Numerical determination of the modulation transfer function from observations of granulation outside the disk centre

I. Rodríguez Hidalgo and M. Collados
Instituto de Astrofísica de Canarias
38200 La Laguna, Tenerife
Spain

Summary

A spectral ratio, similar to that of von der Lühe (1984), is proposed to derive information on the degradation of the mean granular power spectrum at a position outside the disk centre. It has the advantage that the modulation transfer function is obtained directly from the data, without making any assumption on turbulence theory to describe the atmospheric behaviour.

Introduction

The analysis of the morphological and photometric properties of the granulation as seen at different positions on the solar disk involves the task of dealing with very small features, close to the resolution limit of the telescopes. The problem becomes increasingly difficult as one approaches the limb, mainly for two reasons. On the one hand, there is the foreshortening which appears due to the inclination of the solar surface with respect to the line of sight. On the other hand, the granulation itself seems to have a smaller size near the limb. This effect becomes particularly apparent when comparing Figures 1 and 2. This is a fact which is at variance with previous results obtained by different authors from studies of power spectra of granulation (see, for instance, Keil, 1977, and Schmidt et al., 1979), finding that the mean wavenumber decreases towards the limb. Associating this mean wavenumber to a mean granular cell size, it implies that granules are larger at higher layers of the photosphere. The reason for this disagreement may be the loss of the high frequency tail of the power spectrum due to atmospheric and instrumental degradation. Or, perhaps, the increase in contrast of larger-scale structures introduces some power in the low frequency region, thus triggering a decrease of the mean wavenumber, as pointed out by Durrant et al. (1983). A more detailed look at the image of Figure 2 also shows that there are no large granules with a complex brightness structure. Their polygonal shape is totally smeared, rendering extremely difficult the identification of the granular limits. Only the brighter zones are clearly distinguishable, and can be either part of larger granules or individual features.

In any case, it seems obvious that when near the limb one needs as much information as possible of the high frequency region of the spatial power spectrum. This can be reached by two complementary ways. First, high resolution images are needed in order to see the smallest granules. Secondly, the signal to noise ratio can be improved by averaging different power spectra; a technique which was initially proposed by Labeyrie (1970). The mean power spectrum carries more information than the power spectrum of a mean image. Even if the motion of the field of view is removed before averaging frames, there still exist some random distortions on each individual image, which, in the Fourier transform reflect as random phase