On the physical nature of superfluidity and superconductivity

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The possible connection of superfluidity and superconductivity with the nonequivalence of forward and reversed processes in quantum physics is discussed.

"Superconductivity and superfluidity are similar phenomena. Superconductivity can be regarded as superfluidity of electron gas. This suggests that the nature of these phenomena should be based on the same mechanism. Despite the fact that superconductivity and superfluidity were discovered many decades ago, the physics of these phenomena remains unclear." [1, 2].

Today, these phenomena are described using phenomenological theories that do not involve a detailed explanation of the physical mechanism. Superconductivity is described by the phonon theory (so called the BCS-theory) [3], and superfluidity is described by the theory as the formation of a Bose-Einstein condensate [4].

"However, the phonon mechanism destroyed the hypothetical link between superconductivity and superfluidity. There are no phonons into liquid helium which is able to combine its atoms in a single ensemble… Such descriptions of superconductivity and superfluidity create a sense of dissatisfaction due to the fact that is not found the overall mechanism of occurrence of these related phenomena" [1, 2].

As an abstract physical justification, it is assumed that electrons or atoms can be bound together by some attractive energy. This attraction does not allow particles to disperse if the energy of this scattering is less than the energy of attraction.

Here we briefly consider a possible physical explanation of superfluidity and superconductivity based on taking into account the nonequivalence of forward and reversed processes in quantum physics. There is quite a large number of direct and indirect experimental evidence of such nonequivalence (time reversal noninvariance) [5]. The nonequivalence manifests itself in the fact that the differential cross section of the quantum process inverted to the initial state can exceed the corresponding differential cross section of the forward quantum process by several orders of magnitude.

The specific physical mechanism of superfluidity and superconductivity can be represented as follows. 1) An electron moves in a superconductor or a helium atom in a liquid. This is the initial state of the quantum system. 2) An electron collides with a lattice atom or a helium atom collides with another atom and loses some of its energy. This is a forward quantum

process of energy dissipation. 3) The electron or atom collides with another atom (or with the same one) and, due to an effective reversed quantum process, receives back the same previously lost energy. The initial state of the quantum system is restored. This is the reverse process for dissipation. It must proceed with a decrease in entropy. Yes, this is a violation of the second law of thermodynamics.

Here we can discuss the possibility of the existence of a perpetuum mobile [6]. Actually, the movement of a fluid without friction (superfluidity) can be considered as a special variant of a perpetuum mobile. Although it is unlikely that it will be possible to extract energy in this way.

The nonequivalence of forward and reversed processes presupposes the existence of a quantum system's memory of its initial state [7]. Under conditions of dissipation, this memory (entropy) tends to accumulate, burrow, weaken. At the same time, the efficiency of the reversed quantum process decreases rapidly. The speed of this decrease is determined by the number of degrees of freedom of the quantum system and its temperature. He^3 (unlike He^4) has an additional degree of freedom. Perhaps this explains such a low temperature of its transition to the superfluid state.

Today there is no clear experimental evidence of the connection of superfluidity and superconductivity with the nonequivalence of forward and reversed quantum processes. But it will be surprising if such a connection is not confirmed in the future. Time reversal non-invariance is a fundamental property of quantum physics [7]. It manifests itself almost everywhere [5]. The fact that the scientific community is in no hurry to recognize this fact does not make the experimental evidence less obvious.

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