constrained turbulent convection, which we can do with current supercomputers by considering a local area model. Hence we study turbulent, compressible convection in a slab of perfect gas positioned at mid-latitudes on the sphere. Cases with large Rayleigh number \( (Ra < 5 \times 10^6) \), fast rotation \( (Ta < 10^6) \) and low Prandtl number \( (\sigma < 0.1) \) have been studied with high resolution \( (\leq 192^2 \times 96) \). As in a non-rotating case, a laminar network of downflows resembling solar granulation forms in the upper thermal boundary layer, which disguises a turbulent interior punctuated by vertically-coherent structures. With rotation the upper network is more mobile and curvaceous; all downflow lanes shift and distort in time, moving, twisting and tilting the coherent downflow sites. Such motions act through the Reynolds stresses and the Coriolis forces to establish mean shearing flows in the zonal and meridional directions. Despite the moderate 0(1) Rossby numbers of our simulations, such flows are significant, containing on the order of 5% of the total kinetic energy. The mean motions are time dependent, oscillating with the inertial frequency, and the associated fluxes indicate a general upward flux of zonal momentum and downward flux of meridional momentum. While the rotation stabilizes the convection somewhat, the enhanced vorticity coupling it affords also helps to isotropize the turbulence in the interior. This research is supported in part by Lockheed Independent Research Funds.

10.02
The Modifications of Solar Acoustic Oscillations Due to the Presence of a Magnetic Field
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The interaction between solar acoustic waves and a magnetic field is a powerful probe of the magnetic topology. At present, however, this interaction is poorly understood. In order to develop this understanding and determine the signature of a magnetic field on solar p-mode observations, I have solved the linear eigenmode problem for a simple model atmosphere, using the ideal magnetohydrodynamic equations. The atmosphere consists of two adjacent regions. The lower region is a neutrally stratified polytropic atmosphere and the upper is an isothermal atmosphere. A constant vertical field laces both parts of the atmosphere. The resulting eigenmodes are not completely confined by the acoustic cavity and the mode eigenfrequencies are therefore complex. I present eigenfrequencies as well as the frequency shifts and damping rates due to the presence of the magnetic field.

10.03
Status of the Global Oscillation Network Group (GONG) Project
J. W. Leibacher and the GONG Project Team (NSO/NOAO)

The Global Oscillation Network Group (GONG) Project is a community-based activity to develop and operate a six-site helioseismic observing network for at least three years, to do the basic data reduction and provide the data and software tools to the community, and to coordinate analysis of the rich data set that will result. A site survey has been carried out for seven years, and the sites have been selected: Big Bear Solar Observatory (Cal Tech), Mauna Loa Solar Observatory (HAO/NOAO), Learmonth Solar Observatory (Ionospheric Prediction Service), Udaipur Solar Observatory (Physical Research Lab.), Observatorio del Teide (Instituto d' Astrophysica Canarias), and the Cerro Tololo Inter-American Observatory (NOAO). A duty cycle greater than 93% is anticipated with, more significantly, a 10% reduction in the daily sidelobes. The prototype instrument, a Fourier Tachometer, displays robustness, good repeatability and sensitivity. Its Sun-as-a-star velocity signal is excellent, and magnetograms will be routinely available. The prototype will operate throughout the life of the Project, to provide a testbed for engineering problem solving and to provide a part-time, additional site. Data from the prototype is currently available for scientific analysis.

Components and systems for the six field sites are in production, and their integration has begun. The current production schedule aims for deployment of the first instrument in the middle of 1994, and for the first network observations by the end of 1994. Data reduction, analysis, and distribution are major challenges for GONG. The components of the pipeline processing are in place, and processing during full network operations at cadence appears attainable. The prototype Data Storage and Distribution System is operational and undergoing test by users, and the third release of GONG's distributed software for analyzing helioseismic data (the GONG Reduction and Analysis Software Package) will allow early access to the data and the collaborative scientific analysis that the Teams have already initiated.

10.04
Ring Diagram Analysis of Mt. Wilson Data: Current Status
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A ring diagram analysis is being applied to data obtained with the Magneto-Optical Filter at the Mt. Wilson 60-Foot Tower. The data comprise a time series of 1024X1024 pixel Dopplergrams covering the time period of 3-5 July, 1988.

The ring diagram method constructs a three-dimensional power spectrum in a localized region on the solar disk. A slice of this spectrum at constant frequency in the 3-4mHz band shows a set of rings which are the signature of the oscillations corresponding to the more familiar ridges in a two-dimensional spectrum. The positions of the rings are related to the two horizontal components of the flow field beneath the solar surface. The depth variation of the flow components can be inferred via inverse methods, and a three-dimensional map of the flows can be constructed from ring diagrams obtained at several heliographic positions.

An improved method of fitting the rings has recently been developed. Previously, the centroid of power in the rings had been fitted with an ellipse, and the velocities computed from the ellipse parameters. Currently, the entire distribution of power within a ring is fitted with a Lorentzian profile as a function of both frequency and wavenumber. This model explicitly contains the velocity components. The new method is more stable, and provides more reasonable velocity estimates than the previous technique.

The method is being applied to a set of 25 subarrays in the data. Preliminary results show an oscillation in the velocity components as a function of frequency, suggesting the presence of a thin shear layer or jet stream below the solar surface. The horizontal components as a function of depth for some of the subarrays will be displayed.

10.05
Application of Conjugate Gradient Methods to 2D Helioseismic Inverse Problems
P. N. Milford (Stanford University)

Iterative Matrix methods present an efficient technique for solving helioseismic 2D solar rotation least squares inverse problems. In this paper we outline techniques for solving the solar 2D rotation inverse problem with datasets with the order of 1 million modes and order of 10,000 mesh points.

Solving least squares inverse problems directly includes the construction of a matrix \( X = G^T \times G \), and computing \( X^{-1} \). For \( G \) of size \( Nm x Nm \), this method requires \( O(Nm^2 x Nm^2) \) operations, and up to \( O(Nm x Nm) \) storage. For large datasets, this can be impractical.

An alternative technique is to use iterative matrix solution methods, such as the Conjugate Gradient method, which iteratively finds \( m \), such that \( \| Gm - d \|^2 \) (possibly with further constraints) is minimized. Each iteration requires \( O(Nm x Nm) \) operations, and accesses the matrix \( G \) only at a row at a time, in the form of matrix vector or transposed matrix vector products.

The Conjugate Gradient method converges for this type of least squares problem and in practice only requires a small fraction of \( Nm \) iterations. In addition, recomputing part of the matrix \( G \) on each access, the on-line memory can be reduced to \( O(Nm) \).