Review of: "The number of free electrons per atom in a metallic conductor"

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In the paper, the author considers a metallic conductor with a high concentration of electrons. At the same time, the author uses Drude's classic theory and comes to certain contradictions.

This work is a classic example of using an insufficient approximation to describe a physical problem. In Drude's theory, conduction electrons are considered like solid spheres that move in a straight line between collisions. For many cases (quasi-classical approximation), this consideration can give positive results. However, for materials of high conductivity, which are characterized by a high concentration of current carriers, the use of the quasi-classical approximation is not correct. Here, the electron gas is is Fermi gas, it is described by the Fermi-Dirac distribution function, and must be analyzed by the methods of quantum mechanics.

I note that quantum particles are generally more blurred in space. In particular, from the analysis of the probability density for electrons in the hydrogen atom for series of quantum states, we obtain maxima at much larger values of the radial variable than, for example, the radius obtained from the Bohr-Sommerfeld quantization rule. Moreover, such blurring in space is also characteristic of a quantum oscillator, in comparison with a classical one: there the probability density turns into 0 far beyond the classical turning points.

Therefore, it is clear that the estimate given in the work of the radius of the sphere corresponding to the conduction electron is actually a very approximate estimate, not entirely correct for the quantum electron gas.

Regarding the speed, which is perceived as a derivative of the displacement over time (classical approach), I note that in quantum gas they operate with such a concept as momentum (the integral of motion related to the homogeneity of space) and for analogy with classical physics (for illustration) they use the fraction from dividing momentum by mass. Because in quantum mechanics, the time derivative of a physical quantity also contains a commutator term of the Hamiltonian with the physical quantity.

Thanks to the Drude theory, scientists obtained such characteristics of the electron gas as the length of the free path and the relaxation time, but this theory is not sufficient to explain such multiparticle effects as the shielding of the Coulomb potential or the occurrence of polaritons. Because this theory does not allow consideration of multi-particle interaction, other than the collision of spheres of a certain radius.

I consider the work a vivid example of the use of an insufficient approximation and the contradictions obtained in it an

illustration of the fact that the electron gas in copper should be analyzed only as fermions.