topology of the field. Often the oscillations occur in conjunction with gradual adjustments in loop positions in response to the triggering event. We discuss the observations in the context of two models, and evaluate the contraints on coronal properties that can be deduced from them.

URL: http://vestige.lmsal.com/TRACE/POD/TRACEoscillations.html

SH11A-0704 0830h POSTER

New Observations of Oscillating Coronal Loops

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One of the most promising discoveries of the TRACE mission is the first observations of transverse oscillations in coronal loops (Aschwanden et al 1999, Nakariakov et al 1999). Loops are set into motion from nearby flares, oscillate with a well defined frequency and decay on a time scale of 10 minutes. While the theoretical study of MHD waves in the corona has a long history, observational support has dramatically increased over the past 10 years as coronal instruments have improved. The transverse oscillations have been identified as standing kink modes for the 14-July-1998 observations cited above. In this paper we present clear evidence for a decaying global kink modes observed by TRACE on 15-Apr-2001.

Six different loops have been observed to oscillate with a frequency in the range: 15-20 mHz (compared with 4 mHz for 14-July-1998) and a decay time in the range: 8-23 minutes (compared with 11 minutes for the earlier event). The implications for these results for coronal diagnostics and solar coronal seismology will be discussed.

SH11A-0705 0830h POSTER

Impulsive Events and Coronal Loop Cooling Observed with TRACE

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Nearly every active region imaged by TRACE contains sporadic brightenings in coronal loops. Many of these ubiquitous, short-lived events appear nearly simultaneously in the FeIX/X ($\log T_e \approx 6.0$) and the CIV channel ($\log T \approx 5.0$); hence, we interpret them as the rapid cooling of a multifilament loops. A particularly good example of such an event was observed on 21, June 2001, as part of an hour long active region observation; a total of 52 of the TRACE 171 Å and 68 TRACE 1600 Å images have been analyzed from that sequence, as well as 35 images provided by the MDI aboard SOHO. In this poster, we will discuss the analysis of the events and the implications of our cooling model.

SH11A-0706 0830h POSTER

Why coronal flux tubes have axially invariant cross-section

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We present here a model that not only explains the long-standing mystery of why solar coronal flux tubes tend towards having axially in-variant cross-sections but also explains several other enigmatic features, namely: rotating jets emanating from the ends (surges), counter-streaming beams, ingestion of photospheric material, and elevated pressure/temperature compared to adjacent plasma. The model shows that when a steady current flows along a flux tube with a bulging middle (i.e., a flux tube that is initially produced by a potential magnetic field), non-conservative forces develop which accelerate fluid axially from both ends towards the middle. Remarkably, this axial pumping of fluid into the flux tube causes the flux tube crosssection and volume to decrease in a manner such that the flux tube develops an axial uniform cross-section as observed in coronal loops. The pumping process produces counter-rotating, counter-streaming Alfvenic bulk motion consistent with observations. Collision of the counter-streaming beams causes non-localized bulk heating. This picture also has relevance to astrophysical jets and coaxial spheromak guns and explains why these systems tend to form an axial jet along the geometric axis. Supported by USDOE.

[1]J. A. Klimchuk, Solar Phys. 193, 53 (2000)

SH11B MC: Hall D Monday 0830h

Helioseismology and Related Studies

Presiding: **A C Birch,** W.W. Hansen Experimental Laboratory

SH11B-0707 0830h POSTER

Time-Distance Studies of Large Scale Flows on the Sun

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Time distance helioseismology is a valuable tool for examining flows in the convection zone. It can produce vector maps of flows from the travel time of waves traversing subsurface ray paths. This technique has been proven useful for studying solar phenomena ranging in size from supergranules to global flows. (1999) Giles et al has demonstrated the efficacy of using the time-distance technique on meridional and zonal flows. We extend this work and show resulting measurements.

SH11B-0708 0830h POSTER

Time-distance Helioseismology Study Over a Rotating Sunspot

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Time-distance helioseismology has provided a unique tool in studying interior structures of the Sun. The structure of sound speed variations and flow fields beneath the sunspot surface have been obtained by use of inversion technique in some previous studies. In this study we have applied the time-distance measurements from SOHO/MDI and the inversion technique to investigate a sunspot which showed unusually fast rotation around its center for a couple of days from Aug 7 to Aug 8, 2000. The sound speed structure which is related to the magnetic field structures beneath the surface and associated temperature variations was obtained. The results revealed some twists in the sound-speed internal structure of the spot relative to the surface magnetic structure. This kind of subsurface twist was not seen 2 days after the start of rotation. This is consistent with the surface observation showing a reduction of transverse magnetic field twists after the surface rotation stopped. It could be explained as the magnetic field lines were twisted beneath the surface and the untwisting of field lines caused the surface rotation.

Flow fields beneath the sunspot surface were also obtained. A strong vortex was found near the surface and a few megameters below the surface. Whether the subsurface vortical flows caused the magnetic field twists or the untwisting of field lines caused the subsurface vortical flows will be discussed.

SH11B-0709 0830h POSTER

Accuracy of Born and Ray Approximations in Time-Distance Helioseismology

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Time-distance helioseismology attempts to infer localized departures from a nominal state of the solar interior from comparison of observed travel times of acoustic wave packets to those anticipated from the model. Until recently, such time-distance measurements have generally been modeled in the ray approximation, which neglects finite-wavelength effects. Concern that these effects can be important has prompted interest in the Born approximation, which is sensitive to them. In order to elucidate the ranges of validity of the ray and Born approximations and the nature of their limitations, we compare travel-time pertrubations calculated using these approximations to exact travel times for a simple problem, namely the propagation of adiabatic acoustic waves through the center of a spherically symmetric sound-speed perturbation to an otherwise uniform medium.

We show that the Born and first-order ray approximations converge to the same result as the spatial scale of the medium perturbation becomes large compared to the first Fresnel zone, with a fractional error in the travel-time perturbation equal to the fractional strength of the perturbation, while a full ray calculation converges to the exact solution in this limit. For a uniform perturbation having a size the order of the first Fresnel zone, interference between direct and diffracted wave produces travel-time fluctuations that are entirely absent in the ray approximation; these fluctuations are only qualitatively replicated by the Born approximation for moderately weak (e.g., 5%) perturbation strengths. Such fluctuations are, however, largely suppressed for a smoothly-varying perturbation expected to be more representative of solar structures. The so-called banana-doughnut (here, ventilated cigar) form of the Born sensitivity kernels, i.e., a greatly reduced sensitivity of the travel-time perturbation to small-scale medium perturbations that fall near the unperturbed ray path that is absent in the ray approximation, is also shown to be consistent with the exact results.

SH11B-0710 0830h POSTER

Probing Deep Structure of the Sun by Time-Distance Helioseismology

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Time-distance helioseismology is a method for inferring sound-speed perturbations and flow velocities by measuring the travel times for acoustic wave packets as they move between points on the solar surface through the solar interior. It has been successfully applied to infer structures and flows in the upper convection zone. However, probing the deep convection zone and, in particular, the tachocline region at the bottom of the convection zone where the solar dynamo is believed to be operating is quite challenging. Using the solar oscillation data from SOHO/MDI we have attempted to detect deep structures in a low-latitude band of the convection zone. For inversion of the travel-time measurements we used the theoretical sensitivity, in the first Born approximation, of travel times to sound speed inhomogeneities in the solar convection zone. We have obtained synoptic sound-speed maps for two solar rotations in 2000. The results show resolved structures

in the lower convection zone. We compare the sound-speed maps with surface magnetic field synoptic maps and discuss possible relations between the deep structures and the surface field.

URL: http://soi.stanford.edu

SH11B-0711 0830h POSTER

The Linearized Forward Problem for Time-Distance Helioseismology

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The forward problem of time-distance helioseismology is to compute travel-time perturbations which result from perturbations to a solar model. We present a physically motivated general framework for calculations of the sensitivity of travel-times to small local perturbations. The first Born approximation is used to model scattering from local inhomogeneities. We take account of wave excitation by distributed random sources. Travel-time sensitivity kernels depend explicitly on the details of the measurement procedure.

The method is illustrated on an example. We consider the propagation of acoustic waves in an infinite homogeneous medium. Waves are excited by random pressure sources distributed on a thin horizontal sheet. We obtain 3D travel-time sensitivity kernels for local perturbations in sound-speed, damping rate and source strength.

SH11B-0712 0830h POSTER

Are in situ tests of elemental segregation / solar evolution models of the Sun feasible?

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Sophisticated helioseismological models that reproduce the speed of sound in the solar interior to a remarkable degree of accuracy include chemical abundance gradients in the solar interior. These gradients are established in the course of solar evolution by the gradual settling or segregation of elements due to their differing atomic and nuclear properties and masses. Based on current helioseismological evidence, one expects that the heavy elements have been depleted relative to hydrogen on the order of 10% in the course of solar evolution.

We investigate whether this effect can be measured quantitatively with new solar wind and solar nergetic particle elemental and isotopic abundance measurements. SOHO, ACE, and Genesis offer unprecedented precision in such in situ measurements. We compare the most recent SOHO and ACE measurements with meteoritic data and discuss expectations for Genesis.

Our results indicate that for elemental abundance ratios, Ca/Fe is the most promising candidate to investigate, while the isotopic ratio ^{3}He/^{4}He is more promising from the helioseismological point of view. We compare our results with the most recent solar wind and solar energetic particle results and discuss possible difficulties in relating observations to evolutionary segregation effect.

SH11B-0713 0830h POSTER

OBSERVATIONAL ASSOCIATIONS BETWEEN THE SOLAR CORONA AND SOLAR INTERIOR

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Generated in the solar interior, magnetic fields make their way through the solar atmosphere, shaping solar wind flow and determining solar activity. Although essential for understanding and identifying the physical processes by which this occurs, there has been a lack of observational associations between the corona and interior of the Sun. A direct association was recently demonstrated when the latitudinal profile of the correlation of coronal density separated in latitude by 20 degrees was found to be similar to that of the alternating slow and fast zonal bands observed in the outer part of the solar convection zone (Woo et al., ApJ., 538, L171, 2000). The latter are also evident on the surface of the Sun where they are known as torsional oscillations.

In this paper, we summarize further results from investigating and characterizing the morphology of coronal density and its relationship to surface and subsurface solar flow using measurements by the High Altitude Observatory Mauna Loa Mk III K-coronameter.

SH11B-0714 0830h POSTER

Time Series Analysis of Interplanetary Magnetic Field Data

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We report initial results from a careful time series analysis of interplanetary magnetic field (IMF) data that were acquired by the magnetometer instrument on the ACE spacecraft during the interval January 1, 1998, through March 2001. We use 4-min average data in the RTN coordinate system and calculate the power spectra of various data time intervals using a fast Fourier transform algorithm. Typically ten orthogonal prolate spheroidal wavefunction tapers are used, with a time-bandwidth product of 5.5. The Rayleigh resolution varies from $\sim$0.024 to $\sim$0.15 microHz, depending upon the length of the data set. Of particular interest is the frequency band from 0 to 10 microHz, especially around $\sim$5 microHz ($\sim$2.2 days) where we have previously reported evidence for a power enhancement in energetic particle data measured on the Ulysses spacecraft. The ACE IMF data show evidence for enhanced power near 5 microHz period in the total field component for the years 1998 and 1999. This is additional evidence of a deterministic component of the fluctuations in the IMF. In the year 2000, the background IMF power level was considerably higher and therefore masked the signal at this frequency. We also report on other prominent spectral features in this frequency range, as well as the overall spectral shape in the entire band 1 to 1000 microHz.

SH11B-0715 0830h POSTER

Solar Radius Observations by the Michelson Doppler Imager

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The Michelson Doppler Imager (MDI) instrument on the SOHO spacecraft is approaching the completion of six years of observing the Sun. During this period, full disk continuum images with 4 arc-second resolution have been taken at a cadence of at least four images per day. Because of the absence of atmospheric blurring and the stable environment of the L1 halo orbit, these images provide a long term measurement of the solar limb. The determination of changes in the solar radius from these images is affected by both an annual thermal variation in the MDI front entrance window and by a slow shift in the instrument focus due to aging of the entrance bandpass filter. These effects are being modeled in order to determine an estimate of the solar cycle variation in the solar radius. This research is supported by NASA grant NAG5-10483 at Stanford University.

SH11C MC: Hall D Monday 0830h

Solar Magnetic Fields and Irradiance

Presiding: **R Lionello,** SAIC

SH11C-0716 0830h POSTER

Polarized Intensity Measurements of the Corona during the 21 June 2001 Total Solar Eclipse

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We report on the first successful simultaneous polarimetric measurements of the brightness of the Thompson-scattered white light and intensity of the near-infrared Fe XIII 10747 Å line, the strongest of the coronal iron forbidden lines. These observations which extended out to 3 R_s in the corona were obtained during the total solar eclipse of 21 June 2001. The novel technique used to acquire these measurements will be presented. Polarized intensity measurements of the resonantly scattered component of coronal emission lines are the only tools to date that can yield the direction of the coronal magnetic field. Through these simultaneous measurements, we show how the direction of the coronal magnetic field can be placed in the context of coronal density structures. We also discuss the implications of these simultaneous measurements for the source of the solar wind.

SH11C-0717 0830h POSTER

Three-dimensional theory of magnetostatic structures in the solar corona

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Concepts borrowed from magnetospheric physics can be used to develop a three-dimensional theory of magnetostatic structures in the solar corona that simultaneously accounts for the effects of pressure, gravity, and force-free currents. Static here means that time scales are long compared to Alfven and particle transit times along magnetic field lines. As a general matter, it is always possible in principle in quasineutral quasistatic plasma to write a Poisson equation for a magnetic scalar potential, with source term given by the divergence of an effective magnetization; the trick is to determine the magnetization. In the physics of the inner magnetosphere, where slow-flow quasistatic isotropic plasma that neglects gravity and the ion flow