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Seismic metasurfaces for Love waves control

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Elastic metasurfaces consist of resonant inclusions or resonant oscillators, placed at the free surface of an elastic medium, which collectively interact with surface elastic waves to redirect, steer or absorb their energy. Metasurfaces of vertical oscillators over homogeneous elastic half-spaces can inhibit the propagation of vertical polarized waves (i.e. Rayleigh waves) creating band-gaps at selected frequencies [1]. Such ability has inspired the design of meter-scale metabarriers to protect buildings and infrastructures from harmful seismic Rayleigh waves [2].
In this work, we extend the study of metasurfaces to in-plane polarized surface waves, i.e. Love waves, travelling on a soft elastic layer overlaying a stiffer substrate. We derive an original dispersion relation for the Love type waves existing on a bi-layer coupled on its free surface with a metasurface of horizontal resonators [3]. By tuning the mass and the frequency of the resonators we show the possibility of manipulating the phase velocity of the fundamental Love wave, and thus the related metasurface's refractive index at specific frequencies. We exploit this ability to design gradient index lenses (i.e. Luneburg and Maxwell lenses) for Love waves redirection. We analyse the performance of the designed lenses using full 3D FE simulations confirming the analytical predictions. Our work can serve as a guide for the design of meter-scale Love waves barriers for seismic or anthropic vibrations attenuation.

References

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