Application of the Lippmann-Schwinger equation to the propagation of acoustic Bloch waves

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Abstract

FFT methods offer a number of advantages for the homogenization of periodic and random media, such as low memory cost and fast computation, making it possible to study larger systems than the finite element method.
Since the work of Segurado and Lebehnson (2021), FFT methods have been applied to calculating the acoustic properties (dispersion diagram) of arbitrary periodic materials. The calculation of frequencies and wave numbers involves solving an eigenvalue problem, in which the smallest eigenvalues are sought, which requires the inversion of a stiffness-type operator. The disadvantage of their method is that the inversion of this operator requires many iterations when the micro-structure presents high contrasts in mechanical properties. This method is therefore limited to low-contrast systems such as polycrystals.

In this presentation, we propose an alternative FFT method based on the Bloch theorem and the Lippmann-Schwinger equation. We solve it using the work of Sab et al (2024), who introduced an algorithm that is unconditionally convergent, even in the presence of infinitely rigid pores and phases. This makes it possible to extend the calculation of dispersion diagrams by FFT to highly contrasted structures, with a low calculation time.

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