Collision of 3D bipolar light pulses in an array of carbon nanotubes

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***Abstract* - We study the propagation and collision of extremely short electromagnetic pulses in an array of semiconductor carbon nanotubes. The mathematical model takes into account non-uniformity of the pulses' fields and redistribution of electron concentration in the system. We establish a possibility of stable post-collision propagation of pulses over distances much greater than their sizes.**

Keywords - Carbon nanotubes, extremely short electromagnetic pulses, collision of pulses.

We study the interaction of three-dimensional, bipolar extremely short electromagnetic pulses propagating towards each other in an array of semiconductor carbon nanotubes[1-3] along any direction perpendicular to their axis.

Our analysis provides a full account of the effects of the inhomogeneity of the pulses' field along the axis of nanotubes[4,5]. The evolution of the electromagnetic field and the charge density in the sample was derived from the Maxwell's equations and the continuity equation respectively[6,7]. In particular, we investigate the indirect influence of the pulse's field – via the electronic subsystem of the carbon nanotubes array – on the dynamics of another pulse.

The dynamics of the changes in the shape of pulses during their propagation and interaction was analysed by calculating the distribution of the electric field in the system.

Our numerical analysis reveals possibility of a sustained post-collision propagation of pulses over distances much greater than their characteristic linear dimensions.

The key results of our study are the following.

1. For the first time, the complete set of equations describing the evolution of the field and charge density were derived for a system involving the propagation and interaction of light pulses in an array of semiconducting carbon nanotubes. Our modelling framework takes into account the influence of the inhomogeneity of the field along the axis of carbon nanotubes on the formation of a heterogeneous medium.

2. The dynamics of the indirect interaction of electromagnetic pulses in an environment with dynamic heterogeneities was studied by using a method based on two complementary quantities: the distribution of energy density of the electric field (as a characteristic of the field localization) and the projections of the Poynting vector (as a characteristic of the propagation direction of the field).

3. The used numerical model allowed for investigations of different scenarios of the interaction of bipolar electromagnetic pulses in an array of carbon nanotubes. It was established, that after the collision, pulses separate, restore their shape and keep a steady motion, moving over distances much greater than their characteristic linear dimensions.

4. The electromagnetic bipolar pulses induce a dynamic heterogeneity of the electron density in the medium, which in turn can influence the evolution of the electromagnetic waves in the environment that may have possibly far-reaching implications for the development of novel optoelectronic devices.

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