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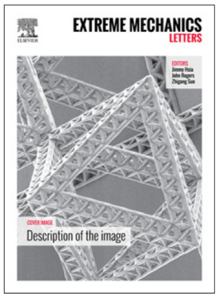

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Solitary waves in a bistable lattice

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Abstract

The design of architectured materials with bistable building blocks holds exciting possibilities. This new class of metamaterials exploits micro-level structural instabilities to obtain extraordinary physical and mechanical properties. Still, the dynamic behavior of these lattice structures is largely unexplored. Here, we study the dynamic response of a 1-D bistable lattice, i.e. a FPU chain with springs having a non-convex double-well energy potential. In addition to metamaterials, this model-problem is prototypical to a large number of systems, such as unfolding/refolding of proteins, crack propagation, plasticity, and mechanisms underlying martensitic phase transformations. We show that, depending only on the stiffness-ratio of the two energy wells of the bistable springs, the system exhibits two fundamentally different responses to impact; either the impact energy is (almost entirely) trapped in the form of large undulations of the first few springs, or the energy of the impact is (almost completely) transmitted along the chain in the form of a solitary wave that involves transition to the secondary energy-well and back. Focusing our attention to the latter, we reveal, based on analytical treatment and extensive numerical simulations, a universal feature of the solitary wave. Namely, the height of the solitary wave is indifferent to the energy barrier separating the two equilibria of the double well potential. This remarkable feature indicates that the spinodal region of the double-well potential affects the behavior only through its breadth.