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Spectrum of polarobreathers in a model for layered silicates

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Abstract— Experiments in layered silicated have shown the capability of nonlinear excitations to couple with electric charge and transport it without the presence of an electric field, a phenomenon called *hyperconductivity*. We have constructed a model for these excitations and using the theory of exact breathers in their moving frame, obtained breathers coupled to a charge that travel carried by a nonlinear localized wave.

1. Introduction

It has been observed during many years the presence of dark tracks in muscovite associated with the trajectories of swift particles as positron, muons and protons. Many other tracks appear at the directions of closed packed lines in the potassium interlayer [1]. This was demonstrated by an experiment where an alpha particle hitting one side of the crystal brings about the expulsion of an atom at the opposite side along a close-packed line of K ions [2]. The observation that only positive swift particles produced dark tracks, and that the majority of the radiation in muscovite is due to $\beta-$ decay of ^{40}K, with the subsequent recoil of a nuclei with an extra positive charge, led to the deduction that the quasi-one dimensional excitations, called *quodons* that left dark tracks in muscovite were also carrying a positive charge [3]. This property opened the way to experimentation and the transport of charge without an electric field, a phenomenon called *hyperconductivity* was observed in muscovite and other layered silicates [4]. It has been constructed a model for the movement of $^{+}$K ions in layered silicates, for which exact moving breathers were found with energies of around 0.2 eV and kinks with energies 26 eV [5].

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2. Results

In Ref. [5], the theory of exact moving breathers in the moving frame was developed. The model was augmented with an electron as a quantum particle, with serious problems of convergence due to the difference of time scales between the electron and the ions. Those problems were solved for a related phenomenological model using splitting algorithm that are symplectic and conserve the charge probability at each integration step [6].

We have adapted the algorithm to the muscovite model and obtained nonlinear excitations travelling with an electric charge, their spectrum and their physical properties will be presented in this paper.

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References

[1] F.M. Russell, Springer Ser. Mat. Sci. **221**, 3 (2015)

[2] F.M. Russell, J.C. Eilbeck, EPL **78**, 10004 (2007)

[3] J.F.R. Archilla, F.M. Russell, Letters on Materials **6**, 3 (2016)

[4] F.M. Russell, J.F.R. Archilla, F. Frutos, S. Medina-Carrasco, EPL **120**, 46001 (2017); F.M. Russell, A.W. Russell, J.F.R. Archilla, EPL **127**(1), 16001 (2019)

[5] J.F.R. Archilla, Y. Doi, M. Kimura, Phys. Rev. E **100**(2), 022206 (2019)

[6] J. Bajārs, J.F.R. Archilla, Mathematics **10**(19), 3460 (2022); J.F.R. Archilla, J. Bajārs, Axioms **12**(5), 437 (2023)