Shepherding intrinsic localized modes in microscopic and macroscopic nonlinear lattices

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The possibility that large amplitude, localized vibrational excitations can exist in periodic physical lattices with nonlinear intersite forces was discovered thirty years ago. The energy profiles of these intrinsic localized modes (ILMs) - also called "discrete breathers" or "lattice solitons" - resemble those of localized vibrational modes at defects in a harmonic lattice but, like solitons, they can propagate; however, in contrast with solitons they loose energy as they move through the lattice - the more localized the excitation the faster the energy loss.

First we review the experimental E&M generation of countable intrinsic localized modes in a 1-D atomic spin lattice, where countable ILMs and their controlled switching is observed.[1] Next we demonstrate that a reexamine of the inelastic neutron scattering measurements of the thermal generation of localized vibrational modes in an NaI crystal is in order.[2]

Our most detailed ILM studies have involved the production and manipulation of localized energy along micromechanical arrays. Such a mode will stay in resonance as the driver frequency is changed adiabatically until a bifurcation point is reached. One such study involves steady state locking of ILMs, and their interactions with impurities. By measuring the linear response spectra of a driven array containing an ILM both the dynamics of bifurcation transitions and the hopping of vibrational energy have been connected to the transition properties of soft modes.[3]

Recently the search for a completely mobile ILM has focused attention on minimizing the resonance interaction that occurs between the localized excitation and small amplitude plane wave modes. Via simulations we demonstrate that when more than one type of nonlinear force is present their Fourier components can often be designed to cancel against each other in the k-space region of the plane wave dispersion curve, removing the resonance. The end result is a supertransmission channel[4] for an ILM in a discrete physical lattice. Such an engineered, intrinsic, low loss channel may prove to be a very useful property for other physical lattices treated within a tight binding approximation.

Keywords: intrinsic localized modes (ILMs), supertransmission channel

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