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Breathers and tail-breathers in a realistic model of a silicate

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Abstract—We perform a thorough analysis of breathers in a model for a layered silicate for which there exist fossil and experimental evidence of moving excitations along the close-packed lines of the K^+ layers. Some of these excitation are likely breathers with small energy of about 0.2 eV. We use a realistic model to obtain the different breathers that propagate in the system. Exact solutions are tail-breathers, that is breathers coupled to a plane wave of small but finite amplitude. The physical significance of the different solutions are analyzed.

1. Introduction

The propagation of nonlinear excitations in the K^+ layers of muscovite have been demonstrated by fossil tracks [1] and experimentally [2, 3]. The existence of moving breathers is of interest because in some mica crystals it can be seen that secondary nonlinear excitations are scattered from a primary one [4], therefore, they should have much smaller energies than primary tacks. It has also been shown that the decay of ^{40}K can lead to different types of perturbations, from kinks to breathers [5].

2. Breathers

Stationary breathers of large energies exist with frequencies above the phonon spectrum because the on-site potential is hard. The particle-centered breathers are stable while the bond-centered ones are unstable. Both can have large energies of 10-20 eV, having the bond-centered more energy. The Peierls-Nabarro barrier is large, but vanishes at frequencies very close to the phonon band where breathers cannot be obtained by continuation methods. These breathers cannot be moved with the usual techniques. However, an asymmetric compression leads to a stationary breather and a moving breather surrounded by phonons. This moving breather can be extracted and located in a clean lattice, giving rise to a long-lived moving breather but also to phonons.

3. Exact tail-breathers

The previous solution can be used as a seed to find exact breathers. These breathers are coupled with a plane wave and we dab them *tail breathers*. They have energies of around 0.2 eV which is coherent with the fossil evidence [4] for secondary tracks. They present a peculiar structure as the attached plane wave moves in opposite direction to the breather core. There is however a representation of the plane wave in the extended Brillouin zone in which both the breather core and its tail move in the same direction and at the same speed. The physical implication of the tail-breathers is considered, specially the problem of interpreting them as genuine physical solutions. In any case they provide good initial conditions for approximate moving breathers with long life.

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