Statistical Theory of Many-body Systems

Wave diagnostics of inhomogeneous inclusions in low-dimensional quasi-periodic structures

Authors: Liudmyla Sidletska[1]; Oleg Gerasymov[1]

[1] *Odessa State Environmental University*

In the classical work Rayleigh showed that a plane wave propagating in a one-dimensional periodic unbounded structure, for some wavelengths, undergoes total reflection at the boundaries of a fragment, called in the modern terminology accepted in the theory of such structures, called photonic crystals, a forbidden band. In this case (by the Bloch – Floquet theorem) the wave amplitude inside the periodic system decays exponentially [1].
In this paper, we consider a quasi-one-dimensional, semi-bounded layered periodic structure, in which the first (in order) layer has characteristics (refractive index, dielectric constant) that differ from other elements. We postulate that such a construction can serve as a model, for example, of a granular chain starting from an isotopic defect (or from an impurity particle).
In this work, a criterion is established for the condensation of the spectrum near one of the boundaries of the forbidden zone corresponding to the non-propagating wave mode. In a real prototype, a granular chain, such a mode (for example, in an electromagnetic wave) is, as it were, "arrested" in a certain vicinity of the impurity.
As a result, it was demonstrated how, when the symmetry of the initial state of the system is violated, say, due to the formation of defects (or deterministic incorporation of impurities), it is possible to form exponentially growing and decaying modes with the formation of a separate one localized in the vicinity of the defect. The established regularities can be used as the basis for wave diagnostics of impurity inclusions, as well as defects in quasi-one-dimensional quasi-periodic physical systems, for example, inhomogeneous low-dimensional crystal structures operating on the principle of a wave diode [2].

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