Envelope vector solitons in nonlinear flexible mechanical metamaterials

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Nonlinear flexible mechanical metamaterials (flexMMs) are architected materials consisting of highly deformable soft elements connected to stiffer ones. Their capacity to undergo large local deformations implies a geometric nonlinearity. Both nonlinear and linear behaviors can be tuned by changing the geometry and the materials of the structure cf. Fig.1(a). Various nonlinear wave effects have been studied and unveiled, including pulse vector solitons, rarefaction solitary waves, transition waves, and topological solitons through bistable structures [1]. Many interesting wave phenomena are expected to occur, including the manifestation of modulation instability (MI) [2] ; up to now theoretically described and numerically observed. Moreover the formation of localized waves, such as discrete envelope solitons (bright and dark solitons) or breather solitons [3] represent intriguing phenomena that hold the potential for yielding conclusive results in the flexMM thematic.

In this presentation, we are interested in modulated wave propagation along flexMMs. Using a lump element approach, we formulate discrete equations that describe the longitudinal and rotational displacements of each individual rigid unit mass constituting the chain. In a second part, analytical and numerical tools employed in order to find an effective nonlinear Schrödinger (NLS) equation are discussed. The final equation describes the envelope of weakly dispersive and nonlinear waves. Leveraging on the bright and dark soliton solutions of the NLS equation, we can ascertain the required initial conditions for propagating these solitons within the lattice see Fig.1(b).

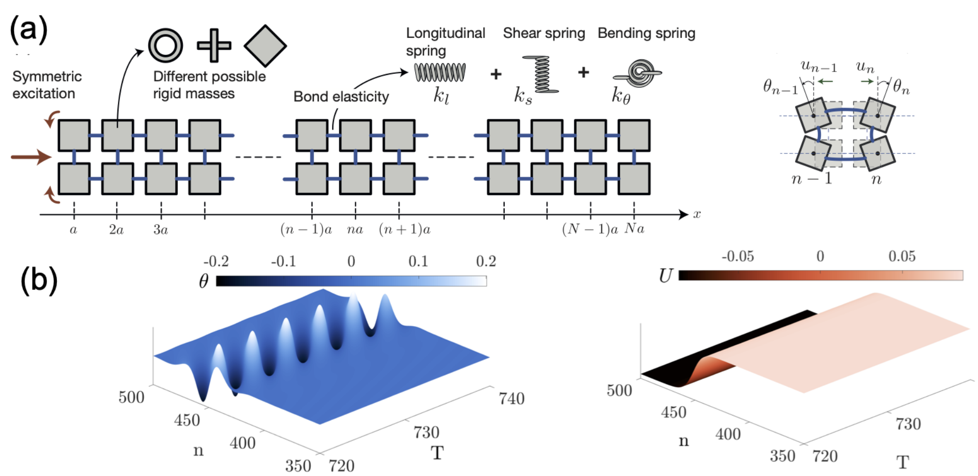

Figure 1. (a) Sketch of the flexMM under consideration. (b) Propagation of a lattice bright envelope vector soliton along the structure.

Références

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