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NON-DESTRUCTIVE WAVE-MONITORING OF LOW-DIMENSIONAL SYSTEMS WITH IMPURITIES

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Анотація

На прикладі одновимірних ланцюжків силових центрів з парно-адитивною взаємодією досліджено вплив домішок (дефектів) на пропускання або відбиття хвильових збуджень. Встановлена можливість формування прозорості декорованих домішками (або з дефектами) таких систем (ефект типу Рамзауера-Таунсенда). Обговорюються можливості застосувань знайдених ефектів в задачах параметризації елементів хвильової схемотехніки, які створюються на основі анізотропних та інших складних систем.

Ключові слова: одновимірний силовий ланцюжок, хвильовий транспорт, резонанси, ефект Рамзауера-Таунсенда, хвильова схемотехніка.

Abstract

The influence of impurities (defects) on the transmission or reflection of wave excitations has been studied on the example of one-dimensional chains of power centers with pair-additive interaction. It is found the possibility of creating the transparency of decorated by impurities or defects systems by means of special values of parameters adjusted(Ramsauer-Townsend effect). Parameterization of elements of wave circuitry, which are created on the basis of anisotropic and other complex system has been shown.

Keywords: one-dimensional force-chain, wave transport, resonancei, Ramsauer-Townsend effect, wave scheme-technique.

Introduction

Applications of big conglomerations of the discrete micro-particles in many scientific and industrial areas became one of the focuses of modern physics and technologies. In this sense enough to mention optic-mechanics which became a significant sector of modern photonics and their applications. Because of the complexity of the problem it is often accepted to use low dimensional models to study the related effects which escort wave monitoring of such a systems.

Results

One-dimensional (1D) granular crystals (granular chains) consist of tightly packed elastically intertwining particles. They can be used as a test sample to study wave phenomena in chains of essentially nonlinear oscillators, and the interaction between structures, including migrating waves, breathers and dispersion shock waves [1–6]. Granular crystals can be constructed from a variety of materials of different types and sizes, so their properties are effectively regulated, and they provide a versatile functional type of meta-materials, fundamental physical phenomena and effects [1,2,7,8,9].

In this work, we will focus on the study of wave scattering on impurities in strongly pre-compressed granular chains. To this end, we first find expressions for reflection and transmission coefficients for wave scattering on a system containing one or two impurities (defects) in a closed form. For single-impurity circuits, we show that within the bandwidth, high-frequency waves are strongly attenuated (so that the transmittance is almost zero when the wave number $k \to \pm \pi$), while low-frequency waves are almost completely transmitted through the impurity. In the case of circuits with two impurities, the obtained ratios for the reflection and transmission coefficients show the presence of resonances, in the mode of which there is a complete passage at a certain frequency, in a means similar to the Ramsauer-Townsend resonance in quantum physics. We also demonstrate that the resonance frequency can be adjusted to any value in the bandwidth of the circuit spectrum. Our theoretical predictions are well correlated with experimental observations and numerical modelling.

Conclusions

The obtained results are proposed to be generalized in order to prove the existence of non-reflective regimes in granular chains (including topologically disordered ones) with deterministic distributions of multiple impurities. We discuss also the possibility of practical applications of the developed approach to provide parameterisation of the elements of scheme-technique which based on wave sensitive sensors incorporated into anisotropic or other complex systems [10].

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