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Electrodynamics of Deformable Solids with Quasiparticle Current Carriers

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Abstract. Current carriers, as well as all elementary excitations in crystalline structures are quasiparticles with complicated dispersion laws describing the dependence of their energy on quasimomentum. Quasimomentum is a quantum number which appears due to the lattice periodicity and has nothing to do with the free electron momentum $\boldsymbol{p} = m\boldsymbol{v}$. Its values are confined in a finite cell – the Brillouin zone, and the energy spectrum consists of energy bands. These are the foundations of the quantum theory of solids. It works perfectly in an undeformed body in rest. The dispersion relation (the energy spectrum) does not depend on the free electron mass, m. However, this is the quantity responsible for inertial effects (e.g. Stewart-Tolman effect, gravitation etc.). How to unify "particle" and "quasiparticle" behavior.

In this work I report a general nonlinear self-consistent theory of electron behavior in a crystalline body subjected to time-varying deformation. The theory is exact in the frame of the quasiparticle approach. It is based on the first principles of the classical and quantum mechanics. New mechanics in a Hamiltonian form is developed to replace the Newtonian one. Transformations to replace the Galilean ones (not valid in lattice structures) are derived. A new Boltzmann-type transport equation is derived to take into account the collective properties of the quasiparticle gas. Nonlinear theory of elasticity in new variables is derived. Finally all these equations are combined with the Maxwell equations.

The theory is applied to solve problems not accessible for previous theories and gives essentially new results. It can be applied to different quasiparticles (not only electrons).

More details can be found in my monograph (in Bulgarian) as well as in the literature in English cited there:

Д. Пушкаров, "Електродинамика на кристални твърди тела с квазичастични токови носители", изд. БАН "Проф. Марин Дринов", София 2015.