Test for Constancy of the Solar Neutrino Flux as Measured by the Homestake Neutrino Experiment

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We evaluate a chi-square statistic to test against the Homestake data the hypothesis that the neutrino flux from the Sun is constant. We use estimates of standard deviations derived from 1,000 simulations of the sequence of 108 runs, and we also use two procedures for deriving standard deviation estimates from the experimental data. All tests indicate that the hypothesis should be rejected, the significance level ranging from 5.8% to 0.1%.

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Search for Periodicities in the Homestake Solar Neutrino Data

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We search for evidence of periodicities in the neutrino flux by evaluating the log-likelihood of finding the actual count rates in a model in which the neutrino flux is modulated with a sinusoidal term. We consider a range of values of the frequency (0–20 cycles per year) and, for each frequency, adjust the modulation parameters to maximize the likelihood. We find no evidence for modulations related to the solar cycle, but we do find some evidence for modulation related to the quasi-biennial (2.2 year) periodicity and to the Riegler (157 day) periodicity. We have also looked for evidence of modulation at a frequency that might be related to the solar rotation frequency, adopting a search band of 12.4 to 13.1 cpy that corresponds to the one-year lower sideband (synodic frequency) of the rotation frequency of the Sun’s radiative zone, as estimated from recent MDI helioseismology data. There is indeed a peak in that band, at 12.88 cpy, that according to the simulation test is significant at the 3% level. We also find evidence of four sidebands near 10.88, 11.88, 13.88 and 14.88 cpy, and we estimate the significance level of this combination of periodicities. A synodic rotation rate of 12.86 cpy corresponds to a sidereal rotation rate of 13.88 cpy or 440 nHz. This work was supported in part by Air Force grant F49620-95-1-008 and NASA grants NAS 8-37334 and NAGW-2265.

Evolution of the Granular Shear Flow

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A series of spectrograms of excellent spatial resolution including absorption lines of different strengths is used to study the dynamics of granular shear flow and its height dependence over two granular turn-over times.

The spectrograms were taken at the center of the solar disk with the German Vacuum Tower Telescope (VTT) in Izaña (Tenerife, Spain) in 1994.

Apart from the convective flow we are able to trace the unresolved “turbulent” velocity field associated with the shear flow at the granular border and to follow its evolution with height in the first 200 km above the continuum.

Our analysis of the granular shear flow includes, (i) an investigation of two characteristic granule types, a regular and an exploding one, and (ii) a statistical approach using a coherence and regression analysis. The data were processed with wavelet techniques.

We find:

- The unresolved (turbulent) velocity field has its origin at the border of the granules and advects into the intergranular space.
- The concentration of the turbulence near the granular border is stronger in the deeper photospheric layers.
- The distribution of the turbulence in the intergranular space is stronger in the higher photospheric layers.
- The small-scale velocity field within a pressure scale height above the continuum is uncorrelated with the field at higher layers.

Preliminary Results Towards a Synoptic Velocity Map of the Solar Subsurface

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The study of large scale velocity flows near the solar surface may be very useful to clarify many aspects of solar convection and dynamo theories. In this sense, the “Ring Diagram Analysis,” a technique applied to tridimensional power spectra of the solar oscillations, has shown to be a good method to get information about horizontal velocity flows in the upper layers of the convection zone.

This work presents the results obtained using this analysis with several regions of about 15 heliographic degrees over the solar surface, as a first step towards a synoptic velocity map of the solar surface with depth dependence.

The data used are solar images taken with MDI (Michelson Doppler Imager) on board of SOHO (Solar Oscillation Investigation) during its Dynamics Program. These images are full-disc Dopplergrams with a resolution of 2 arcsec. The regions are located at different positions over the solar surface and have been tracked over a time span of 1536 minutes.

On the direction of the rotation axis of the Sun

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It is well known that the axis of rotation of the solar surface is inclined by 7.25° to the ecliptic normal. However we cannot exclude that the direction of the rotation axis could vary inside the Sun. Indeed, according to Bai and Sturrock, the study of the latitudinal and temporal distributions of solar flares may support the possibility that the Sun’s core is rotating about an axis which is strongly tilted with respect to the axis of rotation of the envelope. If such an oblique core is large enough, it could have a signature in low-degree p-mode oscillation spectra. Our approach is simply to test whether the hypothesis of rotation about a unique axis is consistent with the LOI/SOHO data. In other words, are the pulsation axes identical to the axis of rotation of the surface? Because we are searching for a tiny effect over a relatively short observation period, our constraints remain weak.

Asymptotic Latitudinal Inversion of Frequency Splitting Data

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In an asymptotic approximation, frequency splitting data is represented as function of coordinates of mode turning point. This asymptotic representation allows efficient averaging of the splitting data. Abel integral inversion is then employed to infer approximate latitudinal dependence of differential rotation. Preliminary results of the method applied to GONG data are shown.

Persistent Convective Structures on the Sun

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A persistent convective structure, which we term duragrulation, has been observed on the solar surface. The geometry of the flow is reminiscent of supergranulation, with size scales about twice as large and lifetimes about ten times longer than that of supergranulation. This velocity structure was detected using Dopplergrams from the Michelson Doppler Imager (MDI)