CANUM 2020 13-17 juin 2022

Low-amplitude transient elastic waves in a 1D periodic array of non-linear interfaces: homogenization and time-domain simulations

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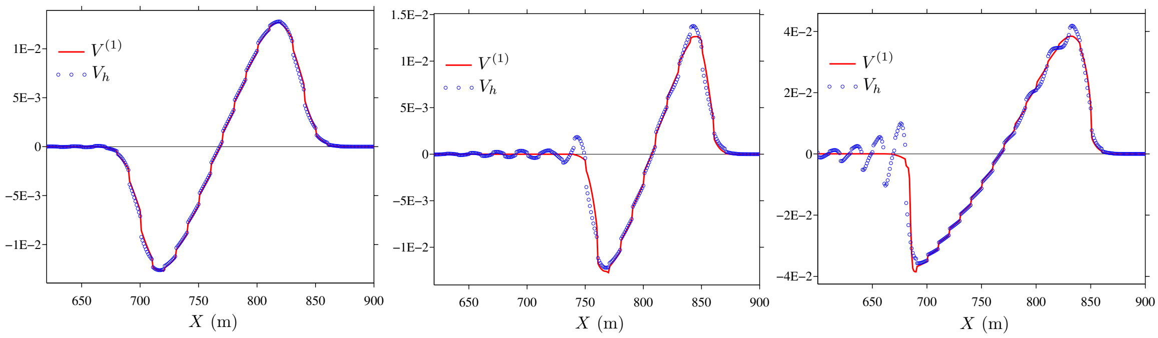
This presentation focuses on the time-domain propagation of elastic waves in a periodic medium that contains imperfect interfaces. Indeed, the contacts between the different solids are often not perfect : defects (e.g. air, cracks, voids) or thin layers of glue can be present. These situations have been modelled by *spring-mass* conditions for the fields in the contact region.
A 1D network of spring-mass imperfect interfaces has been considered : it is generated by a cell, possibly heterogeneous, periodically repeated and linked by imperfect interfaces characterised by linear dynamics but a non-linear law of elasticity. In this context, we study transient waves of small amplitude and long wavelength, and we aim to derive homogenized models that describe their motion. To this end, the two-scale asymptotic homogenization method is used up to the first order [1].
At the zeroth order, a wave equation and a non-linear stress-strain relation are obtained. Consequently, shocks occur in the homogenized model in finite time contrary to the case of the microstructured configuration. From the instant where shocks appear, there is dissipation of energy in the homogenized model contrary to the microstructured configuration. At the first order, the wave equation is linear but with a source term and a cell function that depend non-linearly on the zeroth-order fields.
An estimation is obtained for the time of apparition of shocks in the zeroth-order homogenized model, which is consequently an upper bound of the time of validity of the model. The influence of the dominant wavelength and the amplitude of the wave field is studied numerically, as well as the characteristics related to the non linear phenomena, thanks to comparisons with full field simulations. This underlines a good agreement before shocks appear that deteriorates as the frequency or the amplitude of the source increase, see Figure 1.



(a) Low frequency and amplitude (b) Increasing the frequency (c) Increasing the amplitude

FIGURE 1 – Comparison of the velocity fields V_h and $V^{(1)}$ obtained by full-field simulations and by first-order homogenization, respectively.

[1] C. Bellis, B. Lombard, M. Touboul, R. Assier. *Effective dynamics for low-amplitude transient elastic waves in a 1d periodic array of non-linear interfaces.* Journal of the Mechanics and Physics of Solids, **149**, 104321, 2021. doi :10.1016/j.jmps.2021.104321.

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