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Rotation of Charge Carriers, Cooper Pairs, Superconductivity

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Abstract

Topic: The phenomenon of superconductivity.

Objective: To identify the physical causes of superconductivity.

Subject of Research: The electric field of a rotating charge carrier.

Research Method: Application of the principles of the system theory of the electric field, as outlined in the reference 1.

Main Results:
1. The emergence of an electrokinetic field initiated by the rotational motion of a charge carrier has been established, and its primary characteristics have been determined.
2. It has been discovered that a rotating electron, due to the radial component of the electrokinetic field, can act as a center of attraction for another non-rotating electron; this explains the formation and existence of a pair of bound electrons, known as a Cooper pair.
3. A description of the crystal structure formed under certain conditions within the electron gas of metals is provided.
4. It is shown that the electron crystal possesses a positive surface charge, which prevents it from colliding with the ions of the crystal lattice. The prevention of these collisions leads to a reduction in the electrical resistance of the metal, ultimately resulting in a transition to a superconducting state.

Keywords: charge carrier rotation, electrokinetic field, potential, field strength, cooper pairs, electronic crystals, superconductivity

Introduction

Historically, there are three theories of superconductivity: the London brothers' theory, the Ginzburg-Landau theory, and the BCS theory. All three theories are phenomenological in nature, meaning they do not reflect the cause-and-effect relationships in the mechanism of the emergence and existence of superconductivity. The underlying reason for such a superficial understanding of the superconductivity mechanism is the use of electromagnetic theory to describe the phenomenon. Due to its inherent flaws, this theory has proven incapable of explaining a multitude of phenomena, including superconductivity. For this reason, the system theory of the electric field, the foundations of which are outlined in[1], was used for this research.

The basic premise of this theory is the concept of the electric field as a continuous material medium, the behavior of which, by virtue of its materiality, can be described using the laws of continuum mechanics.

In the first section of this paper, the characteristics of the electric field of a rotating charge carrier (the electrokinetic field) are identified, and mathematical expressions are derived for calculating the scalar potential, vector potential, and field intensity. Unlike the electrostatic field, the electrokinetic field gives rise to two intensity components: radial and polar. The radial intensity of the electrokinetic field has specific features:

1. the radial intensity vector of the electrokinetic field is always directed opposite to the direction of the electrostatic field intensity vector;
2. the radial intensity does not depend on distance and, at certain distances, may exceed the magnitude of the electrostatic field intensity.

The polar intensity vector of the electrokinetic field, in the case of a positive charge, is directed from the equatorial plane toward the poles of the rotating charge carrier; furthermore, this intensity does not depend on the radial distance.

The second section is devoted to the formation of Cooper pairs. A rotating electron acts as a carrier of an electric field formed by the superposition of electrokinetic and electrostatic fields. At distances where the magnitude of the electrokinetic field intensity exceeds that of the electrostatic field, the electron's field intensity takes on a direction characteristic of a positive charge field. This leads to the attraction of a non-rotating electron, resulting in the formation of a Cooper pair.

The third section examines the formation of electronic crystals as structures composed of Cooper pairs. The electric field on the surface of such a crystal exhibits the characteristics of a positive charge field. This field orientation prevents the electronic crystal from colliding with the positively charged ions of the metal crystal lattice. Consequently, there is no dissipation of electric current energy, and the electrical resistance of the metal becomes zero.

The totality of the described processes provides a comprehensive understanding of the nature of the superconductivity phenomenon.

1. The electric field of a rotating charge carrier

Let us assume that a sphere of radius R is located at some point O in space. We charge this sphere by compressing another charged conducting sphere of infinitely large radius. The work A performed during the compression to radius R is converted into the electrostatic field energy W_{es}, the value of which can be easily calculated using Coulomb's law.

$$W_{es} = -A = \frac{Q^2}{8\pi\varepsilon_0 R}, \tag{1.1}$$

As shown in,[1, p. 71] the energy is localized within the electric field occupying the interior space of the sphere. In mechanics, such a field state is defined as a state of volumetric (hydrostatic) compression. This justifies considering the electrostatic energy density w_{es} to be uniform at all points within the sphere and equal to the derivative of the electrostatic energy W_{es} with respect to the volume V of the sphere

$$w_{es} = \frac{dW_{es}}{dV} = \frac{Q^2}{32\pi^2\varepsilon_0 R^4} \tag{1.2}$$

The mass density ρ of the field is defined by Einstein's equation.

$$\rho = \frac{w_{es}}{c^2} = \frac{-Q^2}{32\pi^2\varepsilon_0 c^2 R^4} \tag{1.3}$$

The analysis of the interaction between charge carriers moving relative to each other, performed in,[1, p. 74] has established that, in addition to forces, this interaction gives rise to torques that cause the carriers to rotate. In the case where the charge carriers are electrons forming an electron gas in metals, this rotation, as will be shown below, leads to a change in the properties of the electric field. It follows that it is first necessary to investigate the causes of these changes.

Taking into account the aforementioned localization of the electric field by a rotating object, we shall consider a fragment of this field in the form of a ball of radius R located within the charge-carrying sphere. Let the charge carrier rotate with a constant angular frequency ω = const about an axis passing through its center. The electric field, being inextricably linked to the moving elementary carriers, will also be set into rotation.

In addition to electrostatic energy, the electric field in this case will acquire electrokinetic energy, which depends on the moment of inertia and the angular velocity of rotation. Since the moment of inertia of individual ball layers is are not equal, the electrokinetic energy of these layers will also differ at the same angular velocity (being maximal at the equator and minimal in the polar region). Let us express this consideration in mathematical form.

Let us introduce a spherical coordinate system (r,θ,ψ) and represent the ball as a collection of ball layers of height Δh, one of which is shown in Figure 1.

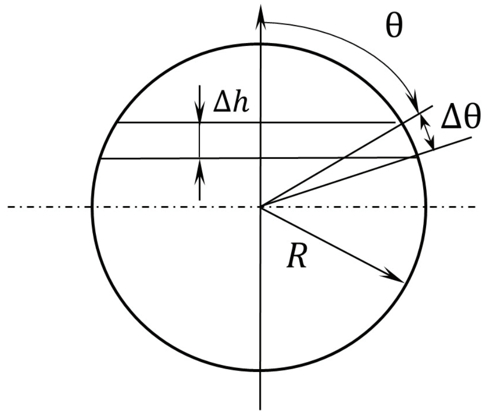

Figure 1

The height of the ball layer Δh is determined by the radius of the sphere R and the angular coordinate θ, such that $\Delta h = R\Delta\theta \sin\theta$. We then isolate an elementary fragment within this layer with a volume $dV_s = 2\pi rR\Delta\theta \sin\theta\, dr$ and, by integrating, determine the volume V_s and the mass m_s of the layer,

$$V_{b.l} = \int_0^{R\sin\theta} 2\pi r dr\ R\Delta\theta \sin\theta = \pi R^3 \sin^3\theta\,\Delta\theta, \tag{1.4}$$

$$m_{b.l} = \int_0^{V_{b.l}} \rho d_r V_{b.l} = \frac{-Q^2}{32\pi^2\varepsilon_0 c^2}\int_0^R \frac{3\pi R^2}{R^4} dR\ \sin^3\theta\,\Delta\theta = \frac{3Q^2}{32\pi\varepsilon_0 c^2 R}\sin^3\theta\,\Delta\theta\,. \tag{1.5}$$

The moment of inertia of the layer, $J_{b.l}$, is given by:

$$J_{b.l} = \frac{1}{2}\, m_{b.l} R^2 \sin^2\theta = \frac{3Q^2R}{64\pi\varepsilon_0 c^2}\sin^5\theta\,\Delta\theta. \tag{1.6}$$

Knowing the moment of inertia, we determine the electrokinetic rotational energy of the layer, $W_{b.l}$:

$$W_{b.l} = \frac{1}{2}\omega^2 J_{b.l} = \frac{3\,Q^2\omega^2R}{128\,\pi\varepsilon_0 c^2}\sin^5\theta\,\Delta\theta\,. \tag{1.7}$$

Let us move from considering the characteristics of individual ball layers to determining the properties of the ball as a whole entity. To this end, we let the angular increment $\Delta\theta$ be an infinitesimal quantity, $\Delta\theta \to d\theta$. Then, the energy of the layer $W_{b.l}$ can be treated as an infinitesimal increment (differential) of the electrokinetic rotational energy of the entire ball, $W_{b.l} \to dW_{ek.rot}$:

$$dW_{ek.rot} = \frac{3\,Q^2\omega^2R}{128\pi\varepsilon_0 c^2}\sin^5\theta\, d\theta \tag{1.8}$$

From this, it follows a formula representing the energy distribution as a function of the polar coordinate θ for a fixed value of R:

$$\frac{dW_{ek.rot}}{d\theta} = \frac{3\,Q^2\omega^2R}{128\,\pi\varepsilon_0 c^2}\sin^5\theta\,. \tag{1.9}$$

Electrokinetic energy serves as the basis for expressing all other properties of the electrokinetic field. By taking the derivative of the previous expression with respect to charge, we obtain the distribution of the scalar electrokinetic potential along the polar coordinate:

$$\varphi_{ek.rot} = \frac{d^2W_{ek.rot}}{d\theta\ dQ} = \frac{3\,Q\omega^2R}{64\pi\varepsilon_0 c^2}\sin^5\theta\,. \tag{1.10}$$

The resulting dependence shows that, unlike electrostatics, where the surface of a charged sphere is equipotential, the electrokinetic potential of a rotating sphere is zero at the poles and reaches its extremum in the equatorial region.

The vector electrokinetic potential $\boldsymbol{A}_{ek.rot}$ is defined as the derivative of the potential $\varphi_{\mathrm{ek.rot}}$ with respect to the linear speed $v(\theta) = \omega R \sin\theta$ of elements of the field. This yields:

$$\mathbf{A}_{ek.rot} = \frac{3\,Q\omega}{64\pi\varepsilon_0 c^2}\sin^5\theta\,\mathbf{1}_v, \tag{1.11}$$

where $\mathbf{1}_v$ is the unit vector of the linear velocity vector **V**.

The force exerted by an electric field on an external charged body is determined by the field intensity E, which, in the case under consideration, includes not only the electrostatic component $\mathbf{E}_{es}$ but also an electrokinetic component (due to rotation) $\mathbf{E}_{ek}$, such that $\mathbf{E} = \mathbf{E}_{es} + \mathbf{E}_{ek}$. Since the formulas for electrostatic intensity are well-established in reference literature, we shall focus solely on determining the electrokinetic intensity. Based on the underlying causes, we subdivide the electrokinetic intensity into a gradient component $\mathbf{E}_{grd} = -\,\mathrm{grad}\,\varphi_{ek.rot}$ and an inertial component $\mathbf{E}_{inr} = -\,(\mathrm{d}\mathbf{A}_{ek.rot}) / dt$, thus $\mathbf{E} = \mathbf{E}_{es} + \mathbf{E}_{grd} + \mathbf{E}_{inr}$,

$$\mathbf{E}_{grd} = -\frac{3\,Q\omega^2}{64\pi\varepsilon_0 c^2}\sin^5\theta\;\mathbf{1}_r - \frac{15\,Q\omega^2}{64\pi\varepsilon_0 c^2}\sin^4\theta\cos\theta\,\mathbf{1}_\theta. \tag{1.12}$$

Under uniform rotation, where ω = const, the inertial component $\mathbf{E}_{inr}$ vanishes; therefore, the resultant field intensity **E** is given by

$$\mathbf{E} = \mathbf{E}_{es} + \mathbf{E}_{grd} = \frac{Q}{4\pi\varepsilon_0}\left(\frac{1}{R^2} - \frac{3}{16}\frac{\omega^2}{c^2}\sin^5\theta\right)\mathbf{1}_r - \frac{15\,Q\omega^2}{64\pi\varepsilon_0 c^2}\sin^4\theta\cos\theta\,\mathbf{1}_\theta. \tag{1.13}$$

Formulas (1.10)–(1.13) provide a means to calculate the key force characteristics of the electrokinetic field of a rotating charge carrier, representing the main outcome of this study. Analyzing these formulas leads to important insights into how the rotation of a charge carrier affects its electric field. Primarily, it is worth noting that the field of a rotating charge carrier is a superposition of an electrostatic field and an electrokinetic field induced by rotation. The electrokinetic field possesses properties that differ substantially from those of the electrostatic field. The main differences are as follows:

1. The electrokinetic field strength \mathbf $\mathbf{E}_{ek}$ is independent of the distance R.
2. The electrokinetic field strength has two components: radial and meridional (polar).
3. The vector of the radial component of the electrokinetic field strength is opposite to the vector of the electrostatic field strength $\mathbf{E}_{es}$.
4. At a polar angle θ = π/2 and an angular frequency $\omega = 4c/(\sqrt{3}R)$, the radial component of the electrokinetic field strength becomes equal to the electrostatic one; for this reason, the strength of the superposition of the fields becomes zero.
5. At an angular frequency $\omega > 4c/(\sqrt{3}R)$ and a polar angle close to π/2, the strength of the superposition of the fields changes its sign; i.e., the field of a rotating electron, for example, acquires the properties of a field created by a positive charge, with the distinction that its strength remains independent of the distance R.
6. The field strength vector in the polar regions retains its direction, which is characteristic of the carrier in its static state.
7. The electrokinetic field strength does not depend on the direction of rotation, as the square of the angular frequency contains in the formulas.
8. The vector of the polar component of the electrokinetic field strength is directed "from the equator to the poles" when a positive charge carrier rotates, and in the opposite direction when a negative charge carrier rotates.

Detailed visualization of the superposition of field lines is shown in Figure 2.

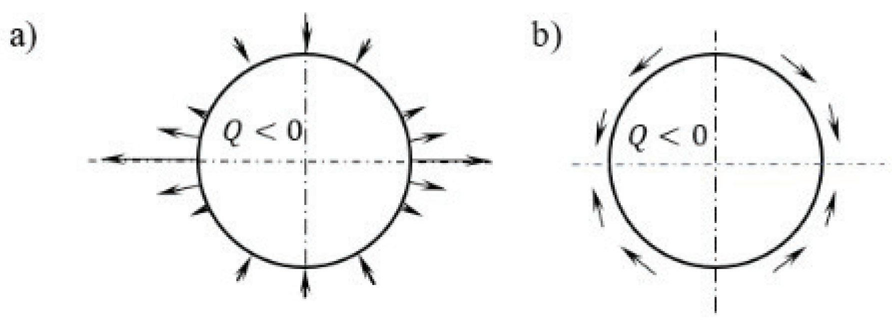

Figure 2: a) radial component of the resultant field strength; b) polar component of the resultant field strength.

In the following explanation of the associated phenomena, we will use the icon shown in Figure 3 as a mnemonic for the radial component of the resultant field, rather than its field line pattern. The "plus" sign denotes a field corresponding to a positive charge, and the "minus" sign denotes a negative charge.

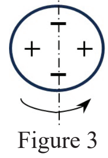

Figure 3

2. Formation of Cooper pairs

2.1 Traditional explanation

A Cooper pair is defined as two conduction electrons that, in some way, maintain their spatial unity despite the Coulomb repulsive force. This state was first described by L. Cooper, after whom such electron pairs were named.

Regarding the mechanism of Cooper pair formation, there are two extreme points of view. One leads into the realm of mystical doctrine, suggesting the use of quantum mechanical formalism for a full explanation of electron pairing; the second honestly admits that a completely satisfactory microscopic theory of superconductivity is currently absent[2] (this was stated 60 years ago, and nothing has changed since then).

Between these extremes, the electron-phonon explanation for the formation of Cooper pairs, proposed by Cooper himself, is currently recognized as satisfactory. He pointed out the possibility of forming a bound state of two electrons due to the dynamic interaction of conduction electrons with the vibrations of the ionic crystal lattice. When an electron passes by ions, it attracts them and creates a disturbance in the electric field of the ions behind it, which draws another electron into this region.

This mechanism is described in the MIPT lectures[3] as follows: Suppose an electron in a state characterized by a wave vector k_1 generates a phonon while interacting with the ionic lattice. In this process, its state becomes k'_1, and the excited phonon acquires a wave vector K. If this resulting phonon is then absorbed by a second electron, this (second) electron also changes its state $k_2 \rightarrow k'_2$. These facts lead to the conclusion that the change in the wave vectors of the two electrons corresponds to the existence of an effective interaction between them.

For the unconditional acceptance of the described mechanism, one would have to explain how an electron with a mass of 9.1×10^{-31} kg can induce oscillations in an ionic lattice, where each node has a mass six orders of magnitude greater than that of an electron. For instance, lead, which was one of the first materials to exhibit a superconducting state, has a lattice node mass of approximately 3.45×10^{-25} kg. To concede that electrons are capable of inducing oscillations in such a massive ionic lattice and generating a phonon is only possible for those at the initial stage of studying mechanics or those who subscribe to some mystical theory.

Furthermore, in the time elapsed between the electron's interaction with the lattice and the absorption of the resulting phonon by another electron, the first electron would be pushed so far away from the interaction site by the lattice reaction that any pairing of these electrons would be impossible. During this interval, the first electron would have interacted multiple times with other objects in the crystal lattice, changing its wave vector arbitrarily many times over.

The obvious dubiousness of the electron-phonon theory regarding the origin and existence of Cooper pairs makes it urgent to explain the phenomenon in some other way, free from these shortcomings. Below, a physically grounded mechanism for the formation of electron pairs is proposed, based on the theory outlined in the first section of this article.

2.2 Physical causes of Cooper pair formation

First of all, let us define the material entity that we will henceforth refer to as an electron. Any body is an inseparable combination of a certain corpuscle (a carrier of a particular field) and the field itself, specifically, an electric field. Electrons within atoms are no different from any other material bodies; each of them also consists of a charge carrier and an electric field. At present, the spatial dimensions of the carrier are assumed to be very small, and sometimes the carrier is even considered to be a point particle; however, this does not justify the claim that the concept of "rotation" is inapplicable to an electron. The electric field of an electron is a material object and, therefore, cannot be devoid of the ability to participate in various types of motion, including rotation. In this case, the rotation of an electron about its own axis should be understood as the rotation of its electric field as well.

Let two electrons be located at a distance r from each other, one of which rotates with an angular frequency ω. Using formula (1.13), we shall find the force **F** with which the rotating electron acts upon the second electron of the pair under consideration.

$$\mathbf{F} = \frac{q^2}{4\pi\varepsilon_0}\left(\frac{1}{R^2} - \frac{3}{16}\frac{\omega^2}{c^2}\sin^5\theta\right)\mathbf{1}_r - \frac{15\,q^2\omega^2}{64\pi\varepsilon_0 c^2}\sin^4\theta\cos\theta\,\mathbf{1}_\theta. \tag{2.1}$$

Assume that the distance between the charge carriers and the angular frequency are sufficiently large such that the first term in the parentheses can be neglected in comparison with the second. In this case, the force F, which has two components radial $\mathbf{F}_r$ and polar $\mathbf{F}_\theta$ takes the form:

$$\mathbf{F} = \mathbf{F}_r + \mathbf{F}_\theta = -\frac{3\,q^2\omega^2}{64\pi\varepsilon_0 c^2}\sin^5\theta\mathbf{1}_r - \frac{15q^2\omega^2}{64\pi\varepsilon_0 c^2}\sin^4\theta\cos\theta\,\mathbf{1}_\theta. \tag{2.2}$$

The presence of the polar component $\mathbf{F}_\theta$ causes the non-rotating electron to move toward the poles of the rotating electron. The radial component $\mathbf{F}_r$, which reaches its maximum value in the equatorial plane (polar angle $\theta = \pi/2$), acts as an attractive force for the non-rotating electron. As a result, we obtain an attraction effect between two charged bodies, each of which was characterized by a negative charge in the static state, but one of which, due to rotation, has acquired a field characteristic of a positively charged carrier. These electrons form a bound state, the stability of which is illustrated in Figure 4, showing the plots of the electrostatic field force component $\mathbf{F}_{es}(R)$ (dashed line), the radial component $\mathbf{F}_{ek.r}(R)$ of the force generated by the electrokinetic field of rotation (dash-dotted line), and the resultant force $\mathbf{F}(R)$ (solid line) at arbitrarily specified distances $\boldsymbol{R}$.

The $F(R)$ dependence graph intersects the abscissa at $R = r_0$, which corresponds to a change in the sign of the electron interaction force. The stability of the resulting Cooper pair is manifested by the fact that at distances $R < r_0$, a repulsive force arises between the electrons (the force is positive), whereas at distances $R > r_0$, the force changes sign, becoming an attractive force.

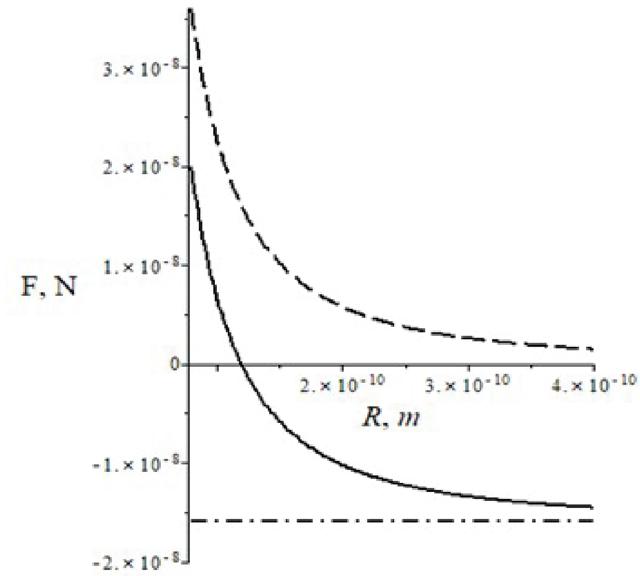

Figure 4

A distinctive feature of this explanation for the existence of Cooper pairs is the absence of any reference to the 'apparatus of quantum mechanics,' without which modern researchers cannot conceive of the development of physics, or to the Special Theory of Relativity with its contrived prohibition on motion at speeds exceeding the speed of light.

3. Superconductivity

3.1 Existing theories

At the beginning of the 20th century, experiments with liquid helium revealed that when metals are cooled below a certain critical value T_c, a sharp drop in their electrical resistance is observed. This phenomenon was named superconductivity.

The first attempt to theoretically conceptualize this discovery was the two-fluid model proposed by brothers Fritz and Heinz London. They hypothesized that a metal contains two fluids: a superconducting one and a normal one, characterized by electron concentrations n_s and n_n, respectively, which sum up to the total electron concentration characteristic of the metal at temperatures above the threshold value: $n = n_s + n_n$. Superconductivity consists in the fact that as $T \to 0$, $n_s \to n$, and as the temperature increases toward $T \to T_c$, $n_n \to n$. The theory remained silent regarding the differences between the electrons forming the different fluids, the reasons for the change in concentration, and the mechanism of this process. The only fact supporting the theory was their derivation of the ideal conductor equation relating current density and magnetic induction. However, this does not seem like a significant result today, since for $T < T_c$ only the superconducting fluid remains in the metal ($n_s \to n$), meaning the metal naturally becomes an ideal conductor.

Sometime later, V. Ginzburg and L. Landau developed their theory of superconductivity by taking a specific type of Lagrangian as the subject of their study. As is typical for mathematicians tackling physical problems, they produced a phenomenological theory in which everything was mathematically impeccable; all that remained was to devise some physical interpretation for the results obtained. This was not difficult, especially since the necessary meaningful interpretation had already been predetermined by experiments.

Dissatisfaction with existing theories led to the development of the BCS theory, which is based on the emergence of an effective attraction between two electrons located near the Fermi level. This process is described in textbook[4] as follows: "Electrons can polarize the crystal lattice, and it may turn out that the polarization regions of different electrons overlap. In that case, the total polarization can counteract the repulsion of the electrons (leading to an effective attraction)". Cooper likely had other arguments; otherwise, he would not have become a Nobel laureate. However, the textbook author failed to convey to the reader the essence of what is denoted by the mysterious terms 'lattice polarization' and 'effective attraction.' The mystery of electron attraction remained unresolved.

In terms of the inadequacy of the explanation, these considerations are equivalent to the author's reasoning in lecture,[3] presented in subsection 2.1.

The need to clarify the physical causes of superconductivity served as the impetus for developing the ontological model of the phenomenon presented below. As it turned out, superconductivity arises as a result of the formation of electronic structures caused by the rotational motion of electrons.

3.2 Superconductivity due to the formation of electron crystals

It was shown above those two electrons, one of which is rotating, can form a stable pair. The role of the positively charged particle in this pair is played by the equatorial region of the rotating electron, while the non-rotating electron forms the negatively charged pole. However, since the rotating electron also possesses polar regions with negative field intensity, the resulting pair remains active, attracting other rotating electrons. As a result, a volumetric electronic structure (an electron crystal) is created, the cross-section of which is shown in Figure 5. In the resulting electron crystal, the electrons lose their individuality, and their behavior becomes collective, characterized by what proponents of quantum mechanics call a single quantum-mechanical state. A distinctive feature of this electronic structure is its ability to undergo spontaneous growth through the addition of new Cooper pairs.

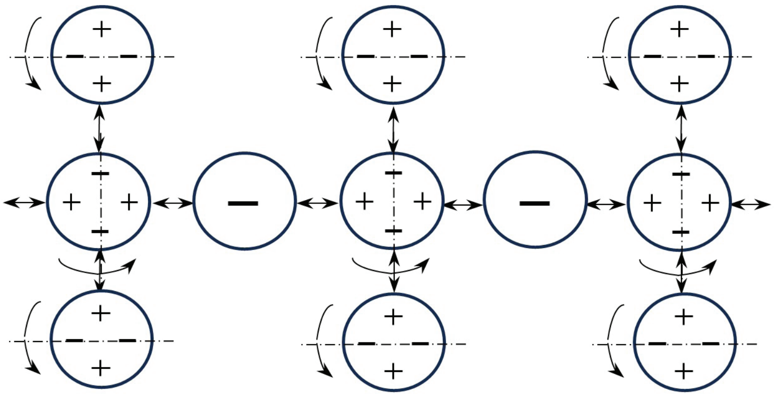

Figure 5

The presence of a positive electric field intensity at the crystal boundaries (see Figure 5) prevents its attraction to the positively charged ions of the crystal lattice. This significantly reduces (and in many cases eliminates) the energy losses that existed prior to the formation of electron crystals, which were caused by collisions of individual electrons with the crystal lattice sites. Now, such a process becomes impossible due to mutual repulsion; consequently, the electrical resistance of the metal drops to zero. The material enters a superconducting state.

The absence of electron collisions with crystal lattice sites in the superconducting state of a metal also manifests itself in a decrease in its heat capacity and a reduction in thermal conductivity. This is fully consistent with the described mechanism of superconductivity.

Another consequence of the described mechanism of electron crystal formation is the disappearance of shot noise. The phenomenon of shot noise consists of random fluctuations in an electric current flowing through circuit elements, caused by the discrete nature of drifting charge carriers. Research on shot noise in materials at low temperatures, conducted at Rice University, has shown that there is a certain temperature threshold near absolute zero below which shot noise vanishes. According to the researchers, this is direct evidence that electric current ceases to exist as the movement of discrete charge carriers and becomes a coordinated collective motion, similar to the flow of a 'liquid-like medium.' As shown above, what emerges in the electron gas is not a 'liquid-like medium,' but an ordered electronic structure with a crystalline arrangement.

Let us now briefly consider the conditions under which the formation and existence of electron crystals are possible. First and foremost, it should be noted that a prerequisite for the emergence and stability of this electronic structure in a metal is a low temperature (not exceeding tens of Kelvin). At higher temperatures, thermal vibrations of the ion lattice disrupt the bonds between electrons, causing the electron crystal to cease to exist.

In cases where a conductor in a superconducting state is part of an electrical circuit, the electrons forming the crystals are subjected to the influence of an electric field generated by the power source within that circuit. If this influence is strong enough to destroy the electron crystals, superconductivity vanishes, and the metal reverts to its normal state. For the same reason, the superconducting state can also be destroyed by an external magnetic field.

Conclusion

The present work is based on the electric field theory outlined in.[1] The main results are as follows:

1. It has been established that, unlike the electrostatic field, the electrokinetic field consists of two components: radial and polar;
2. Formulas have been derived for calculating the scalar and vector potentials, as well as the electric field intensity of a rotating charge carrier;
3. It has been discovered that the radial component of the electrokinetic field intensity is independent of distance, which ensures its long-range nature;
4. It has been established that the radial component of the electrokinetic field intensity varies in the polar direction, increasing from zero at the polar regions to a maximum value in the equatorial region;
5. It has been revealed that the radial component of the electrokinetic field intensity is always directed opposite to the electrostatic field intensity;
6. It has been discovered that, due to the radial component of the electrokinetic field, a rotating electron can act as a center of attraction for another non-rotating electron; this explains the formation and existence of a pair of bound electrons, known as a Cooper pair;
7. The aforementioned features of electric fields allow a multitude of electrons to unite into a structure of a crystalline nature, which explains the transition from individual quantum-mechanical characteristics of conduction electrons to a unified, group-based state;
8. The field intensity at the surface of electron crystals has a positive direction, which prevents them from colliding with the positively charged ions of the crystal lattice. The absence of collisions implies a reduction of the material's electrical resistance to zero, causing the metal to enter a superconducting state.

References

1. M. G. Kolonutov, Physics of Electrical Phenomena: Electric Field Mechanics (LAP LAMBERT Academic Publishing, Mauritius, 2018).
2. K. Mendelssohn, The Physics of Low Temperatures [Fizika nizkikh temperatur] (IL, Moscow, 1963).
3. "Electrodynamics of Superconductors. Fundamentals of Microscopy. Type-II Superconductors" [Elektrodinamika sverkhprovodnikov. Osnovy mikroskopiki. Sverkhprovodniki II roda]. https://kapitza.ras.ru/~glazkov/students/6/6-09-supercond-2022.pdf
4. A. R. Khokhlov, Fundamentals of Condensed Matter Physics [Osnovy fiziki kondensirovannogo sostoyaniya veshchestva]. https://teach-in.ru/file/synopsis/pdf/ofksv-M.pdf