Proposal for a joint analysis of GOLF and VIRGO data:

Flux vs. velocity phase lags and amplitude ratios for p-modes

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Scientific Objectives

The purpose of this observation program is to improve our understanding of the propagation of waves in the upper convective zone and photosphere of the sun and, in this way, to study the structure of these regions. The comparison of phase lags and amplitude ratios is, in wave analysis, a common way to check the validity of theoretical descriptions. Among recent works dealing with the sun in global observations, we may quote the study of phase lags and amplitude ratios by Schrijver, Jimenez and Däppen (1991, hereafter SJD) and the comparison of flux perturbations at different wavelengths by Toutain and Gouttebroze (1993; hereafter TG).

At the present time, it is hard to say that either the precision of data or the quality of theories have reached a satisfactory level. This may be illustrated by two figures extracted from our last poster presented at the 4th SOHO Workshop. These figures show a comparison between our calculations and the measurements of SJD. Both figures show the important scatter of data points. On Figure 2, one may see that a small difference on theories (concerning different ways of specifying the "frozen convection" approximation) may have important consequences on predicted amplitude ratios.

Observations

We plan to perform again the measurements of both SJD and TG, i. e.:
- phase lag and amplitude ratios between flux and velocity variations
- the same quantities for flux variations at different wavelengths

with simultaneous use of GOLF and VIRGO.

We may expect to obtain in this way better data: First, from the fact that velocities and intensities will be observed from the same point, thus avoiding complicated correction procedures. Second, the possibility of obtaining long uninterrupted sequences should give a lower noise level. TT has a long experience in treating IPHIR data, which will be certainly useful in the present case, especially for VIRGO data. On the other side, the knowledge of the GOLF instrument by PB will be very important also.

Theory

The determination of phase lags and amplitude ratios includes three stages:
- solar modeling, including the interior and the atmosphere. The Nice group (especially PM, JP and GB) has a long experience in this field.
- computation of oscillation modes, with frequencies and eigenfunctions (amplitudes of displacement, temperature pertubations, etc., vs. radius). The adiabatic approximation is clearly unsufficient. JP and GB have developed a code treating the radiation either in the diffusion or Eddington approximation. PG has written a similar code and is searching for higher degree approximations. The treatment of convection should also be improved.
- computation of visibilities: Given the model and eigenfunctions, the visibility code computes the amplitude and phase of the flux perturbation. We have 4 different codes: one by JP and GB, one by TT and a third one by PG, all using the "Lagrangean" formulation. The fourth one, by PG, uses the "Eulerian" formulation. At least for p-modes, all these codes are in reasonable agreement.

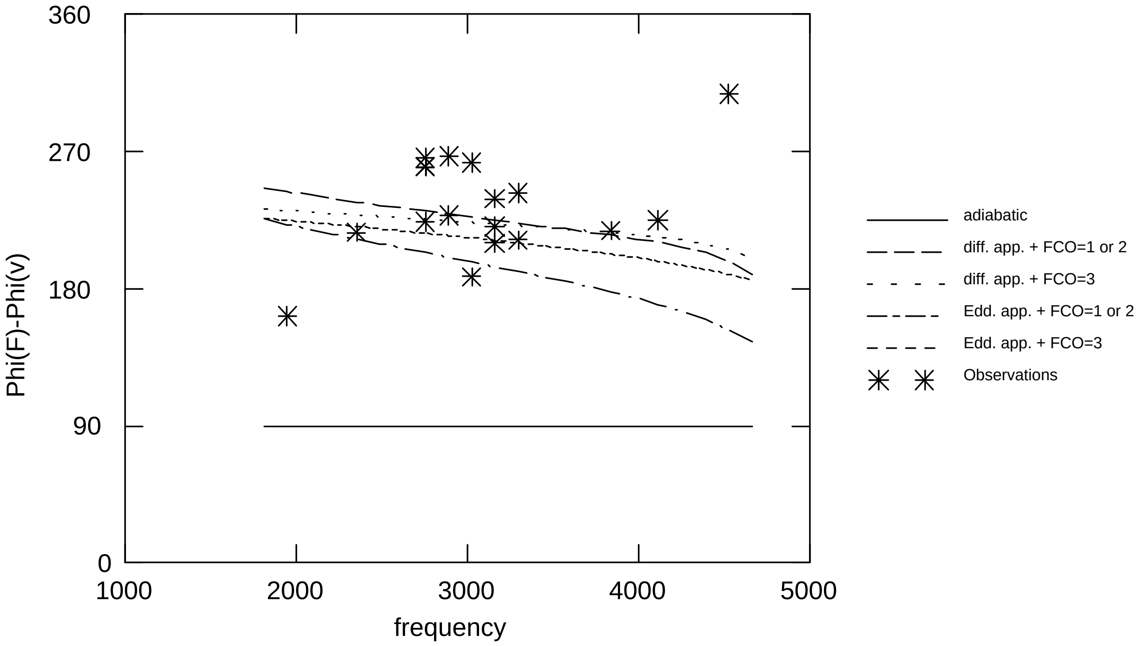

Figure 1: Flux-velocity phase difference (degrees) vs. frequency (μHz) for full-disk measurements. Computations (curves) are compared to observations by Schrijver et al. (1991). (Flux is taken in the solar continuum at λ=500nm)

References:

Schrijver, C. J., Jimenez, A. & Däppen, W. 1991, A&A 251, 655 (SJD)

Toutain, T. & Gouttebroze, P. 1993, A&A, 268, 309 (TG)

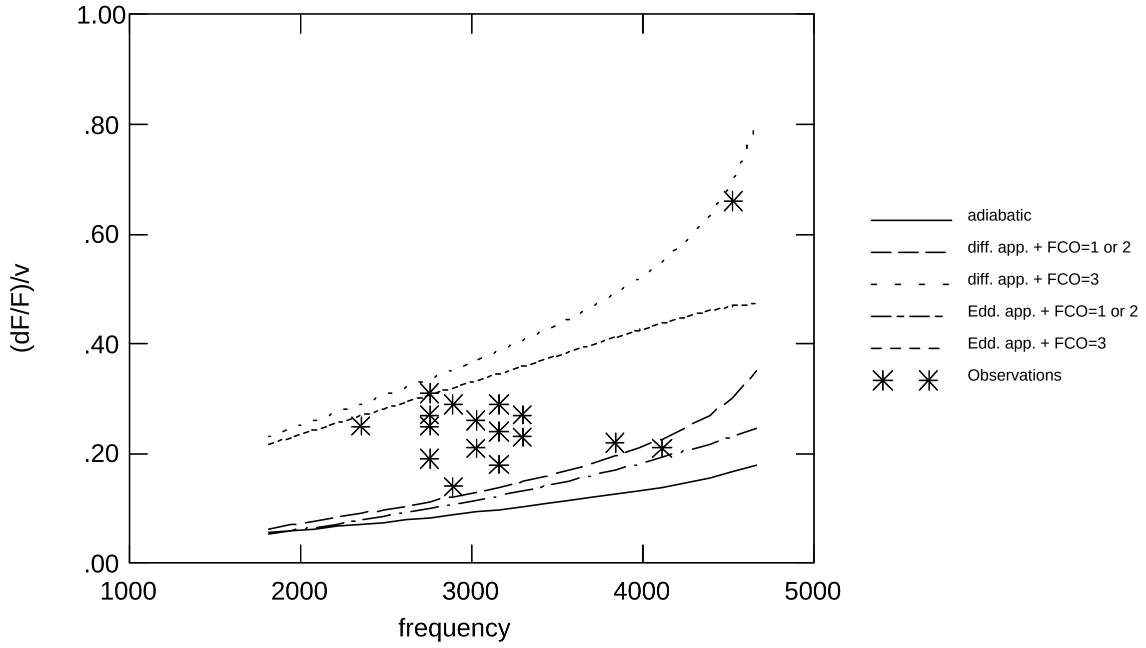

Figure 2: Flux/velocity amplitude ratios (ppm/(cm/s)) vs. frequency (μHz) for full-disk measurements.