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Symposium Contributions

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Wave Propagation in Modulated Phononic Crystals and Metamaterials

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Wave propagation in modulated phononic crystals and metamaterials

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Interest in media with broken time-reversal symmetry has grown significantly in recent years due to their numerous potential technological applications in differential bidirectional wave control. In this talk, we study wave propagation in phononic crystals and resonant metamaterials where some or all of the elastic moduli and mass density are modulated in space and time in a wave-like fashion. The modulation introduces a bias in space-time responsible for the breaking of time-reversal symmetry and reciprocity thus altering the dispersion curve and violating its vertical mirror symmetry. We characterize analytically and numerically how the dispersion curve transforms due to wave-like modulations in various situations but primarily in connection with two phenomena. On one hand, fast high-amplitude modulations in phononic crystals are shown to break reciprocity in the rigorous homogenization low-frequency limit. In terms of the effective constitutive parameters, this gives rise to a non-negligible non-standard stress-velocity and momentum-strain coupling characteristic of Willis materials. On the other hand, low-amplitude modulations of the inner stiffness in resonant metamaterials are proven to couple some incident and scattered plane wave modes. Depending on whether the coupled modes have co- or contra-directional group velocities, the modulated metamaterial behaves as a unilateral converter/transmitter or as a unilateral converter/reflector.