TEMPORAL BEHAVIOUR OF P-MODES FROM VIRGO

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ABSTRACT

The VIRGO investigation onboard the SOHO spacecraft provides for the first time a nearly continous dataset of solar irradiance and radiance sampled every 60 seconds. This continuity makes the available dataset the first which reliably can give the time variation of the amplitudes. In this study wavelet analysis has been applied to the first 6 months of VIRGO data. Data from both the Sun Photometer (SPM) and the Luminosity Oscillation Imager (LOI) have been used.

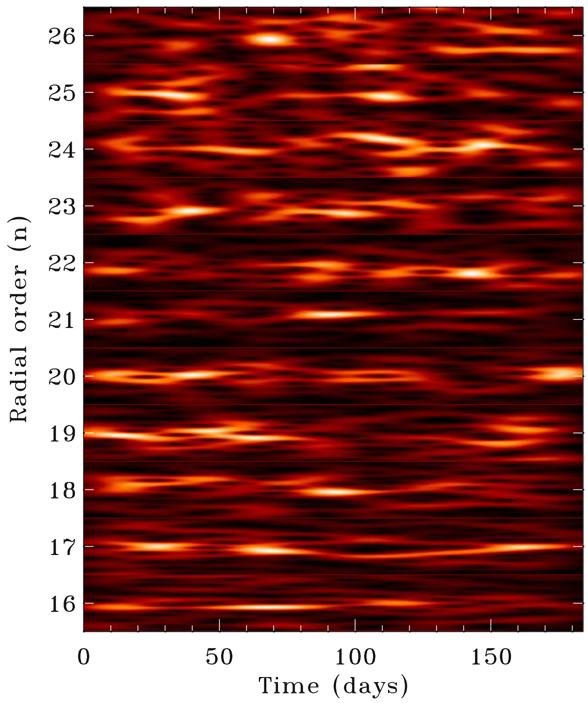

Figure 1: Wavelet analysis of $l = 0, n = 16 - 26$ from SPM blue channel. The frequency coverage for each radial order is 4 μHz.

1. INTRODUCTION

Data from the VIRGO SPM blue channel in the period between January 29. and July 31. 1996 have been analysed with respect to the $l = 0$ modes in the $p-$modes with radial orders 16-26. The $l = 1$ modes with radial orders of $15 - 26$ have been studied using LOI data. Due to problems opening the cover of LOI, these observations span the period between March 28. and July 31. The spatial resolution of the LOI allows for the separation of the $m = +1, 0, -1$ components of the individual modes using a spatial filtering technique (Appourchaux & Andersen 1990).

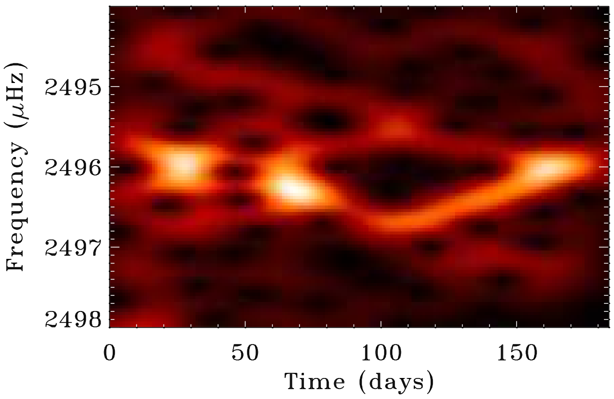

Figure 2: Wavelet analysis of $l = 0, n = 17$ from SPM blue channel.

Wavelet analysis is an appropriate tool for studying time-dependent phenomena. The method is fundamentally more correct for non-stationary phenomena like the solar $p-$modes compared to conventional Fourier analysis and with an optimal selection of parameters it also provides a better combined frequency and time resolution. The method has previously been succsessfully used on IPHIR data (Baudin *et al.* 1994, Leifsen *et al.* 1995).

The different modes have been studied using a variety of combination of temporal and frequency resolution. The best temporal resolution about half a day. For the study of the frequency structure of the modes as function of time a temporal resolution of 15-20 days have been used. The $l = 0$ data have been filtered in the frequency domain to remove the effects of the nearby $l = 2$ modes.

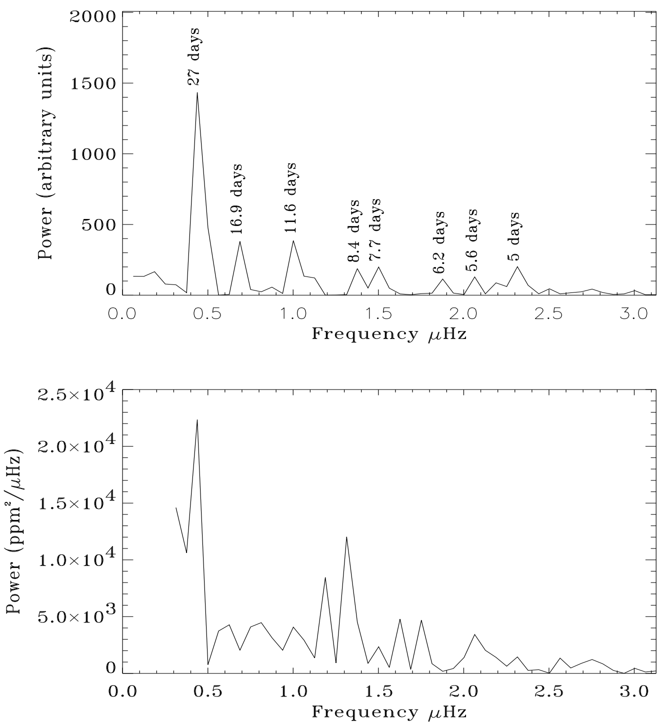

Figure 3: Power spectrum of the average amplitude variation for the modes of Fig. 1 in the very low frequency range (upper panel). The most prominent peaks are labeled with the corresponding period in days. For comparison the power spectrum of the SPM blue channel is shown in the lower panel.

2. RESULTS

The results from high frequency resolution for the $l = 0, n = 16 - 26$ are shown in Figure 1. From the data we see no clear and consistent correlation of the excitation of the different modes as was expected (Chang 1995). The temporal and frequency behaviour is very structured with accumulated pulses appearing down to the time resolution of half a day. Complicated structures with frequency shifts and splittings caused by phase wandering due to the excitation is visible (see Figure 2 for an example), manifested as a power variation in different parts of the average Lorentzian profiles of the modes. This illustrates the problems with fitting Lorentzian profiles to the power spectra of modes in timestrings of only a few months duration.

The variation of the observed power as function of time of the $l = 0$ at low frequencies is shown in Figure 3, upper panel. The frequency behaviour closely resembles the powerspectrum of the irradiance variation (Figure 3, lower panel). Peaks at the period of the solar rotation are prominent. This does not necessarily imply a lognitudinal variation of the excitation since the $l = 0$ mode power should not be dependent of the position of the sources of excitation. Since what we observe is the response of the solar atmosphere to the oscillations, the observed modulation may just be a variation in the surface properties, e.g. active regions or lognitudes.

The results from the LOI on the $l = 1$ modes indicates that there is no correlation between the three different rotationally split components of each radial order. This is as expected if one asumes that the excitation is caused by the turbulence in the upper boundary layer of the convection zone. Figure 4 shows the three rotationally split components of the $l = 1, n = 20$ mode.

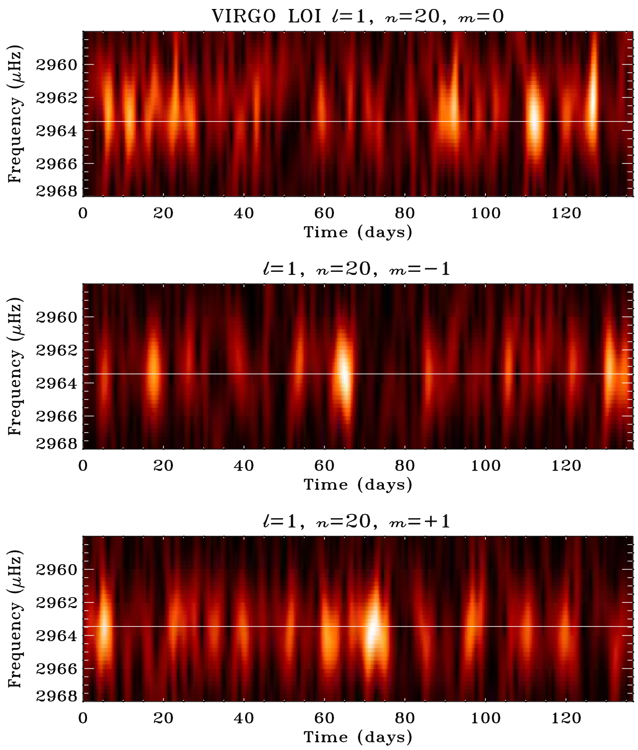

Figure 4: The amplitude variation with time of the rotationally split components of the $l = 1, n = 20$ mode. The three components are separated using spatial filtering of the LOI data prior to applying the wavelet transform.

3. REFERENCES

Appourchaux, T. and Andersen, B. N.: 1990, *Solar Phys.*, **128**, 91

Baudin, F., Gabriel, A. and Gibert, D.: 1994, *Astron. Astrophys.*, **285**, L29.

Chang, H.-Y.: 1995, Ph.D. dissertation, University of Cambridge

Leifsen, T., Hanssen, A., Andersen, B. N. and Toutain, T.: 1995., A.S.P. Conf. Ser., **76**, 520.