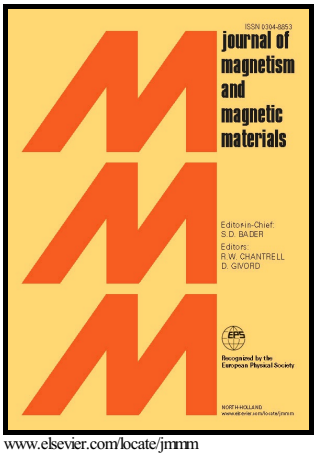

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Self-consistent approximation: development and application to the problem of waves in inhomogeneous media

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Abstract

The paper compares the new self-consistent approximation derived earlier by the authors with various existing approximations, as well as with a numerical simulation of solutions of the wave equation for a medium with one-dimensional inhomogeneities. The Green's function, found using the new approach, is the closest to the result obtained by the numerical simulation. The results show that the new approach has undoubted advantages in the study of stochastic problems in media with longwave inhomogeneities. The new self-consistent approximation in some cases has advantages over a numerical method: a more rapid process of calculation and the possibility of consideration of three-dimensional problems.

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Keywords: self-consistent approximation; Greens functions; vertex corrections; inhomogeneities; correlations; dynamic susceptibility

1. Introduction

A self-consistent approximation (SCA) is widely used in different fields of physics for the approximate calculation of Green's functions. It was proposed by Migdal in the study of electron-phonon interaction [1]. In those same years, a similar version of the SCA was independently proposed by Kraichnan [2] to investigate the effect of inhomogeneities on the dynamic susceptibility of waves in disordered media. A similar version was proposed to study the scattering of electrons in disordered media, as a generalization of the well-known non-self-consistent Born approximation, and has became known as the self-consistent Born approximation (see, e.g., [3]). We will use for all these versions the name of the standard self-consistent approximation. The standard SCA corresponds to taking into account of only the first term of the expansion of the vertex function in a series. In this approximation, there are no diagrams with intersecting lines of correlations (and those of the majority). Lack of diagrams with intersecting correlation lines imposes restrictions on both the range of applicability of the standard SCA and the accuracy of the results obtained with its help. Therefore, intensive studies of amendments to the self-energy by taking into account the next term in the expansion of the vertex function (vertex corrections) are carried out [4–13]. In these works, a significant progress in the study of the vertex corrections has been achieved. However, the discrepancy between the results of different approaches still remains significant. In [14], the self-consistent approximation of a higher level relative to the standard SCA, which taken into account both the first and second term of the expansion of the vertex function, was derived and compared with the standard SCA.

The aim of this work is to compare both the new and the standard SCA with the ladder approximation [15] and with the numerical simulation of the problem.

2. New self-consistent approximation and its properties

The derivation of the new SCA was carried out in [14]. In contrast to the standard SCA, the new SCA is described by a system of two coupled nonlinear integral equations: either for the self-energy Σ and the vertex function Γ (we omit the frequency ω in all expressions, where this does not lead to misunderstandings)

$$\Sigma_{\mathbf{k}} = \gamma^2 (2\pi)^{-d} \int \frac{S_{\mathbf{k}-\mathbf{k}_1} \Gamma_{\mathbf{k}_1,\mathbf{k}-\mathbf{k}_1} d\mathbf{k}_1}{g_{\mathbf{k}_1}^{-1} - \Sigma_{\mathbf{k}_1}}, \qquad (1)$$

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