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3D WAVE PROPAGATION IN MATERIALS WITH FRICTIONAL DEFECTS

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To accompany nonlinear ultrasound NDT experiments, we propose a numerical tool that describes a 3D wave propagation in structures of known geometry containing inner frictional contacts, such as cracks, delaminations, loose joints, etc. Numerical acoustics in materials with inner boundaries subject to friction meets a common difficulty that consists in finding the correct tangential displacement distributions at all contact points in a way that satisfies the Coulomb friction law. This usually results in a cumbersome iterative procedure that tries to match contact stresses by adjusting contact displacements. Here we avoid this difficulty by selecting displacements as arguments and explicitly calculating contact stresses via an original semi-analytical formulation that resembles the Hertz-Mindlin mechanics, except that contact shapes are not necessarily spherical but can be sections of rough surfaces, and the excitation is not a simple prescribed protocol but represents an oblique shift in 3D having an arbitrary time dependence.

The boundary conditions are integrated into a finite element code (COMSOL) describing wave propagation together with nonlinear generation by contact acoustic nonlinearity. We present a number of numerical experiments with different structures and defects excited by various acoustic and vibrational signals. We have also tried to imitate a laser vibrometry experiment looking for harmonics generated by a surface-breaking crack. In the future we plan to use the method to deal with parasite peaks frequently present in nonlinear imaging by assuming cracks at suspicious locations and comparing the numerical results with real data. A more ambitious goal would be to reconstruct exact crack positions, shapes , and orientations by using our modeling tool.