PROPERTIES OF THE SOLAR BACKGROUND SIGNAL FROM VIRGO

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ABSTRACT

The VIRGO investigation provides for the first time high quality datasets which can be used in the full frequency range from a few μHz to about 8 mHz. The data mainly used have been the datastrings from the SPM and the LOI instruments in VIRGO. These data have been used to study the frequency dependence of the solar irradiance and radiance background signal. The results show clear signatures of the granules and the supergranules, but no clear signature in the timescale region where mesogranulation is expected.

1. INTRODUCTION

The study of the solar background irradiance and radiance signals is important in several different aspects. This "solar noise" signal sets limits on the detectability of solar low frequency p-modes and g-modes. The wavelength, frequency and heliographic variations of the solar noise signal gives information about the global properties of the solar surface structures. This latter point is important for future interpretation of data used for asteroseismology.

The VIRGO investigation provides for the first time high quality datasets which can be used in the full frequency range from a few μHz to about 8 mHz. The data mainly used has been the datastrings from the SPM and the LOI instruments in VIRGO. SPM provides irradiance values at 402, 500 and 865 nm while the LOI provides radiance values at 12 different positions on the solar disc at 500 nm. The SPM data from 29-01-96 to 31-07-96 have been used, while the LOI data span the period 25-04- 96 to 31-07-96. The shorter length of the LOI data is due to the problems in opening the cover.

2. RESULTS

The SPM data have been used to study the frequency and wavelength variation of the of the spectral irradiance. The power spectra of the three SPM channels are given in the upper panel of Figure 1. Before the presented power spectra were calculated the p-modes have been filtered out to leave a clean background signal.

The 12 LOI detectors are symmetrically placed around the solar meridian and equator. In the data presented here the radiance measurements of the four pixels with the same heliocentric distance have been averaged before calculation of the power spectra. In addition the power of the signals have been scaled with the relative areas of the pixels. This has been done to take into account the different number of noise elements in each pixel average.

The resulting power spectra at the three intensity weighted heliocentric distances (μ=0.94, 0.54, 0.52) are shown in the lower panel of Figure 1. Due to the much larger number of modes present in the LOI pixels the p-mode filtering has not been as effective as for the SPM data. The turnover of the gradient at the highest frequencies is due to insufficient removal of high frequency noise in the signal.

Each of the spectra shown in Figure 1 have individually been fitted with the sum of three functions each having the following form proposed by Harvey (1984):

$$\begin{aligned} P(\nu) &= 4((\sigma_s{}^2\tau_s/(1+(2\pi\nu\tau_s)^2) \\ &\quad +\sigma_m{}^2\tau_m/(1+(2\pi\nu\tau_m)^a) \\ &\quad +\sigma_g{}^2\tau_g/(1+(2\pi\nu\tau_g)^a)) \end{aligned}$$

The subscripts g, m and s represent the parameters for supergranulation, mesogranulation and granulation. The values of σ and in mesogranulation and granulation made the problem ill posed. Harvey initially set all the exponents to -2, but also stated that this was necessarily not the best choice.

Previously some success have been achieved with a numerical simulation of the time evolution of individual surface structures. However, this model is unable to reproduce the extremely steep falloff at high frequency in an acceptable manner. Revisions of the model are under way, but currently it is not operative.

Several new features are seen in the figures: There is a significant "kink" in all of the power spectra at approximately 1.2 mHz. This was initially attributed to a change in dominant signal source from granulation to mesogranulation. But the position of the kink does not fit with the known timeconstants of mesogranulation and granulation, but rather with someting with smaller timeconstant. The fact that the position of the kink does not change significantly with either wavelength or position on the solar disk indicates a constant contrast ratio with respect to these parameters of granulation and something with lower timeconstant. The falloff with frequency at higher frequency is very steep, $a \approx -4$. An exponent of -2 will not produce and acceptable fit at high frequency.

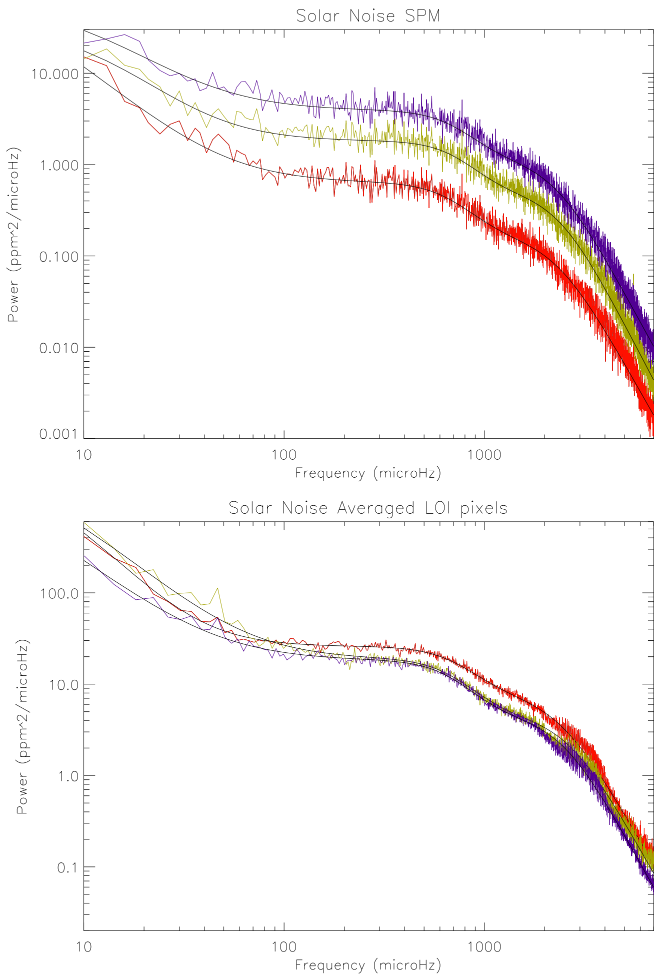

Figure 1: The upper panel shows the solar noise spectra for the blue (top), green (middle) and red (bottom) channels of the SPM. The fitted curves all have the basic formulation given in the formula. The bottom panel shows the solar naise for the radiance measurements from LOI for the averaged heliocentric distances ($\mu = 0.94, 0.54, 0.52$). The top curve is closest to the solar disc centre

The falloff with frequency at higher frequency is dependant on wavelength, with the 402 and 500 nm spectra being steeper than the 865 nm gradient. This can be attributed to the variation of contrast and the effective limb darkening. In addition the different wavelengths will penetrate to different depths in the solar atmosphere. The spectra for the SPM and LOI are very flat in the region 100-700 μHz indicating a single dominant signal source with shorter timescales. The DIARAD spectra have a different behaviour at intermediate frequencies as the supergranulation dominates to a higher frequency. This is either caused by a different timescale of the supergranulation in total irradiance or, more probably, a different ratio of the contrasts of super- and mesogranulation. At frequencies below 60 μHz the effects of supergranulation dominate, but with a significant lower gradient than at high frequency end of the spectra. Setting this exponent as a free parameter (while fixing the other two) also gives a value of $a \approx -1.95$. The functional fittings indicate timescales of 66, 320 and 30000 seconds for the three types of surface structures. This indicates that there is no dominant global or large scale signature of mesogranulation which is assumed to have a time constant of about three hours. The shortest time constant deduced from the data may have connection with bright point type oscillations.

3. REFERENCES

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