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Standing waves associated with resonances in chains of bilinear oscillators

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Rock and rock mass loading response is often non-linear characterised by the presence of different moduli in compression in tension. This can strongly affect the wave propagation. The simplest model of dynamics of such objects is given by a system of coupled bilinear oscillators. Here we consider 1D chains of bilinear oscillators.
The main distinctive feature of a single bilinear oscillator is the presence of multi-harmonic and sub-harmonic resonances. We also studied a system of two coupled bilinear oscillators – two masses connected to each other by a bilinear spring, each mass being also connected to a fixed boundary by a bilinear spring. Thus the system comprises two masses with three identical bilinear springs. Such a system possesses 6 linear states with non-linearity manifesting itself only in transitions between the states. We demonstrated that the resonance could only be achieved in a motion that alternates two linear states with equal eigenfrequencies. We showed that a system of two coupled bilinear oscillators also has super- and sub harmonic resonances, which widens the resonance spectrum and subsequently enhances the energy absorption capacity.
We further consider a chain of N bilinear oscillators with fixed boundaries. The N-degree of freedom system exhibits 2(N+1)-2 linear states; each state possesses N basic eigenfrequencies and N corresponding eigenvectors. We show that resonance frequencies of the system coincide with the resonant frequencies of two basic oscillators: a single mass oscillator and a double mass oscillator separated by stationary masses (stationary points). The positions of the stationary points re determined by the number of elements in the chain and the frequency of excitation. These stationary points form a unique feature of the systems of bilinear oscillators leading to the formation of standing waves whose characteristic depend upon the chain length and the wave frequency.