tained from full-disk measurements by BISON (Elsworth et al. (1991, MN, 251, 7p); from Teide Observatory (Anguera Goban et al., 1990, AA, 255, 363); and from the IPHIL space experiment (Toutain and Föhlich, 1992, AA, 257, 287).

The inversion results show that the overall structure of the solar interior is consistent with a standard solar model constructed by Christensen-Dalsgaard et al. (1993, ApJL, 403, L75) using increased opacities beneath the convection zone in accordance with Iglesias and Rogers (1991, ApJL, 371, L73). Though the new Livermore opacities reduce the differences between the inversed structure and the standard model, significant systematic deviations from the model still remain. They can be explained by large-scale material redistribution in the radiative zone and by further opacity corrections. The low value of the helium abundance in the convection zone (Y ≈ 0.23) inferred by Kosovichev et al. (1992, MN, 259, 538) from the BBSO data gives an indication of gravitational settling of helium. However, the models by Christensen-Dalsgaard et al. with helium diffusion cannot explain all the differences. Current evidence for moderate localized mixing in the energy-generating core and for convective overshoot at the base of the convection zone are discussed.

21.04
Prospects in Helioseismic Holography
C. Lindsey (SPRC), D. C. Braun (IPA) and S. M. Jefferies (Bartol)

The discovery by Braun, Duvall and LaBonte that surface magnetic regions strongly absorb p-modes has motivated serious consideration of the possibility of local helioseismic diagnostics. If local subsurface features, magnetic flux tubes for instance, interact appropriately with acoustic waves in the solar interior, as they do at the surface, then surface oscillations should contain considerable information on these features. Acoustic power maps made from the NSO-Bartol-NASA South Pole Observations of 1987, 1988 and 1990 strongly suggest that this is a real possibility. In this case there exists a range of techniques that could give us a window into local solar subsurface structure. The basic analog of optical diagnostics in helioseismology is accomplished by computational holography. We will present a perspective on this concept and describe our program to develop it.

21.05
Time-Distance Helioseismology
T. L. Duvall Jr. (NASA/GSFC), S. M. Jefferies (Bartol), J. W. Harvey (BSO), and M. A. Pomerantz (Bartol)

The application of seismology to the study of the solar interior has advanced almost solely by the prediction and measurement of the Sun's frequencies of free oscillation. Direct measurement of the travel times and distances of individual acoustic waves—the predominant approach in terrestrial seismology—would appear to be more difficult in view of the number and stochastic nature of solar seismic sources. Here we show that it is possible to extract time-distance information from temporal cross-correlations of the intensity fluctuations on the solar surface. This approach opens the way for seismic studies of local solar phenomena, such as subsurface inhomogeneities near sunspots, and should help to refine global models of the internal velocity stratification in the Sun. We also show that acoustic waves with frequencies greater than the acoustic cutoff frequency are not significantly reflected by the solar atmosphere, with their reflection coefficient being <2%.

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Chair: Richard Bogart
Kresge Auditorium

22.01
The Covariance of Latitudinal and Longitudinal Motions of Small Magnetic Features
R.W. Komm, R.F. Howard, and J.W. Harvey (NSO/NOAO)

In the present work, we study large-scale motions using high-resolution magnetograms taken during 1988 with the NSO Vacuum Telescope on Kitt Peak. Motions are determined by a two-dimensional cross-correlation analysis of 107 pairs of consecutive daily observations from which active regions are excluded, i.e., we analyze the motions of small magnetic features. We analyze the covariance of longitudinal and latitudinal velocities after subtracting large-scale averages of differential rotation and meridional flow. The covariance is generally interpreted as Reynolds stress and linked to the transport of angular momentum. We find that the results depend strongly on the temporal averaging involved and show no simple latitude dependence. Using monthly averages, we find a covariance of ≈37 ± 15 m² s⁻² at 45°, which has the right sign for an equatorial transport of angular momentum, but an insignificant value of 16 ± 46 m² s⁻² at 22.5°, which is typical for the activity latitudes and reflects the increase of noise due to masking. However, these values are more than an order of magnitude smaller than covariances derived from individual sunspots, published by other authors, which implies that small magnetic features are decoupled from the deeper layers of the convection zone, where sunspots are assumed to be 'anchored', or that the coupling decreases with height due to the interaction with convective motions. Without any averaging, we find no apparent correlation between the residual velocities, which indicates that the motion of small magnetic features on this time scale is dominated by the more or less random motion of supergranules.

22.02
The Formation and Break-up of a Simple Delta-type Sunspot
V. Gaižauskas (NRCC/HIA), K.L. Harvey (SPRC), and M. Proulx (NRCC/HIA)

We have studied the disk passage of a nest of sunspots in which three ordinary bipolar pairs of sunspots are aligned collinearly. The usual spreading action of the growing regions brings two spots of leading polarity together (p-p collision) and forces the leading and trailing spots of the two interior regions to overlap into a single penumbra (p-f collision), thus forming a δ-spot in the simplest way possible. As the spots from different bipole push closer together, they neither annihilate immediately (p-f collision) nor merge (p-p collision). Five days after the δ-spot forms, its f-polarity component splits and flies apart. Not until then do any strong flares erupt in the δ-spot.

Using digitally-processed images from the Ottawa River Solar Observatory we have analyzed evolutionary trends in shape, area, relative motions, and brightness of each spot in the elongated nest. We find that changes related to the rupturing of the δ-spot are more compatible with the model of a sunspot as a cluster of flux tubes rather than a monolithic plug of magnetic flux.

We invoke the release of an instability, triggered by a sequence of processes lasting one day or more, to explain the disruption of the f-umbra in the δ-spot. The sequence is initiated when the colliding p-umbrae reach a critical separation around 3200 ± 200 km: their reconnected magnetic fields then