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LETTERS TO THE EDITORS

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On the possibility of the existence of fractional charges 1/2

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Abstract. Arguments are advanced against a recently proposed scheme for producing excitations with the fractional charge 1/2 in liquid helium.

The September 2006 issue of *Uspekhi Fizicheskikh Nauk* (*Physics – Uspekhi*) contained a paper by Bykov entitled "Fractional charge: a new trend in electronics" [1]. In that review paper, the author hypothesized about the feasibility of producing objects carrying half the electron charge and the mass of ordinary electrons. This proposal raised justified remarks from Rubakov [2] and Pitaevskii [3] that such a situation is impossible. I adduce additional arguments why the division of an electron into two is doomed to failure.

As quite correctly noted in [2], Bykov's paper may be divided into two radically different parts. The first part describes the situation where the charge of a particle is distributed over two spatially separated regions. The second part is a review of results in the area of the fractional quantum Hall effect, which testify to quasiparticle excitations of a multielectron system that manifest themselves as objects with the fractional charge $e/3$ (and possibly $e/5$). The approach described in the second part proves its value, because it describes complicated multiparticle processes in terms of the dynamics of a small number of quasiparticles.

But as regards the first part, the Schrödinger equation, which describes the physical processes in a two-well system, exhibits the dynamics of a single particle of charge e. Trying to replace it in some consistent way by a dynamic equation for two objects with charges $e/2$ is doomed by numerous mathematical difficulties.

The author mentions the possibility that a bubble in liquid helium divides into two independently existing parts containing half an electron each. Unfortunately, the description of electron distribution in terms of the wave function, which the author uses in calculations, is possible only under coherence conditions. When the bubbles recede from each other by a macroscopic distance due to the interaction with the environment, for instance electromagnetic oscillations, a collapse occurs and the electron finds itself in one of the bubbles with probability 1/2. The electron density matrix becomes diagonal but retains its symmetry. Naturally, the outcome of every specific experiment is asymmetric, although the expected probability distribution prior to measurement is symmetric.

Similar estimates of the decoherence level in a two-well semiconductor system [4], in which the potential wells are produced by an external potential and the electron therefore need not even be present in the well to prevent the well from collapsing, show that the decoherence rate at a temperature close to absolute zero nevertheless increases rapidly in proportion to the squared distance between the wells, which corresponds to the distance between the centers of bubbles in liquid helium. For shorter distances of the order of 100 nm, the quantum superposition of electron states has recently been observed in the successful experiment in [5].

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