MECHANICS

Efficient and accurate numerical modeling of ultrasonic wave scattering in polycrystalline materials using a space-discontinuous Galerkin framework

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Auteurs : Juan Camilo Victoria Giraldo, Bing Tie

Ultrasonic wave scattering is an interesting phenomenon in which the wave propagation is locally disturbed by the heterogeneities in the media, such as relative crystallographic misorientation in polycrystalline materials. In non-destructive evaluation, it is necessary to perform 3D simulations in high frequencies for microstructures with strong anisotropy and strong multiple scattering. In this particular case, theoretical models are limited and numerical simulation is challenging due to the large ratio between the size of the sample and the characteristic length of the heterogeneities. It is, therefore, necessary to have accurate and reliable numerical solvers capable of controlling the numerical dispersion in such cases. In this work, we model the ultrasonic bulk and surface waves using a space discontinuous Galerkin (sdG) framework. The sdG method used as a solver is a velocity-stress formulation using spatially element-wise discontinuous finite element basis functions with a Runge-Kutta time scheme subjected to the Courant-Friedrichs-Lewy condition (CFL). Due to the deliberately introduced space discontinuity, the resulting mass matrices are composed of diagonal element matrices and together with the explicit time discretization, the parallelization strategies are straightforward. In addition, we consider the pure Rayleigh wave generation and absorbing boundary conditions to optimize the size of the simulated domains. We also attempt to perform simulations in the geometric scattering region, where the average size of the heterogeneity is much larger than the wavelength. Regarding the ultrasonic scattering investigation, we consider the evaluation of the attenuation coefficient, the phase velocity and the structural noise level for bulk and surface waves. We are able to obtain good agreement between numerical and theoretical values, showing that the sdG-Runge Kutta is a versatile solver for elastodynamic problems in anisotropic and heterogeneous media.