Excitation and damping of Solar p-modes

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The dominant interaction between acoustic radiation and free turbulence are quadrupole in nature. In equilibrium, the acoustic energy per mode is equal to the kinetic energy in an eddy with turn over time equal to the period of the mode. For forced turbulence the emission of acoustic radiation proceeds by the dipole process which is more efficient than the quadrupole process by a factor of the square of the Inversc Mach number. Furthermore, when the exciting force is independent of the state of the motion of the fluid the absorption has the same strength as for free turbulence. Therefore, the equilibrium modal energy in this case is comparable to thermal energy of a resonant eddy. The turbulent convection in the sun is an example of this type of forced turbulence; the excitation is caused by the fluctuating buoyancy force. This mechanism implies that the energy of each acoustic mode in the 5-minute band should be comparable to the thermal energy in a typical photospheric granule. The predicted modal energy is in good agreement with the values determined from observation. Additional predictions of this model of stochastic excitation are that the power and line width of the modes of a given frequency should increase with decreasing energy, and that the instantaneous energy in a mode should have a Boltzmann distribution. These results provide a basis for distinguishing between the stochastic and self excitation mechanisms proposed for the p-modes observed in the sun.

Local Response of the Five-Minute Oscillations to a Major Solar Flare


Solar five-minute oscillations of intermediate degree \ell were observed both before and after a major white-light flare. Doppler velocities across the solar disk have been analyzed with 60 s temporal resolution for 50 minutes both before and after the flare of 24 April 1984. The observations were made with the UBF instrument on the vacuum telescope at NSO/Sac Peak. This tunable filter provided simultaneous intensity images of the full Sun on two sides of the Fe I \lambda 5576 spectral line. These were recorded on film and digitized with 2.5'' spatial resolution. The images were converted into Doppler velocities and projected onto a spherical polar grid centered on the flare. This data is analyzed for acoustic waves travelling radially away from the flaring region, seeking evidence for the local excitation of waves by the flare. The Doppler signal, averaged over all the centered on the flare, is studied for the presence of pulse trains as a function of time and then Fourier analyzed. The results are compared with theory. The same analysis is repeated for sites well removed from the flare to assess the significance of the results.

Polar Genesis and Propagation of the Torsional Shear Oscillation

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Recent analysis of Mount Wilson data provides evidence that the torsional oscillation pattern is not an \textit{in situ} side effect of the toroidal magnetic field evolution pattern. The shear oscillation pattern---i.e., the latitudinal derivative of the torsional pattern---shows a wavelike coherence that originates at the poles and propagates toward the equator. The oscillation at the poles is remarkably correlated with the oscillation of the polar magnetic field. The pattern's total transit time from pole to equator, at a roughly constant speed of 2 m/s, is 18 years. It is proposed that these 18 years are the proper duration of the solar cycle.

Helioseismology Results from South Pole Observations

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Solar images were recorded every 90s for a period of 50h with one 4h interruption using a telescope located at the geographic South Pole. The images were filtered to a 6A bandpass centered on the Ca II K line and sampled with 10 arc s pixels. The time series was reduced to a spectrum of solar oscillations in frequency, \upsilon, spherical harmonic degree, \ell, and azimuthal order, \m. Modal oscillations are detected from \upsilon<0.9-6.2 mHz and \ell<8-290. As result of the nearly uninterrupted time series, the spectral sidelobes are unusually small. This fact allows spectral features to be measured with little or no ambiguity. Lorentz functions were fit to spectral features in m-averaged, \upsilon- spectra. A set of frequencies in the \ell range 20-98 was processed to show a jump in the depth gradient of sound speed at the bottom of the convection zone. The fitting also indicates significantly shorter lifetimes for oscillations with higher degrees and frequencies. Frequency shifts due to internal rotation were measured with the result that rotation through the convection zone appears to vary little with depth and shares the same variation with latitude as observed at the surface. There is also evidence for a structural difference between equatorial and polar radii. This work was supported in part by NSF grant DPP 79-22267.

Torsional Oscillation Update and a Search for Longitudinal Structure

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Analysis of Dopplergram data collected with the magnetograph at the Mount Wilson 150 ft. tower telescope reveals the emergence of the mid-latitude traveling wave, characteristic of the net torsional oscillation pattern. The net torsional oscillation pattern for cycle 22 was heralded by polar spin-up "bursts" in late 1979 and late 1981. For reasons still unknown, the traveling wave, like its counterpart in cycle 21, arrived in the northern hemisphere approximately one year earlier than in the southern hemisphere. However, the preceding polar spin-up "bursts" arrived at approximately the same times in both hemispheres. We examine the possibility that the structure of the torsional oscillation pattern might be partially explained by occurrences of fixed localized regions of increased surface rotation "contaminating" averaged slope velocity data. Autocorrelations of slope velocity data, however, fail to reveal such a longitudinal structure.