Mathematical Physics

On the effective shear speed in 2D phononic crystals

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The quasistatic limit of the antiplane shear-wave speed ('effective speed') c in 2D periodic lattices is studied. Two new closed-form estimates of c are derived by employing two different analytical approaches. The first proceeds from a standard background of the plane wave expansion (PWE). The second is a new approach, which resides in $\mathbf{x}$-space and centers on the monodromy matrix (MM) introduced in the 2D case as the multiplicative integral, taken in one coordinate, of a matrix with components being the operators with respect to the other coordinate. On the numerical side, an efficient PWE-based scheme for computing c is proposed and implemented. The analytical and numerical findings are applied to several examples of 2D square lattices with two and three high-contrast components, for which the new PWE and MM estimates are compared with the numerical data and with some known approximations. It is demonstrated that the PWE estimate is most efficient in the case of densely packed stiff inclusions, especially when they form a symmetric lattice, while in general it is the MM estimate that provides the best overall fitting accuracy.

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