybylski's star with HARPS: Constraints on the stellar model and the global magnetic field

D. Mkrtichian[1], A. Hatzes[2], H. Saio[3]

(1) ARCSEC, Sejong University, Seoul, South Korea

(2) TLS, Germany

(3) Tohoku Univ., Japan

We present the detection of a rich ℓ=0-2 p-mode oscillation spectrum in the most chemically-peculiar roAp star HD 101065 (Przybylski's star). Constructed echelle-diagrams exibited both large ($\Delta\nu$=64.07 μHz) and small (5-7 μHz) spacings. We have calculated the nonadiabatic frequencies of axisymmetric high-order p-modes using main sequence models with dipole magnetic fields and masses ranging from 1.5 to 1.7 M_{sun}. Two sets of chemical composition (X,Z)= (0.7, 0.02) and (0.695, 0.025) were adopted. We determined the best fitting models and put sharp constraints on the stellar mass, luminosity, and global magnetic field. Further progress in asteroseismic modelling of Przybyzlski's star requires increasing the accuracy of determination of oscillation spectrum with mode spacings less than 1μHz.

Presentation:	Contributed talk
Time:	17:15 - 17:30

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Asteroseismology: Theory and Modelling

Tuesday, 08:00 - 12:00 **Chair: Mario Monteiro**

Opacity driven oscillations along the Main Sequence

A. A. Pamyatnykh[1]

(1) Nicolaus Copernicus Astronomical Center, Warsaw

History of interpretation of pulsations in the upper Main Sequence (Beta Cephei and SPB variables) will be briefly described. Basic conditions for the opacity mechanism efficiency will be presented together with the explanation of the existence of different oscillation domains along the Main Sequence. Consequences of using updated OP opacities and new solar composition on the pulsational instability will be emphasized.

Presentation:	Invited talk
Time:	08:00 - 08:20

Contact:
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Modelling magnetic oscillators

Hideyuki Saio[1]

(1) Tohoku University

I will talk about the properties of axisymmetric nonradial p-mode pulsations of A-type star models with strong magnetic fields. The magnetic field shifts the pulsation frequencies; the amount of the shift varies cyclically as a function of the frequency or of the magnetic field strength. The frequency shifts predicted from different computational method agree with each other. The presence of a strong magnetic field also stabilizes low-order (δ Sct-type) p-modes, and modifies latitudinal amplitude distribution of high-order p-modes to be more concentrated toward the magnetic axis. Finally I will show some comparisons of theoretical frequencies with some recent observations.

Presentation:	Invited talk
Time:	08:20 - 08:40

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Modelling pulsations in hot stars with winds

A. Noels[1], M.A. Dupret[2], M. Godart[1]

(1) University of Liège

(2) Meudon Observatory

The interaction pulsation/mass loss takes different aspects. Pulsations can trigger mass loss as in LBVs and Miras; on the other hand, mass loss can modify the driving conditions within the stars. But the most spectacular aspect is the effect on stellar models which, in turn, opens a royal way to asteroseismology to test physical conditions inside massive stars, such as, the extent of convective cores or the appearance of new driving mechanisms. We shall start with MS stars and their strange mode instabilities. We shall move on to the excitation of the LBV phenomenon. WR stars and the newly observed MOST period in WR123 will be discussed in view of the power of asteroseismology. We shall then turn to B supergiants, in particular HD163899, and show how asteroseimology can really be a probe of convection, semiconvection and mass loss.

Presentation:	Invited talk
Time:	08:40 - 09:00

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Asteroseismology of β Cephei stars: effects of the chemical composition on the determination of the global stellar parameters.

A. Thoul[1], A. Miglio[1], J. Montalban[1]

(1) Université de Liège

We perform a very detailed modeling of several multiperiodic $beta$ Cephei stars (HD129929, θ Ophiuchi, β Cephei, ν Eridani, and others). We compare the values we obtain for the stellar global parameters using different assumptions about their chemical compositions and using different opacity tables. We also compare the spectra of excited modes we get for those stars using the OPAL and OP opacity tables.

Presentation:	Contributed talk
Time:	09:00 - 09:15

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New aspects on the driving of pulsating stars

Dupret Marc-Antoine[1], Miglio Andrea[2], Montalban Josefina[2], Quirion Pierre-Olivier[3], Théado Sylvie[2], Noels Arlette[2], Grigahcène Ahmed[4]

(1) LESIA - observatoire de Paris

(2) Institut d'Astrophysique de Liège

(3) Institut for fysik og Astronomi, Aarhus

(4) CRAAG-Algiers Observatory

We consider in details new physical aspects of the driving mechanisms in different types of pulsating stars throughout the HR diagram. We begin with the case of hybrid p-g mode pulsators such as the beta Cep - Slowly Pulsating B stars and the delta Scuti - gamma Doradus stars. We show that radiative damping in the g-mode cavity and the size of the evanescent region play a key role in this context. Next we consider the case of the roAp stars. We show the keyrole played by accumulation of chemicals and the shape of the eigenfunctions. Finally, we present for the first time the application of time-dependent convection models to the study of the DBV white dwarfs.

Presentation:	Contributed talk
Time:	09:15 - 09:30

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Modelling solar-like oscillators

P. Eggenberger[1]

(1) Université de Liège

In this talk the computation of models of stars for which solar-like oscillations have been observed will be discussed. The observations of solar-like oscillations will first be introduced. Then the modelling of isolated stars and of stars belonging to a binary system will be presented with specific examples of recent theoretical calibrations.
Finally the input physics introduced in stellar evolution codes for the computation of solar-type stars will be briefly discussed with a peculiar emphasis on the modelling of rotation for these stars.

Presentation:	Invited talk
Time:	10:30 - 10:50

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Modelling compact pulsators

S.K. Randall[1], G. Fontaine[2], P. Brassard[2], S. Charpinet[3]

(1) ESO Garching

(2) University of Montreal

(3) Observatoire Midi-Pyrénées

We currently know of five distinct classes of compact pulsators, defined as oscillating stars with a surface gravity above log g = 5. Three of these fall into the white dwarf regime (GW Vir, V777 Her and ZZ Ceti stars), while the other two are identified with hot B subdwarfs (EC 14026 and PG 1716 stars). In all cases, the instabilities are thought to be driven by a classical Kappa-mechanism associated with the partial ionisation of one of the envelope constituents. We will discuss, for the different types of pulsator, our current theoretical understanding of the observed instability strips and period distributions, as well as attempts to infer key stellar properties from asteroseismology. The latter has been particularly successful for the rapidly pulsating subdwarf B (EC 14026) stars, where we have been able to constrain the fundamental parameters to an interesting accuracy for 10 targets so far. This is sufficient for first comparisons with different evolutionary scenarios, and will most likely play a crucial part in an eventual understanding of the formation of these objects. Moreover, we believe that the techniques developed for the interpretation of subdwarf B stars will also come in useful when modelling other oscillators, and pave the way towards a deeper understanding of compact pulsators in general.

Presentation: Invited talk
Time: 10:50 - 11:10

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Modelling rapid rotators

D. Reese[1]

(1) Department of Applied Mathematics, University of Sheffield

Recent interferomic observations have drawn attention to the effects of rapid rotation on stellar structure. Consequently, a number of 2D models and pulsation codes have been and are being developed in order to gain a better understanding of such stars. These have shed light on effects like centrifugal deformation, gravitational darkening, differential rotation and the transport of chemical elements and angular momentum. Pulsation modes within these stars have a different geometrical structure, characterised by a new organization of the frequency spectrum, as shown by eigenmode calculations and ray dynamics. Numerous challenges lay ahead before being able to interpret pulsation data from these stars and thus better constrain their structure and evolution.

Presentation:	Invited talk
Time:	11:10 - 11:30

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The photometric method of mode identification for rapidly rotating SPB stars. An application to μ Eridani.

J. Daszyńska-Daszkiewicz[1], W. A. Dziembowski[2,3], A. A. Pamyatnykh[3]

(1) Instytut Astronomiczny, Uniwersytet Wrocławski, POLAND

(2) Warsaw University Observatory, POLAND

(3) Copernicus Astronomical Center, Warsaw, POLAND

Pulsations of main sequence stars are usually described in the framework of the perturbation theory, where the basic assumption is that the oscillation frequency is much larger than the angular rotation rate. This condition is not always fulfilled in the case of high order g-modes, which are excited for example in Slowly Pulsating B-type stars.
We present an outline of the method of mode identification, which relies on the traditional approximation and involves instability and visibility considerations. Determination of the angular degrees, (ℓ, m), is done simultaneously with the rotation velocity and inclination angle, taking into account various stellar models consistent with mean measured parameters.
We apply the method to the rapidly rotating SPB star μ Eridani, for which six oscillation modes were found from uvy photometry during the 2003-2004 multisite campaign.

Presentation: Contributed talk
Time: 11:30 - 11:45

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Transport in stellar radiation zones by internal gravity waves influenced by the Coriolis acceleration

S. Mathis[1], S. Talon[2], F.-P. Pantillon[3], C. Charbonnel[3], J.-P. Zahn[4]

(1) CEA/DSM/DAPNIA/Service d'Astrophysique

(2) Département de Physique, Université de Montréal

(3) Observatoire de l'Université de Genève

(4) Observatoire de Paris-Section de Meudon/LUTH

Internal gravity waves constitue an efficient process for angular momentum transport over large distances. They are now seen as an important ingredient in understanding the evolution of rotation and can explain the Sun's quasi-flat rotation profile. Due to the value of the ratio between the frequencies of the excited internal gravity waves at the borders with convective regions and the inertia frequency which caracterized the action of Coriolis acceleration, it is now necessary to go beyond the non-rotating approximation in the treatment of internal gravity waves propagation and its associated transport and to take into account the action of the Coriolis acceleration in a coherent way. To achieve this aim, we adopt the Traditional Approximation which is verified in stellar radiation zones. We present the modified transport equations and the first results issued from their implementation in a stellar evolution code. Consequences for the transport of angular momentum inside solar and stellar radiation regions are discussed.

Presentation:	Contributed talk
Time:	11:45 - 12:00

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Global Helioseismology and Solar Models

Tuesday, 13:30 - 17:30 **Chair: Michael Thompson**

Low degree modes

R.A. Garcia[1]

(1) SAp CEA/Saclay

We review the challenges we have to face today in the study of low degree acoustic and gravity modes and their implications in the study of the solar internal structure and dynamics. We will end by a briefly discussion of the near future developments and what we could expect about the physics behind.

Presentation:	Invited talk
Time:	13:30 - 13:50

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Velocity and intensity power spectra of solar oscillations

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Fitting observed power and cross spectra of medium-degree p-modes in velocity (V) and intensity (I) has been widely used for getting information about the p-mode excitation process and, in particular, for trying to determine the type and location of the acoustic source.
Numerical simulations of solar convection allow to perform the cross-spectrum analysis of the solar surface I and V fluctuations, both in the tau-frame (sampling the oscillations at constant optical depth), corresponding to the observer's point of view, and in the z-frame (sampling the oscillations at constant geometrical height), where the hydrodynamical equations are naturally written. The results of the analysis in the two frames show definite differences, as pointed out by Georgobiani et al. (2003) and Straus et al. (2006). The former paper suggests that the opacity variations are playing a major role in the tau-frame, and the latter paper proposes that the intensity signal of the waves in the z-frame is mainly controlled by the presence of the steep temperature gradient at the base of the photosphere.
We insert the temperature gradient and the opacity effects in the Severino et al. (2001) model of the four helioseismic spectra, which is demonstrated to work very well in fitting p-mode line profiles. On this base we revisit the interpretation of V and I power and cross spectra.

Presentation:	Invited talk
Time:	13:50 - 14:10

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High degree modes & instrumental effects

S. Korzennik[1], M.C. Rabello-Soares[2], J. Schou[2]

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(2) Stanford University

Full-disk observations taken with the Michelson Doppler Imager (MDI) on board the Solar and Heliospheric Observatory (SOHO) spacecraft, or the upgraded Global Oscillations Network Group (GONG) instruments have enough spatial resolution to resolve mode up to $\ell = 1000$ if not $\ell = 1500$. We also know that the inclusion of such high-degree modes (*i.e.*, $\ell \leq 1000$) improves dramatically inferences near the surface (see for instance Rabello-Soares et al. 2000). Unfortunately, observational and instrumental effects cause the characterization of high degree modes to be quite complicate.
Indeed, The characteristics of the solar acoustic spectrum are such that, for a given order, mode lifetimes get shorter and spatial leaks get closer in frequency as the degree of a mode increases. A direct consequence of this property is that individual modes are only resolved at low and intermediate degrees. At high degrees the individual modes blend into ridges and the power distribution of the ridge defines the ridge central frequency, masking the underlying mode frequency. An accurate model of the amplitude of the peaks that contribute to the ridge power distribution is needed to recover the underlying mode frequency from fitting the ridge.
We present a detailed discussion of the modeling of the ridge power distribution, and the contribution of the various observational and instrumental effects on the spatial leakage, in the context of the MDI instrument. We have constructed a physically motivated model (rather than some *ad hoc* correction scheme) that results in a methodology that can produce unbiased estimates of high-degree modes. This requires that the instrumental characteristics are well understood, as task that has turned out to pose a major challenge.
We also present our latest results, where most of the known instrumental and observational effects that affect specifically high-degree modes were removed (following the above mentioned methodology described in detail in Korzennik et al. 2004). These new results allow us to focus our attention on changes with solar activity.
We present a study of the structural and dynamical properties of the near-surface layers of the Sun, analyzed using (a) the difference between the observed and theoretical frequencies; and (b) the solar rotation at different latitudes estimated using a simple analytical method.
Finally, we also present variations of mode frequencies resulting from solar activity over most of solar cycle 23. We present the correlation of medium and high degree modes with different solar indices. Our results confirm that the frequency shift scaled by the relative mode inertia is a function of frequency alone and follows a simple power law.

Presentation: Invited talk
Time: 14:10 - 14:30

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Amplitudes of non-radial oscillations driven by turbulence

K. Belkacem[1], R. Samadi[1], M. J. Goupil[1]

(1) Observatoire de Paris (LESIA)

Turbulent motions in stellar convection zones generate acoustic energy, part of which is then supplied to normal modes of the star. Their amplitudes result from a balance between the efficiencies of excitation and damping processes in the convection zones. For radial oscillations, in the solar case, a good agreement between observations and theoretical modelling is reached (see for instance Belkacem et al. 2006b). We have next developed a formalism that provides the excitation rates of non-radial global modes excited by turbulent convection. It then allows us to investigate both p and g modes in the upper convection zones as well as in stellar convective cores. As a first application, we have estimated-and report here- the impact of non-radial effects on excitation rates and amplitudes of high-angular-degree solar p modes.

Presentation:	Contributed talk
Time:	14:30 - 14:45

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Analytical signal as a tool for helioseismology

Y. D. Zhugzhda[1]

(1) IZMIRAN, Troitsk, Russia

Representation of narrow-band oscillations in terms of analytical signal is outlined. The analytical signal allows to determine uniquely the instantaneous oscillation frequency, amplitude, and phase of narrow-band signal. Analytical signal representation makes possible to separate the effects of spectral line broadening by amplitude and frequency fluctuations. It makes possible to found the true frequency of oscillations and its stability whose are not affected by amplitude fluctuations. An extension of analytical signal for the case of two component signal is developed. It can define the amplitude and frequencies of two narrow-band oscillations whose spectrum are overlapped. P-modes oscillations are an ideal object for application of analytical signal representation. The application of analytical signal representation for p-modes is used for analysis of brightness fluctuations of the Sun observed by multi-channel photometer DIFOS on CORONAS-F mission. It is revealed that broadening of p-modes spectral lines is produced predominantly by fluctuations of its amplitude. Stability of p-mode frequencies determined from spectral line width exceeds in few times the true stability which is defined by stability of its instantaneous frequency. It is found that certain of rather wide asymmetric lines of p-modes consist of two spectrally unresolved components whose amplitudes and frequencies can be found by two-mode analytical signal representation.

Presentation: Contributed talk
Time: 14:45 - 15:00

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Temporal variations of global mode frequencies

J. Schou[1]

(1) Stanford University, Stanford, USA

With more than 11 years of data from both GONG and MDI it is now possible to study how the Sun changes during an 11 year cycle in unprecedented detail. In this talk I will discuss some of these changes, as well as what we may learn from even longer stretches of data. I will also briefly discuss the implications of the planned transition from MDI to HMI and the uncertain future of GONG on such extended studies.

Presentation: Invited talk
Time: 16:00 - 16:20

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Modelling solar and stellar differential rotation

M. Küker[1], G. Rüdiger[1]

(1) Astrophysikalisches Institut Potsdam

Differential rotation (DR) is a powerful generator of magnetic fields and therefore a key ingredient in stellar dynamo models. We present a model based on the mean-field theory of fluid dynamics. DR is driven by Reynolds stress and anisotropic heat transport caused by the Coriolis force. The model reproduces the rotation pattern in the solar convection zone and allows predictions for other stars with outer convection zones. We present results for a range of spectral types, including stars close to the convection limit which have very shallow convection zones, and an explanation for the large values found for the differential rotation of these stars. We discuss the dependence of DR on the rotation rate and spectral type.

Presentation: Contributed talk
Time: 16:20 - 16:35

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Solar structure models

Sylvaine Turck-Chieze[1]

(1) CEA/SAp/DAPNIA

Up to now the solar structure model is obtained in solving the four structural equations of the stellar evolution, like any other star. But the Sun is a unique object as we can estimate the quality of this structure in comparing predicted variables to different observed indicators of the solar interior.
So the talk will be divided in three parts:

- the description of the present solar structure and the comparison of these variables to the high quality observables, the unknown ingredients will be enhanced and the direction of improvements will be described,
- the present existing improvements beyond this classical framework and their limitations when compared to the new dynamical constraints obtained with the SoHO satellite,
- the coming efforts in solar modelling and the necessary associated observations to converge toward a complete dynamical model of the Sun useful to properly describe the Solar-Terrestrial connection.

Presentation: Invited talk
Time: 16:35 - 16:55

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Solar dynamo models

M. Miesch[1]

(1) HAO/NCAR, Boulder, CO

Ever since George Ellery Hale's first measurements of magnetic fields in the Sun a century ago, the question of how these fields are generated has remained at the forefront of solar physics. Inspired by helioseismology and fueled by high-performance computers, modern solar dynamo models have come a long way since the pioneering work of Babcock and Parker. The modern paradigm involves magnetic field generation in the convection zone and the pumping of this field downward into the tachocline where it is amplified and organized by rotational shear. As they gain in strength, toroidal fields in the tachocline become buoyantly unstable and rise to the surface, emerging as bipolar active regions. In the popular flux transport class of models, the 22-year cyclic variability arises from the meridional circulation which promotes polarity reversals by advecting field equatorward at the base of the convection zone and poleward near the surface. After a brief review of this central paradigm, I will discuss in detail two key questions which remain open. First: what is the nature of poloidal field regeneration (often parameterized as the alpha-effect) and where does it occur? Second: What is in fact the role of the meridional circulation and is it consistent among various models? Throughout the talk I will highlight recent results from both 3D MHD simulations and mean-field dynamo models.

Presentation: Invited talk
Time: 16:55 - 17:15

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Estimation of magnetic flux in the solar convective envelope from the initial observations of the sunspots

K. M. Hiremath[1], Lovely, M. R[1]

(1) Indian Institute of Astrophysics, Bangalore-560034, India

Different life spans of the sunspots suggest their origin at different depths (Hiremath, K. M., A&A, 386, 674, 2002) and by measuring magnetic fluxes from their first observation on the surface, one can estimate the strength of magnetic flux at different anchoring depths. From the seven years of SOHO/MDI magnetograms, we infer the strength of magnetic flux and rate of emergence of magnetic flux at different anchoring depths in the solar convective envelope by measuring *initial* magnetic fluxes of the well developed sunspots on the surface. Important findings are : (i) majority of the spot groups that have *first* observation on the surface are bipolar, (ii) irrespective of their sizes, the bipolar spots with different life spans have average magnetic field strengths of $\sim$ 500 G during their first observation, (iii) the average field strength at the site of anchoring depths of the sunspots is estimated to be $\sim 10^6$ G near base of the convective envelope and $\sim 10^4$ G near the surface, (iv) the dynamo-a source of sunspot activity-is distributed through out the convective envelope and, (v) the rate of emergence of *initial* magnetic flux of such a distributed dynamo near base of the convection zone is $\sim 10^{19}$ Mx/day and is 20% higher than the the rate of emergence of *initial* magnetic flux near the surface.
From the line of sight magnetic field of the SOHO/MDI data, we decompose into toroidal and poloidal components, the preliminary results show unequal distribution the two components. That is toroidal component is much weaker compared to the poloidal component of the observed line of sight magnetic field.

Presentation:	Contributed talk
Time:	17:15 - 17:30

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Waves, Waves & Waves

Wednesday, 08:30 - 12:00 **Chair: Laurent Gizon**

Time-reversal acoustics

M. Fink[1]

(1) LOA, ESPCI

Time-reversal invariance is a very powerful concept in classical and quantum mechanics. In the field of acoustics and electromagnetism, where time reversal invariance also occurs, time-reversal experiments may be achieved simply with arrays of transmit-receive antenna, allowing an incident wave field to be sampled, recorded, time-reversed and re-emitted.
Time reversal mirrors (TRMs) may be used to study random media and chaotic reverberating structures. Common to these complex media is a remarkable robustness exemplified by observations that the more complex the medium between the probe source and the TRM, the sharper the focus. TRMs open the way to new signal processing that interest imaging, detection and telecommunications. Moreover Time reversal focusing opens new approaches to super-resolution and these concepts will be discussed in this talk.
Due to the limited frequency range of acoustics waves (KHz and MHz), TRMs have been first developed in the field of Acoustics. They have plenty of applications including ultrasonic therapy, medical imaging, non destructive testing, telecommunications, seismology, underwater acoustics, sound control and even home automation. An overview of these fields will be presented.

Presentation:	Invited talk
Time:	08:30 - 09:00

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Ocean acoustic tomography

B. Cornuelle[1]

(1) Scripps Institution of Oceanography, University of California at San Diego

Ocean acoustic tomography (OAT) was proposed in 1979 by Walter Munk and Carl Wunsch as an analogue to x-ray computed axial tomography for the oceans. The oceans are opaque to most electromagnetic radiation, but there is a strong acoustic waveguide, and sound can propagate for 10 Mm and more. A few distinctive features of OAT compared to earth or solar tomography are:
The strong ocean acoustic waveguide allows long-range propagation with multiply-refracted paths. These ray paths may be very sensitive to initial conditions and perturbations in the medium, leading to chaoticrays and uncertainty about the exact ray sampling. Wave-theoretic finite frequency kernels may show less sensitivity.
Small-scale ocean structures cause significant variations in the amplitude of an acoustic reception over time, but the travel time of a peak arrival is much more robust and can generally be tracked in time and matched to expected propagation paths. These have been the data used in most large-scale experiments. The isolated arrival peaks generally are restricted to the early part of the arrival. The later part of the arrival contains highly-scattered energy, which has so far not been interpretable deterministically. Some information on the statistics of the small-scale field doing the scattering has been inferred from the depth extent of the scattering.
The ocean changes with time scales as short as minutes, and numerical models are becoming available which can reproduce much of the ocean physics. If the ocean model is used in the analysis of the observations, information can be accumulated over time, and the evolution of the ocean can augment the information content of an observing array.
Instruments can be moored at most any depth or location for desired sampling, so controlled sources are often used, although whales, ships, and random noise sources have been explored. Many other measurement systems are available, both at the ocean surface and below. Because there are many alternative ways to observe the ocean, OAT systems must be complementary to other observational methods and have cost-benefit advantages.
The talk will provide an introduction to some ocean physics and phenomenology and survey some concepts and experiments in ocean acoustic tomography.

Presentation: Invited talk
Time: 09:00 - 09:30

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Terrestrial seismic tomography: An overview

G. Nolet[1]

(1) Princeton University

Using transmitted transverse and longitudinal waves, seismologists have been imaging the interior of the Earth since the 1970's with increasing detail. Major discoveries have significantly changed our view of the planet's dynamics. Among these are the imaging of ocean floor subducting into the lower mantle to at least 2000 km depth, the imaging of two 'superplumes', probably hot and heavy masses resting on the core-mantle boundary beneath the central Pacific and Southern Africa, and more recently the imaging of narrower lower mantle plumes that feed volcanic centres such as Hawaii, Tahiti and the Canary Islands.
The spectrum of teleseismic waves covers three orders of magnitude in frequency ranging from 'normal modes' with split spectral peaks near 1 mHz, to pulse-like arrivals or body waves of 1 Hz. Because of the solid nature of the mantle the Earth is significantly richer in wavetypes than the convecting layer of the Sun. But the coverage of the planet with sources and receivers is very uneven, which poses major challenges to the imaging of variations in seismic velocities. Variations in wavespeed are mainly caused by temperature variations, though chemical anomalies cannot be ruled out and may even be required to explain the superplumes. Imaging of anomalies in attenuation – theoretically a very strong proxy for temperature variations – is still in its infancy.
Recent developments are: imaging using random noise much like this is being done in helioseismology; the incorporation of wavefront healing in the interpretation of high-frequency body waves; and the use of adjoint methods coupled with spectral element methods to compute wavefields in a heterogeneous Earth.

Presentation: Invited talk
Time: 09:30 - 10:00

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Diskoseismology

R. Wagoner[1]

(1) Stanford University, CA, USA

The normal mode oscillations of accretion disks around black holes and other compact objects will be analyzed and contrasted with those in stars. The most robust modes are trapped near the maximum of the radial epicyclic frequency. The eigenfrequencies of these modes depend mainly on the mass and angular momentum of the black hole. Their possible relevance to the quasiperiodic oscillations observed in accreting binaries will be discussed.

Presentation:	Invited talk
Time:	10:30 - 11:00

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Oscillations of neutron stars and black holes

B.F. Schutz[1]

(1) Albert Einstein Institute

Disturbed neutron stars and even black holes oscillate with well-defined frequencies, and the oscillations may damp or grow exponentially due to the emission of gravitational waves. Gravitational wave detectors will, within the next decade, begin to determine the masses and spins of black holes, the equation of state of neutron star matter, and the stability limits of relativistically rotating stars by observing these frequencies in the emitted radiation spectrum.

Presentation:	Invited talk
Time:	11:00 - 11:30

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Acoustic oscillations in the early universe

Edward L. (Ned) Wright[1]

(1) UCLA

Acoustics waves in the cosmology connect the astronomically large and the astronomically small. The largest acoustic waves in the Universe are the baryon acoustic oscillations that can be seen on the sky in the Cosmic Microwave Background anisotropy and in the current distribution of galaxies with a wavelength of 8 yottameters, nearly one billion lightyears. The sound travel distance in the 400,000 years prior to the Universe becoming transparent becomes one half of this wavelength, and then the expansion of the Universe stretched all distances by a factor of 1000. Precise measurements of these signals reveal the baryon density (0.4 yoctograms/m^3, the dark matter density (2 yg/m^3), and the radius of curvature of the Universe (more than 700 yottameters).

Presentation:	Invited talk
Time:	11:30 - 12:00

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Local Helioseismology

Thursday, 08:00 - 12:00 **Chair: Markus Roth**

The forward and inverse problems in local helioseismology.

J. Jackiewicz[1]

(1) Max Planck Insitute for Solar System Research

Local helioseismology consists of a set of tools for mapping the solar interior at high spatial resolution. For most applications, there are three main steps needed to obtain such maps: accurate forward modeling, consistent data analysis, and the solution of an inverse problem. I will go through the current status of this procedure with particular emphasis towards the case of time-distance helioseismology. To illustrate each step of the method, a complete example for imaging three-dimensional flows in the near-surface layers of the Sun is presented.

Presentation:	Invited talk
Time:	08:00 - 08:20

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Wave scattering by small-scale inhomogeneities

Thomas Duvall[1]

(1) NASA/GSFC

Much of helioseismology has focused on studying features of the Sun that are large compared to the acoustic wavelengths. But in the regime of small features, there is still significant information in the scattering of the waves. Braun introduced the classical scattering S matrix in the study of sunspots. Birch and Kosovichev first introduced the Born approximation travel time kernels. These kernels depend on scattering taking place. By observationally measuring the kernels for small magnetic elements, we have confirmed that scattering takes place. Using the acoustic simulations of Hanasoge, we have measured kernels for sound speed, damping, and sources. Our measurements of the kernels for small intensity perturbations due to granulation should enable the study of the three dimensional structure of granulation.

Presentation:	Invited talk
Time:	08:20 - 08:40

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Absorption and scattering of acoustic waves from a thin magnetic flux tube

Bradley W Hindman[1], Rekha Jain[2]

(1) University of Colorado, USA

(2) University of Sheffield, UK

Active regions are complex. The magnetic field is highly structured, with a tangle of fibrils within the plage and more confined bundles within sunspot umbrae. The helioseismic observations made within active regions are difficult to understand due to the fragmented nature of the field. We choose to study the propagation of acoustic waves through regions of plage, modelling the magnetic field therein as a collection of thin flux tubes. In this talk we present the first results of this research; the computation of the absorption and scattering of f modes and p modes from a single tube. The calculations are carried out semi-analytically using the thin flux-tube equations. The incoming acoustic waves interact with the flux tube, exciting sausage and kink tube waves which propagate downward carrying away energy and producing absorption. The tube response further scatters the incoming wave into a variety of f and p modes. We present both the absorption and scattering coefficients.

Presentation:	Contributed talk
Time:	08:40 - 08:55

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Subsurface flows from ring-diagram analysis

I. Gonzalez Hernandez[1]

(1) National Solar Observatory

Ring-diagram analysis, a local helioseismology technique, has proven very useful in order to study the solar subsurface velocity flows down to a depth of about 30Mm. Since it was introduced, almost 20 years ago, ring-diagrams have provided a variety of results, from large-scale motions on the Sun, such as differential rotation and meridional circulation, to the more localized studies of flows associated to active regions and filaments.
This talk will present relevant results obtained by several authors using this method and their impact in the solar dynamo models, as well as a discussion of the outstanding issues and areas for future improvement.

Presentation:	Invited talk
Time:	08:55 - 09:15

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Kinetic helicity of subsurface flows and magnetic flux

R. Komm[1], F. Hill[1], R. Howe[1]

(1) National Solar Observatory

The twist of subsurface flows is of interest for the understanding of the evolution and dynamics of active regions. For example, the twist of magnetic flux tubes and the flare production of active regions are related. Previous studies have shown that subsurface flows associated with strong active regions are indeed highly twisted. Observations from the Michelson Doppler Imager (MDI) Dynamics Program and Global Oscillation Network Group (GONG) have been analyzed with a standard ring-diagram technique to measure subsurface horizontal flows from the surface to a depth of about 16 Mm. We derive the vorticity vector and the kinetic helicity density as measures of the twist of subsurface flows for all available GONG and MDI data. We study these quantities and their relation to magnetic flux. We are also interested in the dependence of vorticity and kinetic helicity on latitude and whether they show a sign relation with hemisphere. We will present the latest results.

Presentation:	Contributed talk
Time:	09:15 - 09:30

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Acoustic imaging of magnetic activity

P. Cally[1]

(1) Monash University, Clayton, Victoria, Australia

An overview of techniques and results for acoustically imaging magnetic active regions is presented, with particular reference to surface magnetic effects and the challenge they pose.

Presentation: Invited talk
Time: 10:30 - 10:50

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Acoustic holograms of solar active regions

D.-Y. Chou[1]

(1) National Tsing Hua University

We study the feasibility of applying the principle of optical holography to solar acoustic waves and magnetic regions in the solar interior. A magnetic region in the solar interior scatters the solar background acoustic waves. The scattered waves and background waves could form an interference pattern on the solar surface. We investigate the feasibility of detecting this interference pattern on the solar surface, and using it to construct the three-dimensional scattered wave from the magnetic region with the principle of optical holography. In solar acoustic holography, the background acoustic waves play the role of reference wave; the magnetic region plays the role of the target object; the interference pattern on the solar surface plays the role of the hologram. A model for the solar background acoustic waves and their interaction with a magnetic region in the solar interior is set up to simulate the acoustic hologram on the solar surface. The scattered wave from the magnetic region is reconstructed by "illuminating" the acoustic hologram with a monochromatic wave, using the Kirchhoff integral. Extraction of information on the magnetic region from the constructed wave field is discussed. The prospects and difficulties of solar acoustic holography are also discussed.

Presentation:	Invited talk
Time:	10:50 - 11:10

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Sound speed inversions of a model sunspot using time-distance helioseismology

H. Moradi[1], P. Cally[1]

(1) Centre for Stellar and Planetary Astrophysics, School of Mathematical Sciences, Monash University, Victoria 3800, Australia

Time-distance helioseismology is a powerful diagnostic tool used in local helioseismology to probe the subsurface structure and dynamics of the solar interior, in particular in and around solar active regions. To date however, results obtained by time-distance helioseismology have not directly accounted for the effects of the magnetic field on the wave speed in travel time perturbation maps or inversions, but have indirectly included magnetic effects only through their influence on the acoustic properties of the medium (e.g. the sound speed). However, recent work in sunspot seismology has pointed to the significant influence of near-surface magnetic fields and possible contamination due to their effects in helioseismic inversions for sound speed beneath sunspots. In order to quantitatively assess the effects of the magnetic field in helioseismic inversions, we use a simple 3D axisymmetric sunspot model in hydrostatic and pressure equilibrium with a surrounding stratified field-free Model S atmosphere to simulate artificial travel-time perturbation maps using a full magneto-acoustic wave description to model the wave propagation in the toy sunspot. These travel time maps are then inverted to produce artificial 3D sound speed perturbations using standard time-distance analysis techniques to determine the extent to which wave speed anisotropies produced by the magnetic field alters traditional inversion results obtained using real data from SOHO-MDI.

Presentation:	Contributed talk
Time:	11:10 - 11:25

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Simulations of wave propagation through model sunspots

R. Cameron[1], L. Gizon[1]

(1) MPS

We have performed a series of three-dimensional numerical simulations of solar wave propagation through model sunspots, with the aim of directly comparing the results with MDI-SOHO observations of solar seismic waves. The model sunspots are a family of hydrostatic similarity solutions. The preliminary comparisons between the observations and the simulations have been highly encouraging, and we anticipate that it will be possible to constrain parametric models of sunspots. This study represents a first step towards the full-waveform helioseismic tomography of sunspots.

Presentation:	Invited talk
Time:	11:25 - 11:45

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The nature of running waves in sunspot penumbrae

D. S. Bloomfield[1], A. Lagg[1], S. K. Solanki[1]

(1) Max-Planck-Institut für Sonnensystemforschung

Waves of differing period are observed at different locations in the chromosphere above sunspots: 3-min periods are recorded above umbrae, while wavefronts of 5-min period move outward through penumbrae. Two possible scenarios exist for the presence of these running penumbral wave forms: 1) trans-sunspot waves generated in the umbra and limited to the chromospheric layer; 2) the wavefronts are a 'visual pattern' of field-aligned waves propagating up from the photosphere. We present Stokes spectropolarimetric observations that retrieve the full magnetic vector and line-of-sight velocities simultaneously at photospheric and chromospheric altitudes, thus providing unequivocal evidence that running penumbral waves are a visual pattern of slow-mode waves propagating up from the photosphere along field lines.

Presentation:	Contributed talk
Time:	11:45 - 12:00

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Magnetoconvection, Coronal Helioseismology and Concluding Talks

Thursday, 13:30 - 17:30 **Chair: Jørgen Christensen-Dalsgaard**

Realistic simulations of magnetoconvection

A. Vögler[1], R. Cameron[2], M. Schüssler[2]

(1) Utrecht University

(2) MPS

The interaction of convective flows and magnetic fields in the solar photosphere and in the uppermost layers of the convection zone is crucial for many phenomena of solar activity. Realistic magnetohydrodynamic simulations including an accurate treatment of radiative processes provide insight into the three-dimensional structure of magnetic field configurations in the photosphere and allow a direct comparison with observations. In this talk we present recent results of 3D MHD simulations of photospheric magnetic fields. The topics addressed range from quiet Sun fields and the role of surface dynamo action to larger magnetic features like pores and the structure of magnetic fields in sunspot umbrae.

Presentation: Invited talk
Time: 13:30 - 13:50

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Hinode observations

T. Sekii[1]

(1) NAOJ, Tokyo, Japan

Since its launch in September 2006, Hinode (Solar-B) has been observing the sun nearly continuously. Hinode is equipped with a suite of 3 telescopes: Solar Optical Telescope (SOT), EUV Imaging Spectrometer (EIS) and X-Ray Telescope (XRT). In this brief talk I present a few highlight observations made by Hinode.

Presentation: Invited talk
Time: 13:50 - 14:05

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Three dimensional simulation of local solar supergranulation with realistic physics

S. Ustyugov[1]

(1) Keldysh Institute of Applied Mathematics

Three-dimensional numerical simulation of solar surface convection using realistic model physics is conducted. The thermal structure of convective motions in photosphere, the range of convection cell sizes and the penetration depths of convection are investigated. A portion of the solar photosphere extending 60 x 60 Mm horizontally and from 0 Mm down to 20 Mm below the visible surface is considered. Realistic initial model of Sun with an equation of state and opacities of stellar matter are used. The equations of fully compressible radiation magnetohydrodynamics with dynamical viscosity and gravity are solved. The high order conservative TVD difference scheme for the hydrodynamics, the method of characteristic for the radiative transfer and dynamical viscosity from subgrid scale modeling are applied. The simulations are conducted on a uniform horizontal grid of 600 x 600, with 168 nonuniformly spaced vertical grid points, on 144 processors with distributed memory multiprocessors on supercomputer MBC-1500 in Computational Centre of Russian Academy of Sciences. Study of properties of solar acoustic waves (p-modes) and surface gravity waves (f-mode)by time-distance methods of local helioseismology is conducted.

Presentation:	Contributed talk
Time:	14:05 - 14:20

Contact:
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Coronal helioseismology: Observations

V. Nakariakov[1]

(1) University of Warwick

The review covers observational studies of long period (¿ a few seconds) wave and oscillation phenomena in the corona of the Sun in radio, VL, EUV and X-ray bands, interpreted in terms of MHD theory. These studies provide us with the observational foundation for the remote diagnostics of solar and stellar coronae with MHD waves. Kink and sausage magnetoacoustic modes and longitudinal (or acoustic) modes of coronal loops have already been confidently identified in the data. At present, the main research emphasis is put on, the determination of parametric relations in the wave and oscillatory phenomena, the search for Alfvén (or torsional) modes, the study of multi-modal events, and on the identification of MHD modes in quasi-periodic pulsations of solar and stellar flares.

Presentation:	Invited talk
Time:	14:20 - 14:40

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Coronal helioseismology: modelling

J. Terradas[1], M. Goossens[1]

(1) CPA, KULeuven

Coronal seismology is a rapidly developing topic which seeks to infer the properties of coronal structures from the study of their oscillations. An extensive observational background about oscillations in these structures has been gathered during the last years. From the theoretical point of view, up to now simple models have been set up to explain the oscillations. The review reflects the current trends in the theoretical modelling of MHD waves in the solar corona, and the implementation of the theoretical results for the mode identification.

Presentation:	Invited talk
Time:	14:40 - 15:00

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Conclusion: Helioseismology

A. Birch[1]

(1) NWRA, CoRA Division

Presentation: Invited talk
Time: 16:00 - 16:30

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Conclusion: Asteroseismology

D. Kurtz[1]

(1) University of Central Lancashire

Presentation: Invited talk
Time: 16:30 - 17:00

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Survey of future projects

F. Hill[1]

(1) NSO

The BiSON and GONG++ networks on the ground and the suite of helioseismology instruments on SOHO represent the second generation - after the pioneering efforts at single sites including the South Pole and relatively brief space missions such as IPHIR - and we are about to enter the brave new world of the third generation of helioseismology with the HMI on SDO and Picard to be launched in the next couple of years. Following on the pioneering ground-based spectroscopic asteroseismic results and the space-based photometry from WIRE and MOST, asteroseismology is entering its second generation with the large-scale and long-duration surveys enabled by the very promising first results from CoRoT to be followed in a couple of years by Kepler. The major helioseismic projects have flourished by virtue of their partnerships with the solar activity community and their need for magnetic field measurements, which has subsequently led to significant scientific synergies as well. Similarly, the photometric asteroseismology enterprises have benefited by the shared instrumental requirements with the exoplanetary community, and this partnership has led to the potential for real scientific synergies in the asteroseismic characterization of the central stars of exoplanetary systems. As with any developing field of science, as we answer the questions that we were able to pose we are still finding many more new questions to ask. Helioseismology, as with virtually all other aspects of solar physics, is driven to explore the behavior of the Sun at its poles, and Solar Orbiter is well on its way to giving us the first imagery out of the ecliptic, to be followed by POLARIS which promises significantly extended observations at even greater distances above the ecliptic to explore the structure and flows at the poles. The long search for gravity modes has not reached its goals yet and. after Picard, DYNAMics has been proposed to beat down the solar background. On the asteroseismic scene, a long-term spectroscopic capability should be realized by SIAMOIS at Dome C in Antarctica and the SONG network, while on the photometric front PLATO will dramatically increase the number of stars accessible to asteroseismology - in partnership with the exoplanetary community - and especially nearby bright stars for which subsequent, ground-based follow-up observations will be particularly effective. This review talk will attempt to summarize where we are, how we got here, and where we may be headed.

Presentation:	Invited talk
Time:	17:00 - 17:30

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Splinter Meetings

Friday, 08:30 - 15:00

Splinter Meeting: Future asteroseismology projects

J. Christensen-Dalsgaard (convener)[1]

(1) Aarhus University

The coming decade should see a major expansion in our ability to observe stellar oscillations and hence probe stellar interiors by means of asteroseismology. The great promise of the CoRoT mission will be discussed in this session. Following CoRoT, already late next year the NASA Kepler mission will be launched. Although mainly designed for exo-planet search the mission provides excellent possibilities for asteroseismology; this use of Kepler data will be organized through the Kepler Asteroseismic Science Consortium which is now being set up. Further advances would result from the SIAMOIS project being developed for Dome C in Antarctica, and the planned SONG network. In the further horizon the PLATO project, proposed for ESA's Cosmic Vision 2015 - 2025, would yield outstanding asteroseismic data for a huge number of stars. In this session these projects will be presented and the community involvement in them will be discussed.

8:30	Introduction	J. Christensen-Dalsgaard
8:35	CoRoT	E. Michel
8:55	Kepler	J. Christensen-Dalsgaard
9:15	PLATO	C. Catala (see PA.06)
9:30	SIAMOIS	TBD
9:45	SONG	Frank Grundahl

Presentation: splinter session
Time: 08:30 - 10:00

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Splinter Meeting: Future helioseismology projects

F. Hill (convener)[1]

(1) National Solar Observatory

We are still living in a golden age of helioseismology, with SOHO/MDI, BiSON, and GONG++ still operating; the launch of SDO/HMI scheduled in the near future; and Solar Orbiter under discussion. However, it is timely to begin planning for the post-SDO and GONG++ era. Large scientific projects (both space and ground-based) now take 15-30 years between conceptual and operational status. This long lead time requires the community to plan the next generation of facilities even as the current ones are commissioned. This session will solicit technical and scientific ideas, strategies, and advice for the next generation of large helioseismology facilities.

Future of ground-based networks (F. Hill & BiSON representative)
Future of space-borne missions (SDO, Solar Orbiter and other missions' representatives)
Discussion (Led by F. Hill)
Probing the Sun through g modes and neutrinos (T. Rashba, see PH.23)

Presentation: splinter session
Time: 11:00 - 12:30

Contact:
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Splinter Meeting: HELAS local helioseismology

L. Gizon (convener)[1], H. Schunker (convener)[1]

(1) Max Planck Institute for Solar System Research

Local helioseismology offers a variety of methods to probe the solar interior in three dimensions. The purpose of this splinter meeting is to present the status of the HELAS local helioseismology network and to discuss future plans.
The datasets currently available form the HELAS local helioseismology website will be presented, focusing on the most complete dataset, active region AR9787. This will lead to discussions on what further datasets to include, and what data should be shared between the HELAS and LoHCo initiatives. Handling the forthcoming Solar Dynamics Observatory (SDO) data is also an important issue.
The discussion on the tools for data analysis will include a presentation of the GONG ring analysis pipeline and a short outline of the helioseismic holography code used by Lindsey & Braun. A live demonstration and instructions on how to use the beta version of a HELAS web interface for computing travel-time sensitivity kernels will be given. Among forthcoming modeling tools to be made available on the HELAS internet site are inversion codes used in time-distance helioseismology and the SLiM numerical code to compute wave propagation through a model solar atmosphere.

13:30	Introduction	L. Gizon
13:35	HELAS local helioseismology data website	H. Schunker
13:45	LoHCo Dataset	I. Gonzalez-Hernandez
13:50	Discussion	
14:05	Ring analysis pipeline	I. Gonzalez-Hernandez
14:15	Holography code	H. Schunker
14:25	Discussion	
14:35	Web interface for travel-time sensitivity kernels	Y. Saidi
14:45	Inversion codes for time-distance helioseismology	J. Jackiewicz
14:55	Numerical wave propagation code	R. Cameron

Input is welcome from anyone who would like to offer a contribution and speak about it briefly. Please contact Laurent Gizon or Hannah Schunker during the meeting.

Presentation: splinter session
Time: 13:30 - 15:00

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Poster Session: Asteroseismology and Stellar Physics

Poster Number: PA.01

Near infrared spectroscopy of two HADS stars: V703 Sco and 1 Mon. First steps towards the use of near-IR spectroscopy for the study of pulsating stars

P.J. Amado[1]

(1) Ugr-IAA(CSIC)

Intermediate results of an on-going program to study the possibilities of near-infrared spectroscopy for the always difficult task of providing information on the mode identification of pulsating stars are presented. High-resolution spectroscopy taken with CRIRES shows, for the first time, stellar absorption lines in the near-IR varying with the pulsation cycle in the high amplitude delta Scuti star 1 Mon.

Presentation: Poster

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Poster Number: PA.02

The Beta Cephei star HD 167743

V. Antoci[1], G. Handler[1], B. Shobbrook[2], E. Romero-Colmenerom[3]

(1) Institute of Astronomy, University of Vienna, Austria

(2) Research School of Astronomy and Astrophysics, Australian National University, Canberra, ACT, Australia

(3) SAAO, Capetown, South Africa

The Beta Cephei star HD 167743 has been observed from three different observatories: SAAO, SSO, Washington Camp in Arizona in the year 2006. The data sets are available in the filters Johnson UBV and Strömgren uvy. First analyses confirm the results of Pigulski (2005), who found a non-equidistant triplet in its pulsation spectrum. We present frequency analysis and mode identification, which is simplified by the rather high amplitudes of the star. Preliminary results suggest that the triplet is not due to rotational splitting. Additional ongoing photometric observing campaigns will enhance the accuracy of the data and enable a precise frequency analysis. Granted time on the MPG/ESO-2.20m telescope with FEROS will allow to measure abundances and the v sin i value of the star.
References: Pigulski, A. 2005, AcA, 55, 219

Presentation: Poster

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Poster Number: PA.03

HD 210111 compared to FG Vir and θ^2 Tau: A test of the λ Bootis phenomenon

Paul Beck[1], Michel Breger[1]

(1) Department of Astronomy, University of Vienna

For the λ Bootis phenomenon, several theoretical scenarios have been developed. These include surface phenomena as well as spectroscopic binaries to explain the underabundances of Fe-peak elements.
High-precision photometry of the pulsating λ Bootis star HD 210111, obtained in a multisite campaign in 2005 opens the possibility to compare the pulsation pattern to that of two other, well studied δ Scuti pulsators: FG Vir and the spectroscopic binary θ^2 Tau. Following this approach, we argue that the λ Bootis phenomenon is a surface effect.

Presentation: Poster

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Poster Number: PA.04

The use of eclipses for mode identification in binaries

B.I. Bíró[1], J. Nuspl[2]

(1) Baja Astronomical Observatory of Bócs-Kiskun County, Baja, Hungary

(2) Konkoly Observatory of the Hungarian Academy of Sciences, Budapest, Hungary

We present and compare two purely photometric methods for identifying pulsation modes on members of eclipsing binaries: a simple model fitting, and an eclipse mapping procedure. Both methods exploit the surface sampling effect of the eclipse phenomenon, and require photometric observational data only. In addition, they aim to maximal model-independence, on various levels. The first method uses spherical harmonics for the eigenfunctions. The second one goes even further: it drops the assumption of a specific model, and tries to reconstruct the surface pattern of the pulsation modes themselves, targeting the case of deviations from the simple spherical harmonics form (due to fast rotation, for instance). Our primary goal is to assess the relative strengths and weaknesses of the two methods, as well as the conditions required for their optimal performance.

Presentation: Poster

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Poster Number: PA.05

Asteroseismology of solar-type stars with HARPS

F. Carrier[1], P. Eggenberger[2], J.-C. Leyder[2]

(1) K.U. Leuven

(2) Université de Liège

Since the success of helioseismology, numerous efforts have been made to detect solar-like oscillations on other stars. The measurement of the frequencies of p-mode oscillations provides an insight into the internal structure and is nowadays the most powerful constraint on the theory of stellar evolution. We report here detection of acoustic modes on different solar-like targets.

Presentation: Poster

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Poster Number: PA.06

PLATO: an ESA Cosmic Vision proposal for asteroseismology and exoplanetary transit search

C. Catala[1], and the PLATO consortium[2]

(1) Observatoire de Paris

The PLATO proposal (PLAnetary Transits and Oscillations of stars) was recently submitted to ESA in the framework of the Cosmic Vision 2015-2025 programme. Its main objectives are to search for exoplanetary transits in front of a large sample of bright stars, and to perform seismic analysis of the same star sample.
The PLATO measurements will consist of very long, uninterrupted, ultra-high precision photometric monitoring of a very large sample of stars. The surveyed sample will include at least 100,000 stars down to mV=11-12, for which as well as about 400,000 fainter stars, down to mV=14.
Several instrumental concepts have been proposed for this mission, all compliant with its scientific requirements.
See http://www.lesia.obspm.fr/~catala/plato_web.html

Presentation: poster and splinter session talk

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Poster Number: PA.07

Asteroseismology of red giants: photometric observations of Arcturus by SMEI

N. J. Tarrant[1], W. J. Chaplin[1], Y. Elsworth[1], S. A. Spreckley[1], I. R. Stevens[1]

(1) University of Birmingham

We present new results on oscillations of the K 1.5 III giant Arcturus
from analysis of just over 2.5 yr of precise photometric observations made by the Solar Mass Ejection Imager (SMEI) on board the Coriolis satellite. A strong mode of oscillation is uncovered by the analysis, having frequency $3.47 \pm 0.03\,\mu$Hz. By fitting its mode peak, we are able offer a highly constrained direct estimate of the damping time ($\tau = 21.7 \pm 0.5\,$d). The data also hint at the possible presence of several radial-mode overtones, and maybe some non-radial modes. We are also able to measure the properties of the granulation on the star, with the characteristic timescale for the granulation estimated to be ~ 0.51 to $0.70\,$d.

Presentation: Poster

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Poster Number: PA.08

asteroFLAG: from the Sun to the stars

W. J. Chaplin[1], and the asteroFLAG group[2]

(1) University of Birmingham

(2) From 18 institutes

asteroFLAG is an international collaboration comprising observers and theoreticians involved in asteroseismology. The aims of the group are to help develop and test analysis methods for asteroseismology (in particular of the Sun-like oscillators), from techniques for extracting information on the mode parameters ("peak bagging") through to procedures used to draw inference on the fundamental stellar parameters and the internal structures.
Here, we give an overview on the aims and activities of the group. We also discuss the first round of artificial hare-and-hounds exercises currently underway. These exercises are testing extraction of large frequency spacings of low-degree acoustic modes, from artificial data simulating long-term space observations of Main Sequence stars.

Presentation: Poster

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Poster Number: PA.09

γ Doradus stars in the Pleiades cluster: results from a photometric multi-site campaign.

S. Martin-Ruiz[1], E. Rodriguez[1], A. Grigahcene[2], P.J. Amado[3], J.C. Suarez[1], V. Costa[1], A. Rolland[1], A. Moya[1], E. Hintz[4], et al.[5]

(1) IAA (CSIC)

(2) CRAAG, Algiers Observatory

(3) UGR-IAA (CSIC)

(4) Brigham Young University

The main results obtained from the photometric multi-site observations of some variable stars of the Pleiades cluster are presented in this poster. This campaign was carried out during the autumn - winter of 1998 -1999 using photoelectric and CCD photometry. Thanks to these observations we can confirm the variability of two γ Doradus stars, HD 22702 and HD 23585. New peaks in the frequency spectra have been detected and the multicolour photometry has allowed performing a modal discrimination of the main excited modes for both stars. Additionally, we have determined their physical parameters using high-resolution spectroscopic measurements whose values have helped us to make a study on the pulsating content of these stars.

Presentation: Poster

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Poster Number: PA.10

A study of binary system constraints for seismology of delta Scuti stars.

O.L. Creevey[1]

(1) High Altitude Observatory

Seismology of single δ Scuti stars has mainly been inhibited by failing to detect many of the theoretically predicted pulsation modes, resulting in difficulties with mode identification. Theoretical and observational advances have, however, helped to overcome this problem, but the following question then remains: do we know enough about the star to either use the (few) identified mode(s) to probe the structure of the star? or improve the determination of the stellar parameters? It is now generally accepted that for the observed frequencies to be used successfully as seismic probes for these ubiquitous objects, we need to concentrate on stars where we can constrain the number of free parameters in the problem, such as binary systems or open clusters.
I investigate by how much we gain in our understanding of the star by comparing the information we obtain from a single star with that of an eclipsing binary system. I use Singular Value Decomposition as a technique to explore the precision we expect to obtain in terms of stellar parameters (such as mass and initial chemical composition) as well as how these uncertainties propagate to the Luminosity-Temperature diagram. I will show that the binary system constraints enable us to pinpoint the star in the L-T diagram to a small localized region, and that even with one mode identification, the age of the star can be determined accurately to less than 10%.

Presentation: Poster

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Poster Number: PA.11

A model for the oscillating star CCAnd

G. Dogan[1], Z. Matalgah[2], A. Polatkesen[2], H. Kirbiyik[2], N. Kiziloglu[2]

(1) Atilim University, Middle East Technical University

(2) Middle East Technical University

The oscillation frequencies of CC Andromedae, which is a Delta Scuti variable, have been calculated. It has a rotational speed of ν sini=20 km/s. (Lopez de Coca et al.1990) which categorizes this star as a slow rotator. Quite a few observed oscillation frequencies have been reported in literature. All frequencies have been identified as nonradial oscillations by Jian-ning, F. and Shi-yang, J. (1995), while some of the frequencies were recently identified as radial oscillations by Ekmekçi, F. and Topal, S. (unpublished yet). Among the frequencies, the one that has the highest amplitude was given as 8.005891 cycles/day (P=0.1249 days) by the same authors.
In this work, first a sequence of evolutionary models in a mass range from 1.9 to 2.0 Solar mass was computed. In model calculations, attention has been paid to the point that observational and theoretical parameters of the star agree within a certain precision. Then, oscillation frequencies for the models that are in the acceptable range of the observable parameters have been obtained for l=0,1,2,3 and results are compared with the observational values, obtained by the authors quoted above.

Presentation: Poster

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Poster Number: PA.12

Asteroseismic modeling of the pulsating B star HD 163830

D. Pricopi[1], M.D. Suran[1]

(1) Astronomical Institute of the Romanian Academy

In this paper we report our results regarding the asteroseismic modeling of the slow pulsating B star HD 163830, based on eighteen of the twenty detected frequencies of this star. The powerful method of matching stellar models both to oscillation data and effective temperature and gravity of HD 163830 is applied in order to identify an best fit model. These eighteen frequencies correspond to low-order, high-degree g-modes of an stellar model of 0.0921 Gyr, of a 4.5Msun star, with chemical composition X=0.71, Y=0.015.

Presentation: Poster

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Poster Number: PA.13

Time-dependent convection study of the driving mechanism in the DBV white dwarfs

Dupret Marc-Antoine[1], Quirion Pierre-Olivier[2], Grigahcène Ahmed[3]

(1) LESIA - observatoire de Paris

(2) Institut for Fysik og Astronomi, Aarhus

(3) CRAAG-Algiers Observatory

We apply for the first time Time-Dependent Convection (TDC) models to the study of the driving mechanism of the Pulsating DB (V777 Herculis) Stars. From the blue to the red edge of the instability strip of these stars, TDC appears to play a central role in the driving. More precisely, towards the blue edge, the convection adapts quasi-instantaneously to the oscillations, so that TDC must be included in the models. And on the other side, the red edge of the instability strip is not obtained with frozen convection models ; TDC models including the terms due to the turbulent pressure variations must be considered to stabilize the modes.

Presentation: Poster

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Poster Number: PA.14

The role of chemical segregation in the driving of roAp stars

Dupret Marc-Antoine[1], Théado Sylvie[2], Noels Arlette[2]

(1) LESIA - observatoire de Paris

(2) Institut d'Astrophysique de Liège

We present a detailed study of the driving mechanism of roAp stars. Large grids of models were computed assuming very different chemical compositions. First, models with very different metal abundances in different regions are considered, emphasizing for the first time the key role of metals in the opacity bump of the H partial ionization. The full theoretical instability strips obtained for these models are presented and compared. Second, we consider the role of Helium settling and winds and show how they affect the driving of the roAp modes. Finally, interpretation of these results is proposed, illustrating in particular the complex and important role played by the shape of the eigenfunctions (location of the nodes, ...).

Presentation: Poster

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Poster Number: PA.15

Asteroseismic observations and modelling of 70 Ophiuchi AB

P. Eggenberger[1], A. Miglio[1], F. Carrier[2], J. Fernandes[3], N.C. Santos[4]

(1) Université de Liège

(2) K.U. Leuven

(3) Universidade de Coimbra

(4) Universidade de Porto

The analysis of solar-like oscillations for stars belonging to a binary system provides a unique opportunity to probe the internal stellar structure and to test our knowledge of stellar physics. This poster presents asteroseismic observations of 70 Oph A performed with the HARPS spectrograph together with a comprehensive theoretical calibration of the 70 Ophiuchi system.

Presentation: Poster

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Poster Number: PA.16

New evidence of binary model of the SX Phoenicis star CY Aquarii

J.N. Fu[1], C. Li[1], Y.P. Zhang[1], S.Y. Jiang[2]

(1) Beijing Normal University of China

(2) National Astronomical Observatories of China

New time-series photometric observations were made for Cy Aqr, leading to the determination of two new times of maximum light. Combining with the other 3 new times and those reported in the literatures, new (O-C) diagram is constructed. The location of the 5 new data points are used to check the models of long-term variability of the pulsation period of Cy Aqr, providing new evidence for the binary model of CY Aqr.

Presentation: Poster

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Poster Number: PA.17

Effect of mass loss on the driving of g-modes in Bsg stars.

M. Godart[1], A. Noels[1], M.-A. Dupret[2]

(1) University of Liège

(2) Paris Observatory

Saio et al. 2006 have detected with MOST p and g-modes in a B supergiant star HD163899. The driving of g-modes in a post main sequence star can be explained by the presence of a convective shell which prevents some modes from entering the damping radiative core. We show that this scenario depends on the mass loss rate. If it is too high, the convective shell disappears and all the non-radial modes are stable.

Presentation: Poster

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Poster Number: PA.18

Stellar Oscillations Network Group (SONG)

F. Grundahl[1], J. Christensen-Dalsgaard[1], S. Frandsen[1], H.Kjeldsen[1], T. Arentoft[1]

(1) Aarhus University

Stellar Oscillations Network Group (SONG) is an initiative to design and build a global network of 1m-class telescopes dedicated to asteroseismology and hunting of low-mass exoplanes. In the talk I will outline the SONG project and its current status.

Presentation: Poster

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Poster Number: PA.19

Periodic amplitude changes in different types of variable stars

E. Guggenberger[1], K. Kolenberg[1], M. Breger[1]

(1) Institute for Astronomy, Vienna

Various types of pulsationg stars show periodic amplitude changes. The fourier spectra of these stars typically exhibit a structure of either two or three close frequencies. But the existence of a close peak in the spectrum does not allow to conclude that a real pulsation mode causes the variation in amplitude. Therefore, a test concerning the phasing behavior at different stages of the beat cycle is applied to determine whether the cyclic behavior is caused by beating or by other effects. On this basis a comparison is drawn between several different pulsators. Nonlinear effects in RR Lyrae stars pose an addition challenge to the method.

Presentation: Poster

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Poster Number: PA.20

Constraining convection parameters from the light curve shapes of ZZ Ceti stars: the cases of WD 1524-0030 and EC 14012-1446

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Montgomery (2005, ApJ 633, 1142) developed a method to probe convection in pulsating white dwarf stars which allows the recovery of the thermal response timescale of the convection zone by fitting observed nonsinusoidal light curves. He applied this method to a number of objects and the Whole Earth Telescope undertook a campaign for the pulsating DB white dwarf GD 358 for just this purpose (Provencal et al., in preparation). Given this campaign's success, it is time to apply Montgomery's method to pulsating DA white dwarf (ZZ Ceti) stars. We present observations of two suitable ZZ Ceti stars, WD 1524-0030 and EC 14012-1446, both observed from multiple sites, partly at multiple times. EC 14012-1446 seems to be better suited for a forthcoming Whole Earth Telescope campaign because it has more pulsation modes excited and because its pulsation spectrum appears to be more stable in time.

Presentation: Poster

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Poster Number: PA.21

Radial velocities of giant stars: variability mechanism derived from statistical properties and from line profile analysis.

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Since 1999 a radial velocity survey of about 180 K giants is ongoing at UCO/Lick Observatory, USA. The measurements have an accuracy of 5 to 8 m/s. A large fraction of stars in this sample ($\approx$25%) shows periodic radial velocity variations, although stable stars are also present.
Periodic radial velocity variations can in principle be induced by sub-stellar companions or by phenomena intrinsic to the star, such as pulsations or spots. As no photometric variations are present for the investigated K giants, pulsations are more likely than spots.
In order to reveal which mechanism is causing the variations, a relation between the amplitude of the radial velocity variations and surface gravity is investigated. The presence of a correlation between these parameters, indicates that an intrinsic mechanism possibly induces the radial velocity variations in a large fraction of the stars.
Furthermore, spectral line shape analysis and temperature measurements over time are performed for a sub-sample of K giants, with high resolution spectra obtained with SARG mounted on the TNG, La Palma, Spain. Line shape variations indicate a mechanism intrinsic to the star, while no line variations, but only shifts, could indicate the presence of a companion. For some stars line shape and/or temperature variations could be obtained, which indicates that the observed radial velocity variations are most likely caused by an intrinsic mechanism in these stars.
In addition, a statistical comparison between possible sub-stellar companions orbiting K giants in this sample of 180 stars and the known sub-stellar companions orbiting F, G and K dwarfs is made. This reveals that orbital parameters of inferred sub-stellar companions orbiting K giant stars show different statistics compared to the ones obtained for companions orbiting F, G and K dwarfs.

Presentation: Poster

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Poster Number: PA.22

The oscillations of Procyon A: First results from a multisite campaign

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The bright F5 subgiant Procyon A is an excellent target for asteroseismology: It is nearby and extremely well studied, it is an astrometric binary which has provided precise fundamental parameters, and it is in an interesting stage of evolution near the end of core hydrogen burning. Procyon's stochastically excited oscillations have been known for more than a decade. However, the individual oscillation frequencies have so far been extracted from single-site data, which makes it difficult to identify the genuine frequencies. We present the data from the first major multisite campaign targeting Procyon. The campaign included 10 high-quality spectrographs worldwide, and more than 100 hours of radial velocity data with m/s precision were collected during 20 days in early 2007.

Presentation: Poster

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Poster Number: PA.23

High-frequency modes in solar-like stars

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p-mode oscillations in solar-like stars are excited by the outer convection zone in these stars and reflected close to the surface. The p-modes are trapped inside an acoustic cavity, but the modes only stay trapped up to a given frequency (known as the acoustic cut-off frequency) as modes with larger frequencies are generally not reflected at the surface. This means that modes with frequency larger than the acoustic cut-off frequency must be travelling waves. The high-frequency modes may provide information about the physics in the outer layers of the stars and the excitation source and are therefore highly interesting as it is the estimation of these two phenomena that causes some of the largest uncertainties when calculating stellar oscillations.
High-frequency modes have been detected in the Sun, β Hydri and in α Cen A & B and the large frequency separation as a function of frequency have been estimated. The large frequency separation has been compared with a simple model of the acoustic cavity which suggests that the reflectivity of the photosphere is larger at high frequency than predicted by standard models of the solar atmosphere and that the depth of the excitation source is larger than what has been estimated by other models and might depend on the order n and degree l of the modes.

Presentation: Poster

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Poster Number: PA.24

Inferences from high-resolution spectroscopic data of RR Lyrae Blazhko stars

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Exactly a century ago, Sergei Nikolaevich Blazhko was the first to notice a modulation in the light curve shape of the RR Lyrae star RW Dra. Nowadays, it turns out that a large fraction of RR Lyrae stars shows this so-called Blazhko effect. There is still no consensus on the physical origin of the effect: a magnetic field, a resonance effect, or something else?
Until not so long ago, most detailed studies of Blazhko stars were based on photometric data. In the course of the past 3 years, spectroscopic data of Blazhko stars with unprecedentedly high resolution and signal-to-noise ratio have been obtained from different observing sites. Besides the long-awaited line profile analysis, other applications of the data are a study of the phase lag between lines from different elements and a detailed abundance analysis at different phases in the pulsation and Blazhko cycle, yielding values for the projected rotational velocity and turbulent velocity.
The results of these analyses for the Blazhko star RR Lyrae will be discussed in this talk, as well as their consequences for our understanding of the Blazhko effect.

Presentation: Poster

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Poster Number: PA.25

1907-2007: What’s new on the Blazhko front?

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On the centenary of the discovery of the Blazhko effect, it is time to give a rundown of what progress has been made over the past decades in the understanding of the phenomenon.
The Blazhko effect is a periodic amplitude and/or phase modulation of the light curve, shown by a large fraction of the astrophysically important RR Lyrae stars.
Despite numerous devoted observational studies and elaborate models attempting to reproduce the modulation, it still defies a definitive explanation.
I present an overview of the observational and theoretical studies devoted to the phenomenon, and conclude with the present status.

Presentation: Poster

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Poster Number: PA.26

Spectroscopic eclipse mapping of oEA stars

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We introduce the project of a new computer program code for modeling the spectra of eclipsing binaries. In its actual state, the program uses simple predefined intrinsic line profiles and is able to compute synthetic composite line profiles in integrated light from both components of EBs in all orbital phases including eclipse mapping. Basic stellar parameters like the radii of the stars in units of the semi-major axis, the vsini, inclinations of the rotation axes, limb darkening coefficients as well as the orbital elements can be determined. The program will be extended to include synthetic line profiles calculated from atmosphere models and to allow for an optimization of the corresponding parameters as well. In its final state, the program will deliver spectroscopic solutions that are comparable to the photometric ones like those delivered by the Wilson-Devinney code. We present first results of an application to the oEA star RZ Cas.

Presentation: Poster

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Poster Number: PA.27

On the occurrence of close frequency pairs in selected Delta Scuti stars

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Amplitude variability is a common feature in Delta Scuti stars. Such variations can be explained by beating of close frequencies or by true amplitude variability. Observations have shown that the occurrence of amplitude variability follows regularities in the frequency spectra. In the present work we compute the expected incidence of close frequency pairs in pulsation models of a selected sample of Delta Scuti stars. Different stellar evolutionary stages are considered. We estimate how many close frequency pairs are predicted and examine the regularities in their positions in the frequency spectra.

Presentation: Poster

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Poster Number: PA.28

A method to estimate the parameter uncertainties of frequencies, amplitudes, and phases of the pulsating white dwarf PG 0122+200

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In asteroseismological research, the power spectra of observed light curves constructed from Fourier transformation are extensively used to analyze the pulsation properties of variable stars. There are a number of computer programs dedicated to the statistical analysis of large astronomical time series containing gaps. However, the parameter uncertainties are usually estimated from analytically derived formulae assuming an ideal case, which does not match the condition of real data.
The Monte-Carlo method is applied to construct simulated data based on observed time-series and provided observation errors, which are analyzed with the software Period04 (Lenz & Breger 2005) to estimate the parameter uncertainties of frequencies, amplitudes, and phases. Both an artificially-created dataset and the observed light curves of the pulsating white dwarf PG 0122+200 are used to test the method, providing reasonable results. Moreover, the calculated signal-to-noise ratios provide clues on the selection of peaks in the power spectra.

Presentation: Poster

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Poster Number: PA.29

Second order rotational effect on the oscillation frequencies of V1162 Ori

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V1162 is a delta Scuti type variable star for which a rotational velocity of Vsini=46 km/s has been observed. The star has been modelled according to its observed parameters and oscillation frequencies.
The results obtained by approximating rotation to the first order have been compared with the ones provided by new calculations that include rotation up to the second order.We found that second order rotation term should be included in frequency calculations for comparatively high rotation speeds.

Presentation: Poster

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Poster Number: PA.30

Pulsating components of eclipsing binaries from the OGLE-II Galactic data

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If a pulsating star belongs to eclipsing binary, its global parameters can be easily derived and then used in modeling. We present results of a search for pulsating components of eclipsing binaries among over 10,000 systems already found in the OGLE-II database of variable star candidates in Galactic fields. In particular, main-sequence pulsators: β Cephei, SPB, δ Scuti and γ Doradus, are searched for.

Presentation: Poster

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Poster Number: PA.31

The effect of rotationally induced mixing on the frequencies of gravity and mixed modes in main-sequence pulsators

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The understanding of mixing inside stars is one of the main goals of asteroseismology.
Rotationally induced mixing (see e.g. Maeder & Meynet 2000) can influence the internal distribution of μ near the energy generating core, having an effect on the evolutionary tracks similar to that of overshooting. This mixing also leads to a smoother chemical composition profile near the edge of the convective core, which is reflected in the behaviour of the Brunt-Väisälä frequency and, therefore, in the frequencies of gravity modes.
Firstly we recall an analytical approximation of high order gravity modes that takes into account the effect of sharp variations in the Brunt-Väisälä frequency. We then describe the effects of rotationally induced mixing on the frequencies of gravity modes in main sequence stars. In particular, the case of high-order g modes (that are observed in γ Dor and SPB stars) and of mixed modes (δ Scuti and β Cephei) are considered.

Presentation: Poster

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Poster Number: PA.32

Spectroscopic and photometric study of Kepler asteroseismic targets

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Kepler is a new NASA space mission that is scheduled for the launch in November 2008. We describe this mission and the asteroseismic part of the scientific investigation that will be carried out by the Kepler team.
Then, we present our program of ground-based observations of the Kepler asteroseismic targets. This program was started in 2005 and its main scientific goals are the determination of astrophysical parameters of stars, study of spectroscopic binaries and time-series analysis of stars from NGC6811 and NGC6866, two open clusters that fall into Kepler field of view.
Finally, we show results of the spectroscopic and photometric study of Kepler asteroseismic targets that were observed in the first two years of realization of our program.

Presentation: Poster

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Poster Number: PA.33

The neon content of nearby B-type stars and its implications for helioseismology

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The recent downward revision of the solar CNO photospheric abundances now leads to severe inconsistencies between theoretical models for the Sun's internal structure and the results of helioseismology. There have been claims that the solar neon abundance is underestimated and that an increase in this ill-defined quantity could alleviate (or even completely solve) this problem. To address the validity of this hypothesis, here we present preliminary results of a fully homogeneous NLTE abundance analysis of the optical Ne I/II lines in a sample of 18 nearby B-type stars.

Presentation: Poster

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Poster Number: PA.34

On the nature of the Delta Scuti star HD115520

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Observing Delta Scuti stars is most important as their multi-frequency spectrum of radial pulsations provide strong constraints on the physics of the star's interior; so any new detection and observation of these stars is a valuable contribution to asteroseismology.
While performing uvby-beta photoelectric photometry of some RR Lyrae stars acquired in 2005 at the Observatorio Astronomico Nacional, Mexico, we also observed several standard stars, HD115520 among them. After the reduction this star showed indications of variability. In view of this, a new observing run was carried out in 2006 during which we were able to demonstrate its variability and its nature as a Delta Scuti star.
New observations in 2007 permitted us to determine its periodic content with more accuracy. This, along with the uvby-beta photoelectric photometry allowed us to deduce its physical characteristics and pulsational modes.

Presentation: Poster

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Poster Number: PA.35

Pulsating B-type stars in the young open cluster h Persei (NGC 869)

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We present preliminary results of a search for pulsating B-type stars in the open cluster h Persei (NGC 869). We find over 10 β Cephei stars in the cluster and a large population of stars showing λ Eri-type variability that might be also interpreted in terms of pulsations. We conclude that, like its twin χ Persei, the cluster contains many interesting targets for asteroseismic modeling and propose to organize a multi-site campaign.

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Poster Number: PA.36

"Nonadiabatic Asteroseismology" with GW Vir stars

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The temperature and the chemical composition of very hot white dwarfs is well constrained by spectroscopic measurement. However, a large incertitude on the gravity of these object still exist. We use the fact that some of these very hot stars are part of the pulsating GW Vir class to improve our knowledge on the value of their gravity.
We show how we can use GW Vir models' nonadiabatic calculations to improve our knowledge of these stars' atmospheric parameters. The error on the gravity of some of the GW Vir stars can be reduced by a factor of 10. Especially, the gravity of PG 1159-035 is set to log g = 6.85 Å± 0.05.

Presentation: Poster

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Poster Number: PA.37

Strömgren photometry of the δ Scuti star 67 UMa

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We present preliminary results derived from the data obtained during four observing campaigns in 2001, 2003, 2004 and 2006, of the δ Sct-type variable star 67 UMa, at Sierra Nevada Observatory, Spain. In all the cases, simultaneous uvbyβ photometry was carrried out. The analysis of the data was performed in the *v* band, by means of the Fourier Transform method, and results are shown. The intrinsic b-y, m_1 and c_1 values are derived and the physical parameters of this star are determined.

Presentation: Poster

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Poster Number: PA.38

Photometric multi-site campaign on massive B stars in the open cluster χ Persei

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Recent breakthroughs in the asteroseismic modelling of β Cephei stars have resulted in a better understanding of the interior structure of these stars. To improve our comprehension of this class of variable stars, we set up a photometric multi-site campaign on the open cluster χ Persei (NGC 884). Studying ensembles of stars which have a similar age and chemical composition will provide us with more severe constraints for the seismic interpretation of the observations. Twelve observation sites joined the 2005-2007 campaign for NGC 884 which resulted in more than 1200 hours of data taken by about 60 observers. The reduction of the 73650 CCD frames is still ongoing. Preliminary results showed the existence of 7 β Cephei stars of which 2 were already known. Up-to-date results for the variability search, especially from the 1.2-m Mercator telescope (La Palma, Spain), will be presented.

Presentation: Poster

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Poster Number: PA.39

The exoplanet-host star μ Arae: new seismic analysis

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We present here the detailled modelling of the exoplanet-host star μ Arae, which is known to harbour a four-planets system. This star presents a metallicity excess compared to stars without detected planets. Asteroseismology can help determining precisely its internal structure. μ Arae was observed with the HARPS spectrograph at La Silla Observatory in June 2004, and 43 p-modes were identified. Using the external parameters provided by spectroscopy and the seismic constraints, we computed new stellar models, in a wider range and more precisely than Bazot et al. 2005, with various assumptions (overmetallic or accretion scenario, overshooting or not, Y enriched with metals or Y fixed to its solar value). We tried to find which ones give the best fit to the observations.

Presentation: Poster

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Poster Number: PA.40

Seismic predictions for the CoRoT main target HD 52265

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HD 52265 is the only exoplanet-host star selected as a main target for the seismology programme of the CoRoT mission, and so it will be observed continuously during five months. This is of great interest in the framework of asteroseismology of exoplanet-host stars, in order to understand the planetary formation and migration. We performed and extensive analysis of this star, computed models and analysed their frequencies. CoRoT observations should enable us to discriminate between the various models allowed from spectroscopic observations.

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Poster Number: PA.41

Towards the understanding of radial velocity pulsation in roAp stars

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High-resolution spectroscopic time series of rapidly oscillating Ap stars show evidence for a co-existence of standing and running waves in their atmospheric layers. With the purpose of understanding these observations we have carried out a theoretical analysis of the pulsations in the outermost layers of these stars, starting from the simplest possible model that still retains all important physical ingredients. In our analysis we considered an isothermal atmosphere in a plane-parallel approximation. Moreover we assumed that in the region considered the magnetic pressure is much larger than the gas pressure and, consequently, that the magnetoacoustic wave has decoupled into its acoustic and magnetic components. Using the analytical solutions for the velocity components appropriate to this model we estimate the velocity component parallel to the line of sight averaged over the visible stellar disk. Fitting the latter to a function of the form Acos(wt+phase), with w the oscillation frequency and t the time, we derive the amplitude A and the phase for our model as function of height in the atmosphere. Finally, we compare these results with corresponding amplitudes and phases published in the literature determined from the analyses of high-resolution spectroscopic data of roAp stars.

Presentation: Poster

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Poster Number: PA.42

Improved estimates of solar and stellar oscillation parameters

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Quantitative asteroseismology requires extremely precise measurements of the frequencies, amplitudes, and lifetimes of the global modes of stellar oscillations. Unfortunately continuous observations of stellar oscillations are rarely available and the Fourier analysis of such gapped time series is not straightforward. In particular, Fourier amplitudes at different frequencies are correlated because of the convolution of the signal with the observation window. We have derived and implemented maximum likelihood estimators of stellar oscillation parameters, which explicitly take frequency correlations into account. Using Monte-Carlo simulations of stochastically excited solar-like oscillations, we find that our new fitting method retrieves oscillation parameters with less bias and greater precision - especially for data with large gaps and low signal-to-noise ratios.

Presentation: Poster

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Poster Number: PA.43

Pulsating stars in the region of Carina Nebula

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We present the results of a search for pulsating stars in the region of Carina Nebula which includes three very young open clusters: Trumpler 14, 15 and 16. The search was made with the Wide Field Imager (WFI) on the MPG/ESO 2.2-m telescope in La Silla (Chile). In total, about 16,000 stars have been analyzed using classical Fourier techniques. We found over 20 pulsating δ-Scuti type stars in this region. Most of them are probable members of open clusters at the pre-main sequence evolutionary stage.

Presentation: Poster

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Poster Number: PA.44

A complete and homogeneous seismic solution for five delta Scuti stars in the Praesepe cluster

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The present paper focuses on seismic modelling of delta Scuti stars in clusters, particularly stressing on convection diagnostics. To do so, linear analysis is confronted with observations, using refined descriptions for the effects of rotation on the determination of the global stellar parameters and on the adiabatic oscillation frequency computations. The method provides, in addition, an estimate of the global parameters of the selected stars. We found a single, coherent and complete seismic solution for all the selected stars which provides significant constraints to the convection description in a certain range of effective temperatures.

Presentation: Poster

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Poster Number: PA.45

ROMOSC between MOST and CoRoT space missions

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This is a presentation of the LNAWENR method and the asteroseismological package ROMOSC which were implemented in the Bucharest Observatory, to be used in MOST and CoRoT space missions. Also some results obtained using this software package are discussed.

Presentation: Poster

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Poster Number: PA.46

Close-up of primary and secondary asteroseismic CoRoT targets and the ground-based follow-up observations

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The asteroseismic window of the CoRoT satellite mission aims at the monitoring of several types of pulsators along the Main Sequence. To optimise the science results, its targets are carefully chosen en selected. Preparatory observations from ground have been a key stone in the selection process. Also with the CoRoT satellite succesfully launched, simultaneous ground-based observations are very important and are complementary to the space data. Multi-colour photometry provides information on amplitude ratios and phase shifts while high-resolution spectroscopy allows the detection of high degree modes and the identification of both l and m values. I present a couple of protagonists in the CoRoT asteroseismic play (the gamma Dor HD49434, the beta Cep HD180642, the delta Sct stars HD50844 and HD172189, and the hybrid delta Sct/gamma Dor HD44195), an analysis of their behaviour in the ground-based time-series, and a look-out for the refined results provided by the CoRoT data.

Presentation: Poster

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Poster Number: PA.47

Time series photometry to search for B type variables in two young open clusters NGC 1893 and NGC2175

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B type variables, such as β Cephei and Be stars, have become vivid objects in asteroseismology. In this poster, we shall introduce our efforts in searching for B type variables in two open clusters NGC1893 and NGC2175. The two clusters were observed from December of 2006 to Janurary of 2007 with a 50-cm telescope equipped with a 1340×1300 CCD camera in Johnson B and V. Time series photometry of the stars in the clusters is used to search for new variable stars and to study the pulsation of known variables as well. The location of the stars on the Color-Magnitude-Diagram, combining with the pulsation information, will help us in making the classification of the variable stars. These two clusters would be the candidate targets of future international observation campaigns for asteroseismology of β Cephei stars in open clusters.

Presentation: Poster

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Poster Number: PA.48

Main-sequence instability strip for different opacities and heavy element abundances: a comparison with observations

T. Zdravkov[1], A. A. Pamyatnykh[1]

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Updated theoretical instability domains are presented for the Beta Cephei and SPB star models. Calculations were performed using new OP opacities for old and new solar composition (Grevesse & Noels 1993; Asplund, Grevesse and Sauval 2005). The position of observed Beta Cephei and SPB variables in the HR and related diagrams is compared with theoretical domains for three different heavy element abundances: Z=0.020, Z=0.015 and Z=0.010.

Presentation: Poster

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Poster Session: Helioseismology and Solar Physics (PH)

Poster Number: PH.01

Some topics in numerical simulations of magnetoconvection instabilities

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In this study we build Magnetoconvection advanced workable numerical algorithm based on finite spectral methods. Our aim is to resolve some spatial Magnetoconvection stability problem. Also, free, rigid (no-slip), and mixed boundary conditions will be investigated. Spectral domain decomposition numerical method would be adopted to accurately resolve boundaries interaction. We shall show how dividing problem(s) domain into sub-domains help to reducing the computational resources. The extension of the constructed algorithm will be suggested.

Presentation: Poster

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Poster Number: PH.02

Probing the subsurface structure of active regions with ring-diagram analysis

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(2) Yale University

(3) Stanford Univeristy

(4) Tata Institute of Fundamental Research

We analyze the variations in the near-surface profiles of sound-speed and adiabatic constant between active regions and neighboring quiet-sun areas using the technique of ring-diagram analysis and inversions of the frequency differences between the regions. This approach minimizes the systematic observational effects on the fitted spectral model parameters. The regions analyzed have been selected from a large sample of data available from both GONG and MDI, and include a wide range of magnetic activity levels as measured in several respects, as well as locations and morphological types.

Presentation: Poster

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Poster Number: PH.03

Introducing VFISV: a Very Fast Inversion of the Stokes Vector for the Helioseismic and Magnetic Imager

Juan M. Borrero[1]

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The Stokes vector measured in photospheric spectral lines allows to recover the magnetic field vector in the solar atmosphere. This is done thanks to the so-called ICs (Inversion Codes). Current and future satellite instruments yield huge amount of data that needs to be processed almost in real time. In this poster we present details about VFISV, a very fast inversion code for the Stokes vector that will work with low spectral resolution data. This code is ideal to analize data from instruements like HMI-SDO, ImaX-Sunrise, VIM-Solar Orbiter, NFI-Hinode. Preeliminary results from inversion of high resolution spectral recorded with Hinode's spectropolarimeter are presented. In the case of the Helioseismic and Magnetic Imager (HMI) this will allow to obtain full disk maps of the magnetic field vector every 10 minutes or less.

Presentation: Poster

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Poster Number: PH.04

Detecting solar g modes and gravitational waves with ASTROD

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We present an up-to-date estimate for the prospect of using the Astrodynamical Space Test of Relativity using Optical Devices (ASTROD) for an unambigous detection of both solar g modes (f<400 micro Hz) and gravitational waves. Gravitational waves are predicted by Einstein's theory of general relativity and there are currently two major efforts to detect low-frequency waves, ASTROD and the Laser Interferometer Space Antenna (LISA). Using the most recent g mode surface velocity amplitude estimates, both observational and theoretical, it appears that LISA is unlikely to be capable of sucessful detection. However, the ASTROD mission is ideal for detecting these waves as its optimal frequency is shited lower to that of LISA's to approximately 200-300 micro Hz.

Presentation: Poster

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Poster Number: PH.05

Latitudinal distribution of travel times in the upper solar convection zone

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We applied time-distance technique to GONG+ data in 2001 (maximum) and 2006 (minimum) to study the influence of surface activity on latitudinal distribution of travel times of acoustic waves in the upper solar convection zone. We analyzed 50 days in each epoch. Active regions were masked out and travel times of the acoustic waves obtained with and without masking of active regions were compared. We found that excluding of active regions from cross-correlation analysis reduces travel-time difference between 2001 and 2006 only in active latitudes. We do not see those travel-time changes at the solar equator and high latitudes.

Presentation: Poster

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Poster Number: PH.06

Solar heavy element abundance: constraints from frequency separation ratios of low-degree p modes

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We use very precise frequencies of low-degree solar-oscillation modes measured from 4752 days of data collected by the Birmingham Solar-Oscillations Network (BiSON) to derive seismic information on the solar core. We compare these observations to results from a large Monte Carlo simulation of standard solar models, and use the results to constrain the mean molecular weight of the solar core, and the metallicity of the solar convection zone. We find that only a high value of solar metallicity is consistent with the seismic observations. We also demonstrate that it is possible to determine the mean molecular weight of the solar core to a very high precision. Our results indicate that the discrepancies between solar models constructed with low metallicity and the helioseismic observations extend to the solar core and thus cannot be attributed to deficiencies in the modeling of the solar convection zone.

Presentation: Poster

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Poster Number: PH.07

Analysis of low-degree helioseismology data: Results from the second round of solarFLAG hare and hounds

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(2) From 12 institutes

We report on results of the second round of hare-and-hounds exercises conducted by the international solarFLAG collaboration. The artificial data used for the exercises were made to mimic just under 10 years of "Sun-as-a-star" Doppler velocity observations (e.g., like those made by the ground-based BiSON and the space-borne GOLF instruments). These new data were generated in a slightly more sophisticated manner than their older counterparts from the first round of hare and hounds: principally, the artificial modes were excited in the time domain by noise which has a granulation-like spectrum. The new method allows for inclusion of peak asymmetry and correlations between modes.
Here, we present results on extraction of some of the principal mode parameters – e.g., the mode frequencies, peak asymmetries, damping rates and powers – from fitting ("peak bagging") performed by members of the group who acted as hounds. We also discuss implications of the results for analysis of real data, and our understanding of the interior structure of the Sun.

Presentation: Poster

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Poster Number: PH.08

Inferring the sub-surface rotational gradients using f-modes and ridge fitting analysis.

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In a previous work (Corbard & Thompson, 2002), MDI f-modes with spherical harmonic degrees up to l=300 have been used to infer properties of the radial gradient of angular velocity in the near sub-photospheric layers. This information is very important in order to better constrain numerical models of the convection in this layer. Local helioseismology however gave hints that the resolution reached by our global mode analysis might not be enough to reveal the full complexity of the angular velocity gradients and their radial variations.
In this work we use frequency splittings estimated from a ridge fitting technic for degrees up to l=1000 (Reiter, 2007) in order to reach more resolution in the radial direction close to the photosphere. We show how the linear assumption used in the previous work cannot be kept anymore when using this new dataset and present our first results obtained by inverting the new data.

Corbard, T. & Thompson M.J., 2002, Sol. Phys. 205, 211
Reiter J. 2007, Astron. Nachr., 328, 245

Presentation: Poster

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Poster Number: PH.09

Inversion of the Sun's internal structure and rotation after 2088 days of MDI observations.

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(2) Harvard-Smithsonian Center for Astrophysics

A mode set comprising frequency multiplets spanning $\ell = 1, 125$ and frequencies ranging from 1 to 3.9 mHz was calculated from 2088 days-long MDI observations. The frequency range of this mode set is the largest ever calculated, and new information in the very low frequency range is available for the first time. This mode set was inverted to infer the solar internal sound speed, density and rotation profiles, using in all three cases the same inversion methodology, namely Regularized Least Squares with a radial and latitudinal dependent smoothing constrain.

Presentation: Poster

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Poster Number: PH.10

BiSON's pearl anniversary: Thirty years of BiSON data

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The Birmingham Group have been collecting data for over thirty years. We now have observations covering almost three complete eleven-year solar cycles.
Our first instrument was deployed during the summer of 1976 in Tenerife. Further sites were selected and commissioned through the years, culminating in the six-station network of today in 1992. Since then, the group have been officially known as the Birmingham Solar Oscillations Network. We are currently looking at installing a modern instrument in Tenerife to complement our existing Mark-I design, and also possibly a second site in Carnarvon in association with the OTC regeneration project.
Having completed the task of replacing all our old DOS-based computers with new Linux-based PCs we are taking full advantage of the enhanced networking and multi-tasking abilities of these new systems. We now have real-time data being collected from all stations, including our site in Carnarvon that has finally been connected to the internet. Almost all of our electronics are in the process of being replaced with new remote-controlled PIC-based hardware, including a new mount-controller that will allow variable auto-guider-gain throughout the day, and new temperature-controllers that will allow on-the-fly monitoring and adjustment of instrument temperatures.

Presentation: Poster

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Poster Number: PH.11

Effects of surface magnetic activity on meridional circulation measurements

I. Gonzalez Hernandez[1], S. Kholikov[1], F. Hill[1], R. Howe[1], R. Komm[1]

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The temporal variations of the meridional flow with the solar cycle have been reported by several authors. This work examines the possible contamination of these measurements by the extra velocity fields associated with active regions as well as the uncertainties in the data obtained where strong magnetic fields are present. We compare meridional flows obtained by both ring-diagram and time-distance analysis before and after masking the areas of strong magnetic field.

Presentation: Poster

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Poster Number: PH.12

Activity-related helioseismic frequency shifts as a function of spatial and temporal scale

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(1) NSO

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Variations in the frequencies of solar acoustic modes with activity level are well known. With modern observing systems, such as MDI and GONG, providing continual spatial and temporal coverage we now have more detailed information on the shifts. The observations show that $d\nu/dB$ depends not only on frequency, but also on the spatial and temporal scales of the observations; on the phase of the solar cycle; and on latitude. These complex relationships may be caused by the interaction between the p modes and two classes of the magnetic field (background fields and active regions).

Presentation: Poster

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Poster Number: PH.13

2+1 dimensional inversion of helioseismic travel times to infer solar flows.

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(2) NWRA, CoRA Division

It is well known that wave travel times contain the signature of solar flows. Extracting that information from observations requires a model of the effect of flows on travel times and a robust inversion procedure. For these purposes, we have developed three-dimensional travel-time sensitivity kernels for vector flows in the first Born approximation, as well as a 2+1 dimensional optimally localized averaging inversion scheme. We present results of inversions for near-surface flows using surface-gravity wave (f-mode) and p-mode travel times measured from full-disk MDI/SOHO Doppler data. We find that we can obtain three-dimensional maps of the vector flows at a spatial resolution as high as several megameters, and we apply this technique to image quiet-sun supergranulation as well as flow structures around an active region.

Presentation: Poster

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Poster Number: PH.14

Solar acoustic radius measurements

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We used GONG and MDI low degree (l=0,1,2,3) time series to measure the solar acoustic radius. Autocorrelation functions have been analyzed to obtain a very precise measurements of the large separation and solar acoustic radius. Results from both GONG and MDI data show clear temporal variations of the acoustic radius and activity level.

Presentation: Poster

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Poster Number: PH.15

YAOPBM - Part 2: Extension to high degrees and application to shorter time series of Yet an Other Peak Bagging Method.

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In 2005 I presented a new fitting methodology (Yet an Other Peak Bagging Method - YAOPBM), derived for very-long time series (2088-day-long) and applied it to low degree modes, $\ell \leq 25$. That time series was also sub-divided in somewhat shorter segments (728-day-long) and fitted for low degrees in order to measure changes with the solar activity level.
I present here the extension of this method in several "directions": 1) to substantial higher degrees ($\ell \leq 125$), 2) to shorter time series (364- and 182-day-long), and, 3) to additional 728-day-long segments, covering now some 10 years of observations.
I discuss "issues" with the fitting, namely the leakage matrix, and the f-mode and present some of the characteristics of the observed temporal changes.

Presentation: Poster

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Poster Number: PH.16

The effect of the length of helioseismic time-series on the frequency estimates and its impact on the inverted rotation and structure profiles.

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The connection between the solar activity cycle and the sun's internal rotation and structure distributions could be studied through helioseismic inversions of frequency sets calculated from time series that cover different epochs of the solar cycle. The length of the time series will affect the frequency estimates in various ways: the longer the time series the lower the level of uncertainties in the frequency estimates; the longer the time series, the larger the calculated frequency range (in particular at low frequency), and finally the length of the time series will greatly affect the frequency estimates at high frequency, where the solar surface effects are larger. In this work we analyze frequency sets calculated from 2088 days of MDI observations, slicing this period of time in shorter sub-series 728, 364 and 182 days-long. These mode sets were also inverted to infer the internal rotation and structure profile to look for signatures of the solar activity cycle.

Presentation: Poster

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Poster Number: PH.17

Improvements in global mode analysis

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As with any data analysis, the standard MDI medium-l analysis pipeline is based on several approximations. Physical effects such as line asymmetry, horizontal displacement at the solar surface, and distortion of eigenfunctions have been ignored, as well as cubic distortion in the optics and instrumental errors in the plate scale and orientation of the CCD. Furthermore, we see several systematic errors in the results of the analysis, most notably an annual variation in f-mode frequencies and a bump in the normalized residuals of the a-coefficients around 3.4 mHz, which may also relate to polar jets in the inversions. We have reprocessed several years of data applying the above corrections, and made improvements in the pipeline algorithm itself by recomputing the locations of bad data points and using updated routines for detrending and gapfilling. Along the way the pipeline has been almost entirely automated. In this poster we discuss the resulting changes in mode parameters and their effect on the magnitude of systematic errors. This work has been funded by NASA Grant NNG05GH14G.

Presentation: Poster

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Poster Number: PH.18

Dynamical processes in the subsurface layers of the Sun

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Recent results obtained by Lefebvre and Kosovichev (2005) using f-modes frequencies from SOHO/MDI, indicate a change in the stratification of the subsurface layers, more precisely a non-homogeneous variation of these layers with depth and time. To progress on this transition zone between the solar interior and the external part, we begin to analyse the problem from a theoretical point of view. Using the CESAM code, we show how a small variation in the radius implies a variation in the subsurface structure. We use the theoretical f-modes frequencies to examine the corresponding changes in the stratification. Furthermore, we discuss the related physics, very complex in this zone, and show the variations of the temperature gradients, the density and pressure scale heights caused by the change in radius. Finally we compare this study to the solar change during the last solar cycle.

Reference : Lefebvre and Kosovichev, 2005, ApJ, 633, L149

Presentation: Poster

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Poster Number: PH.19

On the relationship between the quality of the potential g-mode observations and the quality of the inferred solar core rotation profile

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The characterization of g modes could significantly improve our understanding of the dynamics of the solar burning core. The unprecedented quality of SoHO observations shed a new light onto the g-mode research, in both individual modes detection and characterization of global properties. Indeed, some mixte and g-mode candidates have been proposed and discussed (Gabriel et al., 2002, Turck-Chieze et al., 2004) whereas an average rotation rate of the core was deduced from the detailed analysis of the asymptotic behavior of the g modes (Garcia et al., 2007). In this work, we attempt to find a link between the quality of the precision of the extracted splittings of these potential candidates and the inferred rotation profile inside the core.

Presentation: Poster

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Poster Number: PH.20

Structure and evolution of supergranulation from local helioseismology

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Maps of the horizontal divergence of the near-surface velocity field have been obtained using time-distance helioseismology and SOHO/MDI full-disk data. These maps provide a continuous coverage for two to three months each year during 1996-2002 with a cadence of 12 hr. The geometrical and evolutionary properties of supergranulation are studied with 2D and 3D segmentation algorithms. Supergranular cells have a mean circular diameter of 29 Mm. Several supergranules can be followed for as much as 4.5 days. We observe a clear trend for larger cells to have stronger divergence values and longer lifetimes than the smaller ones.

Presentation: Poster

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Poster Number: PH.21

Calculation of spectral darkening functions for solar and stellar oscillations

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We present calculations of spectral darkening functions for solar and stellar oscillations over a broad range of the visible and infrared spectrum. The procedure includes the computation of depth-dependent derivatives of the opacity due to variations of temperature and density caused by p-modes.
We find that the observations of global solar oscillations are best observed at wavelengths close to the Balmer continuum.
Our results might help to improve further photometric observations of global solar and stellar oscillations.

Presentation: Poster

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Poster Number: PH.22

Analysis of the characteristics of solar oscillation modes in active regions

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We analyse the characteristics of high-degree solar acoustic modes in the vicinity of magnetic active regions and compare with those of magnetically quiet regions at the same latitude and at nearly the same time. We are engaged in a systematic examination of local mode characteristics for a representative sample of active regions during the whole epoch in which GONG+ data suitable for ring-diagram analysis are available, using the 13-parameter mode-fitting model of Basu & Antia (1999). We explore the correlations of variations in mode frequencies, amplitudes, widths, and asymmetries with the total magnetic flux of the analysed regions.

Presentation: Poster

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Poster Number: PH.23

Probing the internal solar magnetic field through g-modes and neutrinos

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I will discuss the effect of radiative zone magnetic fields on g-mode frequencies. It will be shown that a 1% g-mode frequency shift with respect to the Solar Seismic Model (SSeM) prediction, currently hinted in the GOLF data, can be obtained for magnetic fields as low as 300 kG, for the radial order mode n=-20. On the other hand, a similar shift for the low order g-mode candidate (l=2, n=-3) cannot result from central magnetic fields, unless these exceed 8 MG. I will also comment that future solar neutrino observations may provide us some information about g-modes and central magnetic fields.

Presentation: poster and splinter session talk

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Poster Number: PH.24

Sensitivity kernels for flows in spherical geometry

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The general problem of the computation of the sensitivity of helioseismic travel times to small-amplitude localized perturbations in the Sun is relatively well understood. Solutions have been obtained in plane-parallel geometry for sound-speed and flow perturbations. Here we present kernels for flows computed in spherical geometry. These kernels are required to interpret travel-time measurements at large travel distances, i.e. to probe deep into the Sun.

Presentation: Poster

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Poster Number: PH.25

Distant computation of travel-time sensitivity kernels over the internet

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We describe a system architecture based on open-source technologies that enables distant users to run computations at the Max Planck Institute for Solar System Research over the internet. This system currently runs MATLAB code to compute travel-time sensitivity kernels for local helioseismology. Multiple jobs can be distributed over several machines without the need for additional MATLAB licenses. The user is notified of the status of the computation by email. This work was funded in part by the European Helio- and Asteroseismology Network (HELAS).

Presentation: Poster

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Poster Number: PH.26

Observation of low-frequency p modes: frequency comparisons between coeval datasets

D. Salabert[1], et al.[2]

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The rotation-corrected m-averaged spectrum technique has been shown to be a powerful tool to detect long-lived low signal-to-noise modes at low frequency. This is done by shifting the m spectra of a multiplet (ℓ, n) by a fixed amount corresponding to the theoretical values of the rotational splittings or so-called a-coefficients (Schou 1998, 2002, 2004; Appourchaux et al. 2000). Here, we adapt the method to find the a-coefficients that yield the narrowest profile for each mode.
This technique is applied to ≈4000 days of Global Oscillation Network Group (GONG) data for modes of low- and medium-angular degrees. Modes down to n=2 (900μHz) have been observed and their parameters estimated (central frequency, amplitude, linewidth) by fitting the rotation-corrected m-averaged spectrum.
We compare the GONG frequencies obtained with the rotation-corrected m-averaged spectrum technique with observations from coeval datasets using classic peak-fitting methods. Any systematic bias and errors due to the technique can be then estimated. We also apply this technique to the Michelson Doppler Imager (MDI) data and we test the limit of detectability of the low-frequency p modes with this technique.
We also address some details of the method, like the peak asymmetry, the m leaks, the sinc interpolation of the power spectrum, and the fit of very narrow lines.

Presentation: Poster

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Poster Number: PH.27

On the rotation and structure of the deep solar interior as seen by GONG

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We use 3960 days of Global Oscillation Network Group (GONG) data to derive the rotation and the structure of the radiative solar interior. This long dataset has allowed the detection of new low-radial order modes. The rotational splittings and central frequencies of low signal-to-noise modes at low frequency are determined by using an adaptation of the rotation-corrected m-averaged spectrum technique. This adaptation finds the a-coefficients that yield the narrowest profile for each (n, ℓ) multiplet. The corresponding mode parameters (central frequencies, amplitudes, linewidths) are then estimated by fitting the rotation-corrected m-averaged spectrum. Low-radial order multiplets of low- and intermediate-angular degrees are detected well below 1 mHz. We present rotational and structure inversions of the deep solar interior, and discuss how these recently detected long-lived low-frequency modes contribute to the inversions.

Presentation: Poster

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Poster Number: PH.28

A search for mode conversion in sunspot penumbrae

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Magneto-acoustic mode conversion may be occurring in the near surface layers of the sun within strong magnetic field regions. Here we present an attempt to detect evidence of this by searching for an amplitude signature that depends on the angle between the magnetic field and the wave vector. We study several sunspots observed with the MDI-SOHO instrument.

Presentation: Poster

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Poster Number: PH.29

HELAS local helioseismology data webpage

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One aspect of the HELAS Network is to collate multipurpose datasets and make them available to the helioseismology community for analysis. This involves acquiring and selecting high quality, useful datasets. The HELAS local helioseismology webpage at http://www.mps.mpg.de/projects/seismo/data.html provides documented data ready for download and analysis. The data mainly consists of Dopplergrams, magnetograms and intensity images from SOHO-MDI but also includes GONG+ and MOTH datasets. The webpage is designed to provide and link to as much relevant information about the data sets as possible to allow a full analysis. The data has undergone minor reduction to further hasten analysis and details of how this is done are provided. The webpage will continue to be updated with appropriate data providing easy access to useful data sets for local helioseismology.

Presentation: Poster

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Poster Number: PH.30

Reliablity of P mode event classification using contemporaneous BiSON and GOLF observations

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P modes are acoustic waves that propagate in the solar interior. It has been shown that solar flares could excite free modes of oscillation in the Sun just as the Earth is set ringing for several days after a major earthquake.
Motivated by an interest to link the solar interior to the atmosphere through the observed behaviour of the p modes, we aim to characterize the rare, high-amplitude excitations through their temporal features in power and phase.
As part of the process of validating the categorization of large excitations, we carried out a comparison of the signal seen in contemporaneus BiSON and GOLF data. We show that the results from the two datasets are consistent, hence we will be able classify the events according to their temporal features using the extensive BiSON database. Some classes of events are not seen in artificial data and the hope is that these events will be linked with episodes of solar activity.

Presentation: Poster

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Poster Number: PH.31

Numerical simulations of a resonant spectrometer

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The Global Oscillation Low Frequency New Generation (GOLF NG) project instrument is devoted to detect signals in the 0.1 mm/s range or even less, to search for gravity modes. To this aim has been developed a 15-point resonant spectrometer working on the NaD1 line, in order to observe the oscillatory signal at different altitude of the solar atmosphere. By combining the signal coming from different heights, we aim to suppress the non coherent part of the signal, in order to reveal the faint g mode signal. While waiting the prototype to be installed at the Teide observatory, we present numerical simulation of the GOLF NG instrument.

Presentation: Poster

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Poster Number: PH.32

2D artificial helioseismic datasets

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In this poster we discuss a method to construct artificial timeseries for p-modes as if they were observed with an imaging instrument like MDI or HMI. The procedures used are based on a generalization of the method used to make artificial datasets for p-modes observed in integrated sunlight. P-mode peak asymmetry is taken into account introducing a correlated background noise. Frequency shifts, arising from the effects of the solar activity, are also modelled.

Presentation: Poster

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Poster Number: PH.33

Geometric mapping comparisons for ring diagram analysis.

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Mapping the solar surface is a crucial step in any local helioseismology technique. We consider different types of mapping in the estimation of surface velocity flows from ring diagram analysis of GONG data. Because the acoustic waves propagate along great circles at the solar surface, it has been shown that these circles need to be used in the geometric mapping. Until know the same projection has been used for estimating both zonal and meridinal flows. However it is known that a single projection cannot both be made up of great circles and preserve distances in the two spatial directions. In this work, we test the idea that the oblique cylindrical projection could be an accurate geometrical configuration for meridional flow estimations whereas the zonal flow could be better estimated by the transverse cylindrical projection.

Presentation: Poster

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Poster Number: PH.34

Theory of three-minute oscillations and seismology of sunspot chromosphere

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There is no question that 3-min oscillations are slow waves travelling through sunspot atmosphere. Capture of 3-min oscillation by sunspot is not possible since there is no noticeable reflection of slow waves from subphotospheric layers of sunspot. Local seismology shows that the waves are going free into and through sunspot. This is an evidence that only filtering of the waves by sunspot atmosphere can explain the appearance of multi-peak spectrum of 3 min oscillations. Complete revision of the filtering theory of 3-min oscillations is presented. Zhugzhda and Locans(1981) showed that sunspot chromosphere could work as a Fabry-Pero filter for slow waves at the frequency of chromospheric resonance. But this effect is responsible only for one peak in the spectrum which occurs at the frequency below cut-off frequency. Besides, the peak at cut-off frequency appears. However, the spectrum has, in most of cases, more than two peaks. It is revealed that all peaks at frequencies over cut-off frequency appear due to antireflection effect which is known in optics as a blooming by multilayer coating. The effect of nonlinearity of 3-min oscillations on filtering is explored. The interpretation of spectrum of Lites, Maltby and Staude empirical models of sunspot atmosphere is performed. Comprehensive filtering theory allows to develop the basics of sunspot atmosphere seismology.

Presentation: Poster

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Poster Number: PH.35

Analytical Signal as a Tool for Helioseismology

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Representation of narrow-band oscillations in terms of analytical signal is outlined. The analytical signal allows to determine uniquely the instantaneous oscillation frequency, amplitude, and phase of narrow-band signal. Analytical signal representation makes possible to separate the effects of spectral line broadening by amplitude and frequency fluctuations. It makes possible to found the true frequency of oscillations and its stability whose are not affected by amplitude fluctuations. An extension of analytical signal for the case of two component signal is developed. It can define the amplitude and frequencies of two narrow-band oscillations whose spectrum are overlapped. P-modes oscillations are an ideal object for application of analytical signal representation. The application of analytical signal representation for p-modes is used for analysis of brightness fluctuations of the Sun observed by multi-channel photometer DIFOS on CORONAS-F mission. It is revealed that broadening of p-modes spectral lines is produced predominantly by fluctuations of its amplitude. Stability of p-mode frequencies determined from spectral line width exceeds in few times the true stability which is defined by stability of its instantaneous frequency. It is found that certain of rather wide asymmetric lines of p-modes consist of two spectrally unresolved components whose amplitudes and frequencies can be found by two-mode analytical signal representation.

Presentation: Poster

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Poster Number: PH.36

Sensitivity of helioseismic travel times to internal flows

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Time-distance helioseismology is a technique for measuring the time for waves to travel from one point on the solar surface to another. These wave travel times are affected by advection by subsurface flows. We present a computation of the linear sensitivity of wave travel times to weak, steady, inhomogeneous vector flows, using the first Born approximation.

Presentation: Poster

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Poster Number: PH.37

Measurements of helioseismic travel times

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In time-distance helioseismology wave travel times are measured from the cross-correlation between Doppler velocities recorded at any two locations on the solar surface. We compare two different methods to extract the travel times from the noisy cross-correlation functions. The first method consists of fitting a 5-parameter analytic function to the crosscorrelation to obtain the phase travel time. The second method consists of linearizing the distance between the observed cross-correlation and a sliding reference cross-correlation (the only parameter is the travel time). We find that the oneparameter fits are more robust with respect to noise. Using SOHO data from the MDI Structure Program for the years 1996-2003, we study in detail the statistical properties of the noise associated with the travel-time measurements for the two different fitting methods.

Presentation: Poster

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Poster Number: PH.38

Sensitivity of ring diagrams to weak local flows

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Ring-diagram analysis is a technique of local helioseismology used to infer plasma flows in the solar convection zone which generates intermediate data products known as ring-fitting parameters. In this poster, we show computations of the linear sensitivity of ring-fitting parameters to weak, steady, local flows. We show that these parameters have a sensitivity in depth that is proportional to the mode kinetic energy density, as has traditionally been assumed.

Presentation: Poster

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Poster Number: PH.39

Helioseismology of small magnetic flux tubes: Three dimensional simulations

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Small magnetic concentrations on the solar surface usually have field strengths in the kilogauss range, a result which can be understood in terms of convective collapse. At these field strengths the tubes are almost completely evacuated near the surface and, due to buoyancy effects, almost vertical. Such tubes can have an influence on the waves which propagate through them, and have a helioseismic signature. Forward modeling of wave propagation through such tubes is obviously desirable. This poster presents a series of numerical calculations of plane wave propagation through flux tubes of different sizes.
We used the SLiM (see Cameron et al 2007) code to propagate waves through an enhanced polytropic atmosphere (see Cally and Bogdan 1997). An almost evacuated flux tube is superposed on the background atmosphere. The tubes are defined to have a top-hat profile given by $B = B_0 e^{-r4/r_0 4}$, where r_0 is defined to be the tubes radius and B_0 is 4820G (which corresponds to an almost evacuated tube for this atmosphere). The initial condition consists of an f-mode wave packet with a central frequency of 3 mHz.

Presentation: Poster

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Poster Number: PH.40

Solar Orbiter: prospects for helioseismology

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Solar Orbiter is ESA's next solar mission. By approaching the Sun as close as 0.22 AU, Solar Orbiter will view the solar atmosphere with a spatial resolution of less than 150 km and will perform the closest ever in-situ measurements. In the course of the mission the inclination of the spacecraft orbit to the ecliptic will incrementally increase to reach heliographic latitudes larger than 30°, hence providing the first views of the solar polar regions. A unique aspect of the mission is the combination of comprehensive remote-sensing and in-situ instrumentation to study solar features from the photosphere to interplanetary space.
Solar Orbiter will offer novel perspectives for helioseismology, thanks to the unique vantage points from which the Sun will be viewed. Not only will out-of-the-eclipic observations enable us to probe higher heliographic latitudes, but Solar Orbiter in combination with Earth-side observations will also mean the advent of stereoscopic helioseismology.

Presentation: Poster

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Poster Number: PH.41

Prediction of amplitude and period of solar cycle 24 and beyond

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Deviating from the traditional dynamo mechanism, we model the solar cycle as a forced and damped harmonic oscillator (Hiremath, K. M., 2006, A&A, 452, 591) and from all the 22 cycles (1755-1996), we obtain the long-term physical parameters such as amplitudes, frequencies, phases and decay factor. In the present study, with an *autoregressive* model and by using these physical parameters of 22 cycles, we predict the amplitudes and periods of future 16 solar cycles.
Predicted amplitude of the present solar cycle (23) with a period of 11.73 yrs matches very well with the observations. With these encouraging results, we also predict the profiles of future 15 solar cycles. Important predictions are : (i) the period and amplitude of the cycle 24 are 9.34 years and 110 (±11), (ii) the period and amplitude of the cycle 25 are 12.49 years and 110 (± 11), (iii) during the cycles 26 (2030-2042 AD), 27 (2042-2054 AD), 34 (2118-2127 AD), 37 (2152-2163 AD) and 38 (2163-2176 AD), the sun might experience a very high sunspot activity, (iv) the sun might also experience a very low (around 60) sunspot activity during cycle 31 (2089-2100 AD) and, (v) length of the solar predicted cycles vary from 8.65 yrs for the cycle 33 to maximum of 13.07 yrs for the cycle 35.

Presentation: Poster

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Poster Number: PH.42

Deep meridional circulation below the solar convective envelope

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With reasonable assumptions and approximations, we compute the velocity of the meridional flow in the convective envelope by using Chandrasekhar's (1956, Ap.J., 124, 231) MHD equations. We assume that in the convective envelope, the fluid is incompressible and the large-scale magnetic fields and the fluid motions are symmetric about the rotational axis. We also assume that the magnetic eddy diffusivity η and the eddy diffusivity due to viscosity ν are constants with values represented by the appropriate averages. Further we assume that strength of toroidal magnetic field is less than (or at most comparable to) that of strength of steady part of the rotational velocity. These assumptions lead to complete decoupling of meridional velocity equation $\Delta_5(\Delta_5 U) = 0$, where U is the meridional velocity and Δ_5 is five dimensional Laplace operator as defined by Chandrasekhar. This equation has two solutions : either $U = 0$ a trivial solution and, $\Delta_5 U = 0$ a non trivial solution.
The nontrivial solution is $U(x, \mu) = \sum_{n=0}^{\infty}[u1_n x^n + u2_n x^{-(n+3)}]C_n^{3/2}(\mu)$, where x is non-dimensional radius, $\mu = cos\vartheta$, ϑ is the co-latitude, $C_n^{3/2}(\mu)$ are the Gegenbaur polynomials of order 3/2, $u1_n$ and $u2_n$ are the unknowns determined from the boundary conditions. Taking a clue from the helioseismic inferences that meridional velocity increases from the surface towards base of the convective envelope, we neglect first part in the series solution and solve only the second part $u2_n$ only. For the sake of understanding and simplicity of the problem we consider $u2_1$ and $u2_3$ modes only. In order to solve two unknowns uniquely, we match the observed surface meridional velocity at the two latitude zones with the meridional velocity obtained by the solution. Finally we get the meridional velocity U from the determined two unknowns and compute iso-meridional velocity flow in the convective envelope. *Preliminary results show that meridional velocity extends deep below base of the convective envelope*.
With such a deep flow below the convective envelope, it is very unlikely that the return flow will reach the surface (with period of solar cycle) as required by some of the turbulent mean field dynamo models. On the other hand, deep meridional flow is required for burning of the lithium supporting observed lithium deficiency over the surface.

Presentation: Poster

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Poster Number: PH.43

Cross-spectral analysis of global solar oscillations

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Couplings of solar oscillation modes manifest in time-dependent relationships between them. Linear relationships among solar oscillations can be investigated using the cross-spectral analysis. Here we present cross-spectra of solar oscillations, estimated between modes of different harmonic degrees and azimuthal orders observed with the MDI/SOHO instrument. We used simulated data in order to investigate the influence of spatial leakage to the cross-spectra estimation. The results show, that spatial leakage influence the cross spectra significantly, depending on the investigated degree l and order m.

Presentation: Poster

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Poster Number: PH.44

A remarkable dataset for local helioseismology: active region AR9787

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AR9787, observed continuously by SOHO-MDI over 9 days in January 2002, consists of a large, isolated and nearly-circular sunspot. Because of its simple geometry and slow temporal evolution, this sunspot is ideal for local helioseismic studies and would appear to be particularly amenable to theoretical modeling. We discuss the observations in some detail and show some preliminary helioseismic analyses.

Presentation: Poster

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