ON THE ENERGY DISTRIBUTION IN WAVENUMBER SPECTRA OF THE GRANULAR VELOCITY FIELD*

(Research Note)

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Wavenumber spectra of spatial velocity fluctuations measured in selected high resolution solar photospheric spectrograms are presented. The statistical stability of the power estimates of particular 'peaks' in these spectra is discussed.

Recent attempts to derive extended wavenumber spectra of granular velocities from selected high resolution spectra agree in finding, that there is still considerable convective energy in elements smaller than 1". The qualitative appearance, however, and the amount of detail visible in these wavenumber spectra change drastically with the author, due to different transform and smoothing techniques. Mattig and Nesis (1974) have compared recently the relevant work on high resolution spectra of the granulation with their own data. They come to the conclusion that certain details or 'peaks' are persistently visible in all of the wavenumber spectra reviewed, and the positions of the four most prominent peaks are given.

Unfortunately, not all authors give confidence limits for their computed spectra. In these cases a realistic judgment of the significance of certain spectral features is left to the readers' intuition or, we should better say, is impossible. We should also consider in this connection – as a salutary example – the multiple peaks or 'eigen-modes' in the frequency spectra of the 300 s oscillations, which only recently have disappeared from the solar scene (Cha and White, 1973; Deubner, 1972) as a result of combined observational and numerical efforts.

In order to gain more quantitative insight into the stability of such spectral features, we made use of a series of spectrograms obtained in September 1971 at the vacuum tower of Sacramento Peak Observatory under excellent seeing (<1") conditions. Two series consisting of 320 individual spectra extending 202" on the quiet solar disk were photographed at regular intervals of 6 s (3 s exposure time) at two positions: \( \mu = 1 \) and \( \mu = 0.8 \). The displacements of the C I line at 5380 Å (\( X_e = 7.68 \) eV) were recorded with a lambdameter as described in more detail by Deubner (1974). From this material, for each position only the best 10\%, i.e. 32 spectra were selected which had the largest integrated power in the wavenumber band corresponding to wavelengths from 1" to 3". The average unreduced rms velocities derived from the complete series is 600 (610) m s\(^{-1}\), the contribution in the range: \( 11 \times 10^{-4} \) km\(^{-1}\) < \( k_x < 90 \times 10^{-4} \) km\(^{-1}\) ('granular' rms velocity) being 430 (490) m s\(^{-1}\). The average granular rms velocity of

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the selected group of spectra is 540 (580) m s\(^{-1}\) (the values for \(\mu=0.8\) are given in brackets). These numbers clearly demonstrate the high quality of the material under investigation.

The data of the selected spectra were now divided into 6 subsets of equal length corresponding to adjacent 32° sections along the spectrograph slit. By means of standard FFT techniques, average raw one dimensional wavenumber spectra were computed for each of these subsets and smoothed by Hamming. The overall mean spectrum was also computed. The Fourier spectra are plotted on a logarithmic scale in Figure 1 for \(\mu=1\), and 80% confidence limits are indicated by bars according to Edmonds (1966). The mean spectrum was finally corrected for two dimensional radial symmetry using the integral transform given by Uberoi (1955). Figure 1 also shows the corrected spectra for both positions on the disk. Corrections for seeing or finite instrumental aperture were not applied.

Upon inspection of the uncorrected spectra one immediately notices the great amount of scatter in spectral density among the 6 subsets. Not only do the fluctuations of the power estimates considerably exceed the confidence limits, especially in the