Reflection of acoustic waves from a surface in the presence of an anharmonic defect

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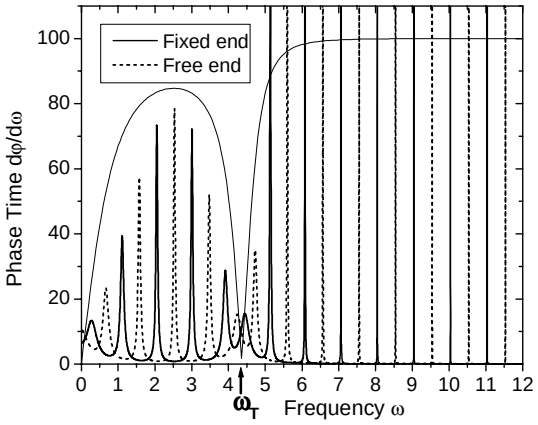
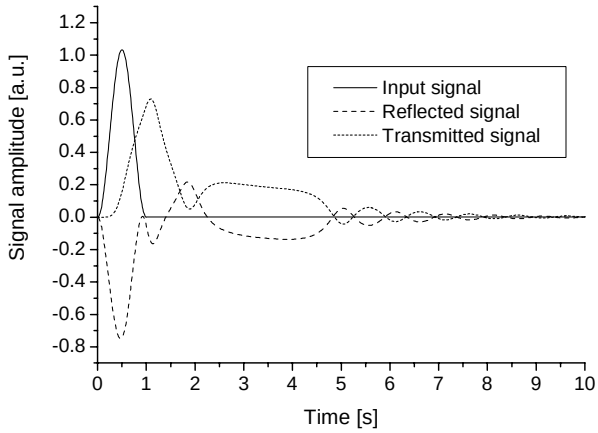
An anharmonic resonant defect has been used to model the interface between a thin layer and an underlying dispersionless semi-infinite bulk crystal. The defect is known to present a special frequency ω_T at which the corresponding monochromatic wave is entirely transmitted [1]. The equation of motion for the defect placed near the surface is no longer a differential equation but a particular case of the Volterra integro-differential equation [2]. The Green function technique [3] allowed us to solve this equation in the harmonic approximation. A series of leaky waves (surface resonances) have been found in this way. Whereas the resonances have remarkable widths below ω_T, they are extremely narrow above (Fig. 1). Effects of anharmonictity of the interface have been studied with the use of an electric circuit obeying the same equation of motion. The reflection coefficients as well as the intensities of higher harmonics then have been determined as functions of the amplitude of the incident wave. Some selected wave forms have been studied. A delay in the reflection and a deficit of the reflected energy have been found as concomitants of anharmonicity (Fig. 2).





Instances of chaotic behavior have been also noticed. The effects found are relevant in the interpretation of experiments with ballistic phonons [4]. Possible applications of the results to anharmonic junctions in optoelectronics [5] will be also discussed.

[1] Z. Łodziana and P. Zieliński, Europhys. Lett., **50**, 216 (2000).
[2] P. Zieliński, Z. Łodziana and T. Srokowski, Eur. Phys. J. **B 9**, 525 (1999)
[3] L. Dobrzyński, Surf. Sci. Reps. **11**, 139 (1990)
[4] B. Scheffold and O. Weis, Z. Phys. B **98**, 479 (1997)
[5] see e.g. L. Dobrzyński, B, Djafari-Rouhani, A. Akjouj, J. Vasseur and J. Zemmouri, Eurphys. Lett., **46**, 467 (1999) for a purely harmonic device

Fig. 1: Surface resonances below and above ω_T.

Fig. 2: Transmission and reflection of a wave packet by an anharmonic interface.