
Wave propagation in nonlocal elasticity of Klein-Gordon type with internal length and time scales

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Abstract

Generalized continuum theories like nonlocal elasticity and gradient elasticity are powerful continuum theories valid at small scales unlike classical continuum theories such as classical elasticity which cannot capture effects at small scales (see, e.g., (1,2)). Nonlocal elasticity considers long-range interatomic interaction, it has a close link to the underlying microstructure and is valid down to the Ångström-scale and therefore it can be considered as a generalized continuum theory of Ångström-mechanics (2).

In this work, a nonlocal elasticity model of Klein-Gordon type, characterized by nonlocality in space and time, is developed including one characteristic internal time scale parameter in addition to the characteristic internal length scale parameter (3). Such a nonlocal elasticity theory describes spatial and temporal nonlocal effects at small scales. The wave propagation for homogeneous isotropic media in the framework of nonlocal elasticity of Klein-Gordon type is investigated. The dispersion relations are analytically derived showing for the first time in the framework of nonlocal elasticity theory, optic modes (high-frequency modes) and frequency band-gaps in addition to the acoustic modes (low-frequency modes). The phase and group velocities for all four modes (acoustic and optic branches of longitudinal and transverse waves) are determined showing that all four modes exhibit normal dispersion with positive group velocity (3,4). The proposed nonlocal model of Klein-Gordon type possessing only 4 constitutive parameters (2 elastic constants, 1 length scale and 1 time scale) provides an appropriate framework for the modelling of accurate frequency band-gaps and overall physically realistic dispersive wave propagation.

REFERENCES

- (1) A.C. Eringen, *Nonlocal Continuum Field Theories*. Springer, New York, 2002.
- (2) M. Lazar, E. Agiasofitou, G. Po, Three-dimensional nonlocal anisotropic elasticity: a generalized continuum theory of Ångström-mechanics. *Acta Mechanica* 231: 743-781, 2020.
- (3) M. Lazar, E. Agiasofitou, Nonlocal elasticity of Klein-Gordon type: fundamentals and wave propagation. *Wave Motion* 114: 103038, 2022.
- (4) E. Agiasofitou, M. Lazar, Nonlocal elasticity of Klein-Gordon type with internal length and time scales: Constitutive modelling and dispersion relations, *Proc. Appl. Math. Mech.* 2023; e202300065.

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