

Thermoelastic Modelling of Rayleigh Waves in Nonlinear Metasurfaces

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ABSTRACT

Nonlinear seismic metasurfaces (NSMs) offer a promising approach for attenuating long-wavelength seismic vibrations through periodic subwavelength structures. This work presents a theoretical analysis of Rayleigh wave propagation in such metastructures under thermo-mechanical effects, based on Moore–Gibson–Thompson (MGT) thermoelasticity. A semi-infinite, thermally conducting, isotropic elastic half-space is modeled with a surface-mounted spring–mass–damper array. Analytical expressions for displacement amplitude, thermal stresses, and temperature are derived. Dispersion relations for Rayleigh waves in linear and nonlinear metasurfaces are obtained using harmonic balance and appropriate boundary conditions. Parametric studies highlight the effects of thermal relaxation, mass ratio, and stiffness on wave attenuation and band gap formation. The results show that nonlinearities—both softening and hardening enable tunable vibration absorption and frequency-selective filtering. These findings contribute to the design of thermoelastic metastructures for advanced seismic wave control.

Keywords: Nonlinear metasurface, Rayleigh wave, Moore–Gibson–Thompson (MGT) thermoelasticity theory, Dispersion relation, Thermal relaxation parameter.