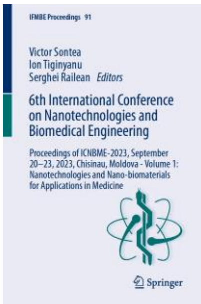

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Parametric Anomaly of the Phonon Spectrum of a Thin Free-Standing Membrane

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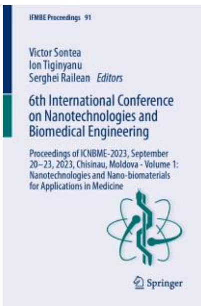
Abstract

We consider modification of the acoustic Rayleigh-Lamb phonon spectrum in a thin homogeneous membrane upon variation of parameters characterizing the medium. It is emphasized that single-valued parametric dependence of the frequency-wavenumber spectrum is related to the performance of acoustic sensing applications and a single layer membrane has been known to fully support this requirement. To capture the behavior in the full three-dimensional parametric space of the considered basic structure we analyze the solutions in terms of variables scaled with material parameters. The main finding is that not all the branches of the spectrum demonstrate the regular monotonic evolution in the parametric space (e.g., an increase of the bulk velocity is associated with an increase of the phonon eigenfrequencies). Thus, the resonance frequencies of a whole range of phonon modes are shown to decrease if the bulk velocity of the propagation medium is increased. It is noteworthy that the respective anomalous branches, S1 and A2, are the ones which show the strongest dispersion anomalies, like zero group velocity and backward wave propagation. However, the anomalous parametric variation of the spectrum is located in the region of shorter wavelengths than the dispersion anomaly of the same branches. So that the “abnormal” parametric behavior is observed for the modes on the S1 and A2 branches which a have a “normal”, i.e., positive group velocity.

Keywords: ultrathin layers, vibration spectra, Rayleigh-Lamb phonon modes, free-standing membranes



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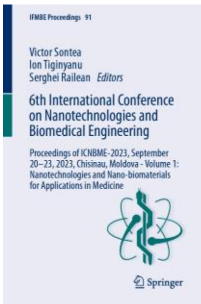

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