Nonlinear electromagnetic waves in a graphene ribbon system under the deformation gauge fields

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As it is known from the literature [1], one of the main purposes of modern optics is the design of all-optical devices in which light can be controlled by light. The object of investigation should be a material with pronounced nonlinear properties, on the one hand, and a material important from the viewpoint of practical applications, on the other hand. One of the promising directions in this area is the investigation of the propagation of ultra short light pulses in carbon nanomaterials (nanotubes, graphene). In view of all the aforementioned factors and circumstances, the study of nonlinear dynamic processes in carbon nanotubes is an important problem from both the theoretical and practical stand points.

In constructing the model of propagation of an ultrashort optical pulse in a parallel graphene ribbon system, we assume that the electric field strength vector $\mathbf{E}(x, t)$ is parallel to the ribbons and the electromagnetic wave propagates in the transverse direction to ribbon planes. For simplicity and definiteness, it is assumed that the ribbons are ideal, have a armchair conformation, and are equally spaced at 0.34 nm. The interaction between carbon nanoribbons is disregarded.

The electromagnetic field of the pulse is classically described in terms of the Maxwell equations. The evolution of an ensemble of Fermi particles is described by the Boltzman kinetic equation in the relaxation-time approximation. We obtain the effective equation for the vector potential. The equations under investigation were numerically solved according to the cross type finite difference scheme [2]. The time and coordinate steps were determined from the standard conditions of stability. The steps of the finite difference scheme were sequentially decreased by a factor of two until the solution changed in the eighth significant figure.

We have considered the gauge fields which arise in defect-free graphene ribbons due to smooth elastic deformations. We investigate the evolution of ultra short light pulses of a graphene ribbons system. The existence of stable nonlinear electromagnetic waves is confirmed by the results of numerical calculations. The influence of a electric field magnitude on the wave propagation is analyzed. As result we observed effect of electrical pulse rectification.

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[2] N.S. Bakhvalov, Numerical Methods: Analysis, Algebra, and Ordinary Differential Equations (Nauka, Moscow, 1975; Mir, Moscow, 1977).