Comparison of Solar *p*-Mode Lifetimes from GONG, MDI and TON Data

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Abstract.

We present results of *p*-mode lifetime measurements obtained from GONG, MDI and TON (Taiwan Oscillation Network) data using the time-distance technique. Lifetimes of solar *p*-modes in the range ℓ=100-600 and ν=2.5-4.5 mHz were estimated from the decrease of the amplitude of the cross-correlation function of the surface oscillations with time. We also include the effect of dispersion of the wave packets in our measurements. The results from GONG, MDI and TON data are in good agreement taking into account the different spectral lines of the observations.

Method.

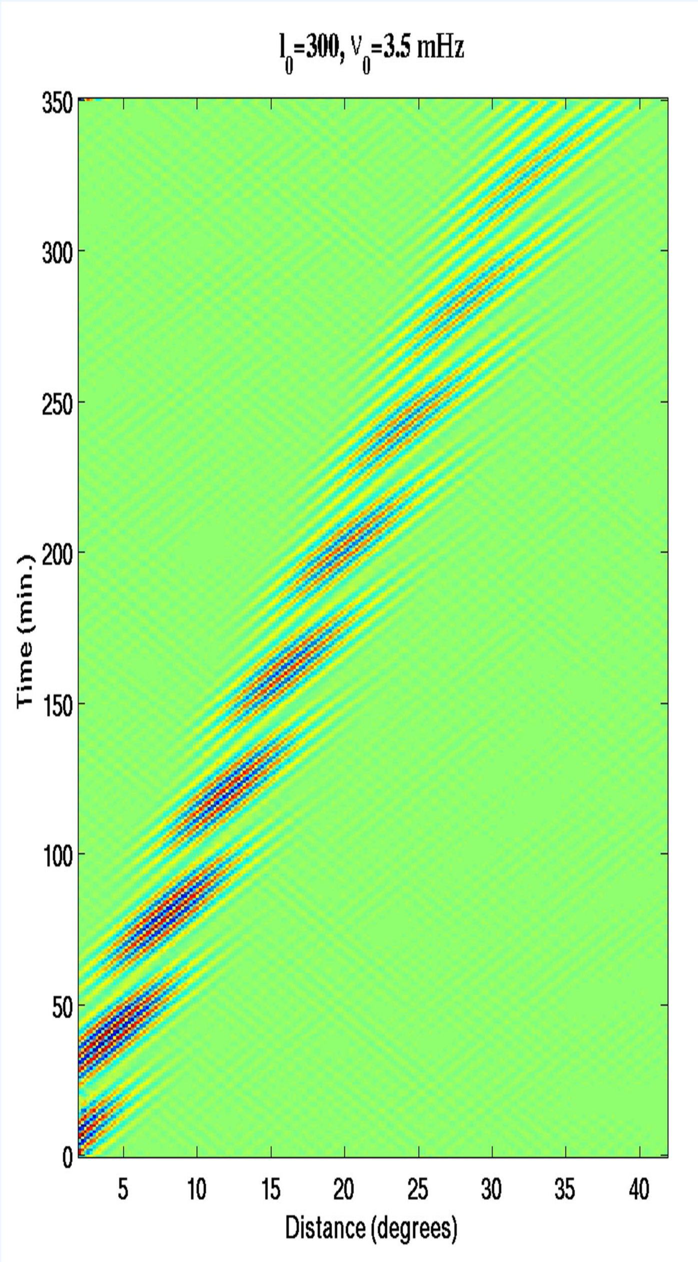
The lifetimes of *p*-modes are determined by the changes in the amplitude and width of the cross-correlation function of a wave packet with number of skips. The amplitude of the cross-correlation function decreases exponentially with travel time. This phenomenon has been interpreted as the dissipation of solar *p*-mode power.

Since the wave packet consists of many *p*-modes in some interval of frequencies ν and ℓ-range, the wave packet must be affected by the dispersion, i.e. its width increases and amplitude decreases as it propagates. The width of the cross-correlation function of a wave packet increases with the number of skips. This phenomenon has been interpreted as the effect of the dispersion of the wave packet.

From energy conservation, dispersion would not change the product of amplitude squared and width of the wave packet. Therefore, if we take into account both dissipation and dispersion the lifetime, *T*, of the wave packet is determined from the following equation:

$$A_n^2 W_n = A_0^2 W_0 e^{-n\tau_{en}/T} \qquad (1)$$

where A_n and W_n are the amplitude and width of the cross-correlation of skip *n*, respectively. τ_{en} is the one-skip envelope time. Since W_n increases with *n*, $A_n^2 W_n$ decreases more slowly than A_n^2. The lifetime determined with Eq. 1 should be longer than the lifetime time determined without including the effect of the width.



Data analysis.

We used velocity Ni-line GONG and MDI images and intensity Ca K-line TON images. For each of them we have studied six 512-minute time series in 2001.

The following analysis was applied to the data:

1. The data after preliminary reduction are transformed into the (l,m,ν) domain, where *m* is the azimuthal degree.

2. A Gaussian filter of FWHM=2 mHz centered at a frequency ν_0 is applied.

3. A phase velocity filter is applied to isolate wave packet characterized by the central frequency ν_0 and the corresponding degree l_0.

4. The data are reconstructed back to the space-time domain.

5. Cross-correlation function is computed. *Figure 1* shows an example of cross-correlation function.

6. For each skip, *A* and *W* determined by approximation the cross-correlation function by a Gabor wavelet are averaged over 5 angular distances near the maximum of the amplitude to improve signal-to-noise ratio.

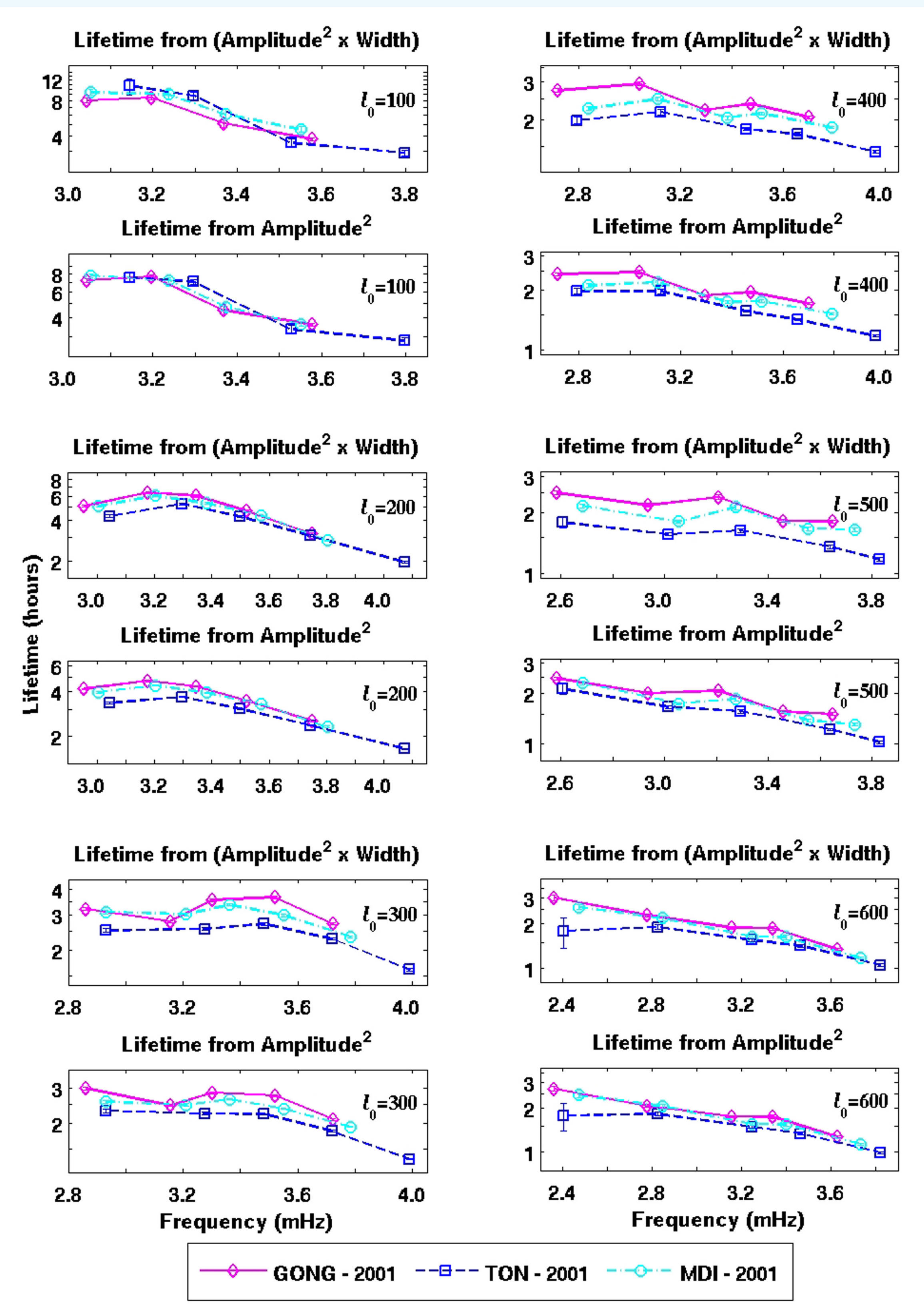


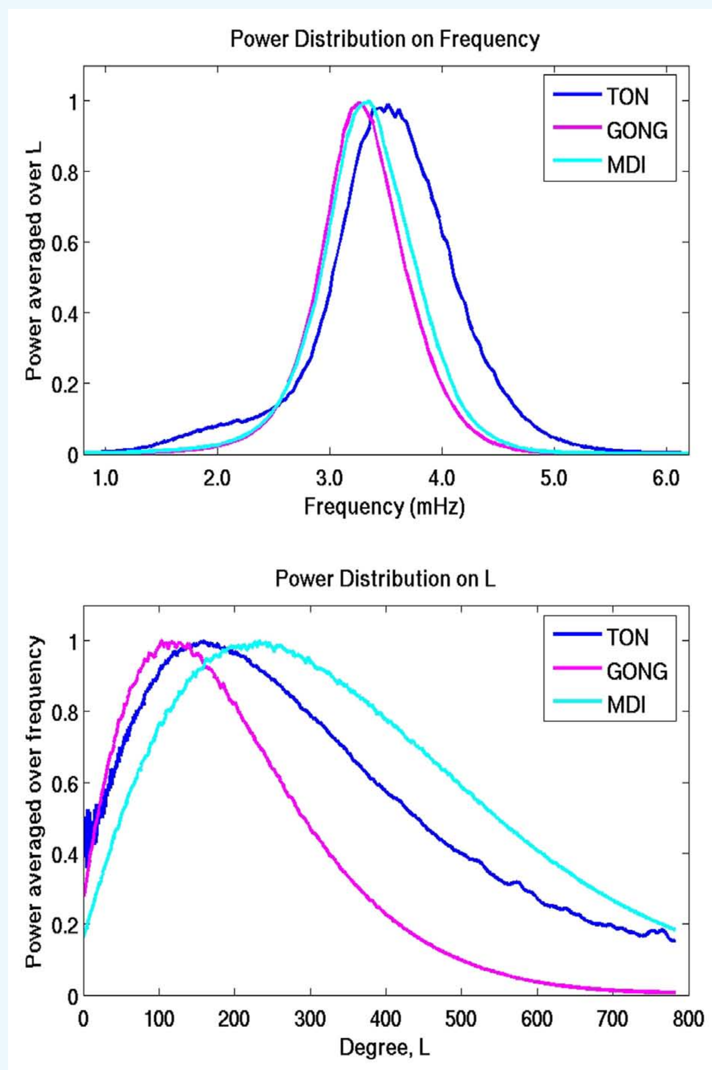
Fig.1 (top): Cross-correlation function as a function of angular distance (horizontal axis) and travel time (vertical axis) for a phase-velocity filter of $2\pi\nu/\ell = 7.3\times10^{-5}$ rad/s, computed from 512-minute time series of MDI data on Aug.20, 2001. The cross-correlation function is an average of positive and negative time shifts.

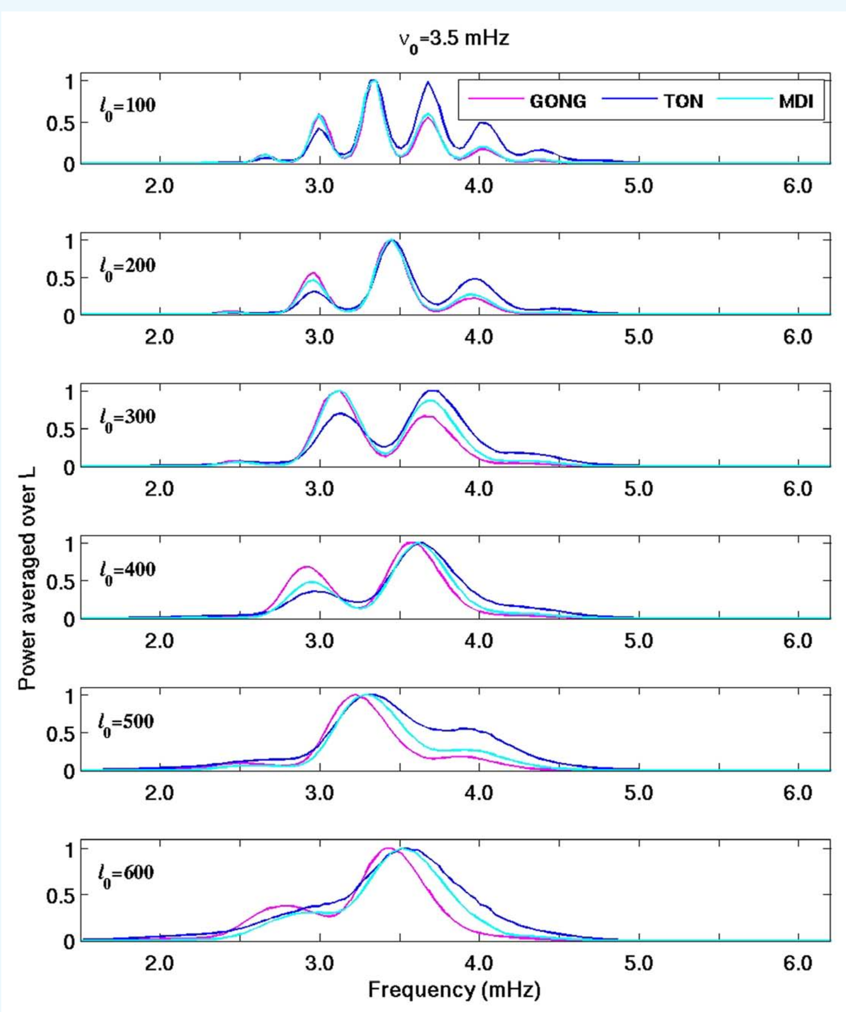
Fig.2 (left): Lifetime obtained from GONG, MDI and TON data averaged over six time series in 2001 versus frequency for various ν_0 and ℓ_0. The lifetime is determined from $\ln(A^2W)$ (*top panels of same* ℓ_0) and $\ln(A^2)$ (*bottom panels of same* ℓ_0).

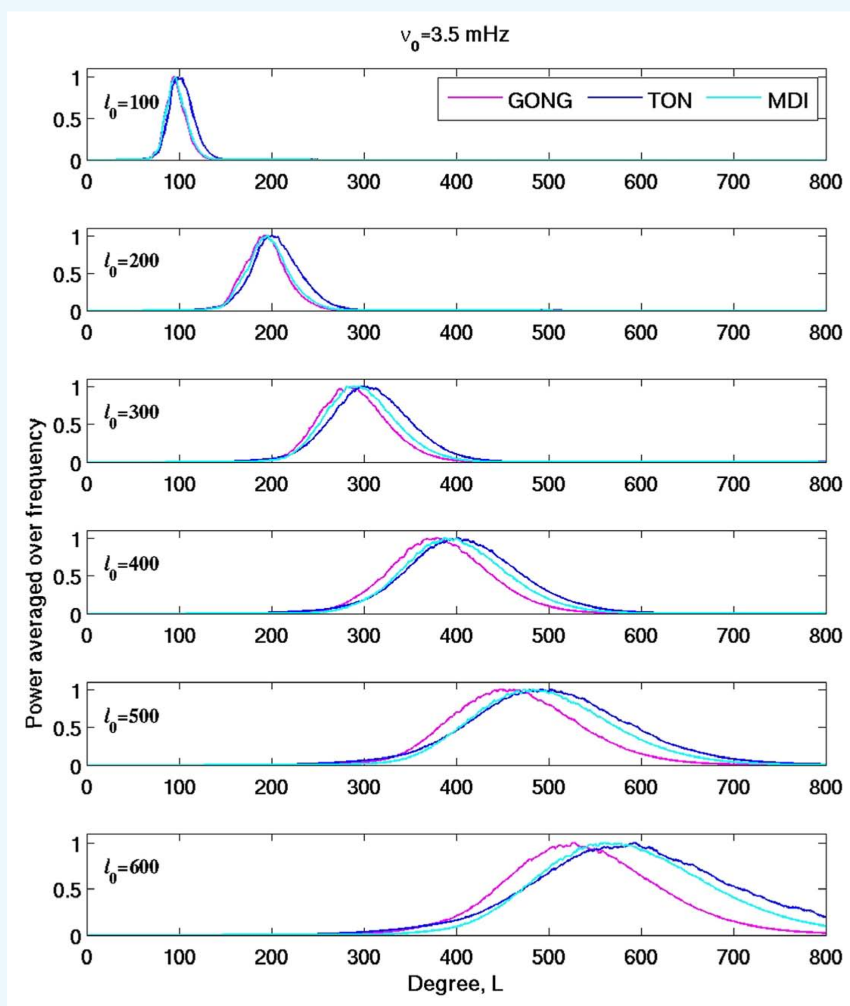
Fig.3 (right): Acoustic power distribution with frequency (*top panel*) and mode degree (ℓ) (*bottom panel*) in the GONG, MDI and TON spectra.

Fig.4 (bottom, left): Acoustic power distribution with frequency in the GONG, MDI and TON spectra filtered with a phase velocity filter. The example shows power distribution for six k/ω filters with ℓ_0=100-600 and ν_0=3.5 mHz.

Fig.5 (bottom, right): Acoustic power distribution with mode degree (ℓ) in the GONG, MDI and TON spectra filtered with a phase velocity filter. The example shows power distribution for six k/ω filters with ℓ_0=100-600 and ν_0=3.5 mHz.







Results and discussion.

- The lifetimes for various wave packet frequencies and degrees are shown on *Figure 2*. The lifetimes of the wave packets with ℓ_0 = 100 - 300 increase by factor ~ 1.5 if dispersion is considered. In case of wave packets with ℓ_0 = 400 - 600 the difference in the lifetimes is negligibly small or absent.
- The results from GONG, MDI and TON data are in good agreement taking into account different spectral lines of the observations and therefore different distribution of the acoustic power with frequency and mode degree in the GONG, MDI and TON spectra (see *Figure 3*). Thus the wave packets obtained from GONG, MDI and TON data characterized with same ℓ_0 and ν_0 are different. This can be seen from *Figure 4* and *Figure 5* where examples of power distribution with frequency and mode degree in k/ω filtered spectra are presented.