Understanding superconductivity: a new approach

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All electrons, nucleons, and other particles undergo a persistent spin motion without possessing any infinite energy source, and therefore, they should have a unique structure that maintains their spinning and provides all the properties that they display. Additionally, because nothing in nature occurs without a reason or purpose, there should be an explanation for their persistent spinning motion. Therefore, the unique structures of electrons and nucleons, and purpose why they display persistent spinning motion have been determined. The results of these determinations provide the knowledge of a new force possessing characteristics of nuclear force and both attractive and repulsive components, and very clear and complete explanation of: 1) all the phenomena; 2) all the properties and effects of their systems; and 3) structures of their systems, e.g., deuterons, alpha particles, and nuclei; those are generated due to these particles. Present study is focussed on to provide understanding of how in substances at their transition temperature, resistance-less state, superconducting state, numerous properties, and effects, e.g., Meissner effect, levitation of magnet above the superconductor, and Josephson's tunnelling, those the substances exhibit at their transition temperature, are generated.

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1 Introduction

It is known that nothing in nature occurs without a reason or purpose. For example, the human heart beats persistently without an infinite energy source only because this beating serves an important purpose, and their unique structure that maintains this persistent beat provides all the properties that they display. Therefore, because all electrons, nucleons, and other particles demonstrate persistent spinning motions without possessing an infinite energy source, some reason or purpose should exist to explain this motion. Additionally, these particles should possess a unique structure that helps to maintain this persistent spinning and provides all their displayed properties.

It is known that all phenomena or activities relating to human hearts, including continuous blood circulation throughout the body, are consequences of the reason why the heart beats persistently, its unique structure, and properties. Similarly, all phenomena and activities related to electrons, nucleons, and other particles should be the consequences of the purpose behind their persistent spinning motion, unique structures, and properties.

Therefore, unique structures of electrons, Fig. 1, and nucleons, their properties (see Section 3, [1]), and purpose why they display a persistent spin motion (see Section 2, [1]), have been determined. The results of these determinations [see bullets 1), and 2), and bullets i), ii), and iii), Section 2] provide the knowledge of a new force which possesses the characteristics of nuclear force and both attractive and repulsive components (see Section 4.2, [1]), and provide very clear and complete explanations of: 1) all the phenomena (see Section 4.1, [1]); 2) all the properties, and effects of their systems, e.g., their beams, substances at their both the normal and superconducting states, deuterons, alpha particles, and nuclei (see Section 4.2, [1]); and 3) structures of their systems, e.g., deuterons, alpha particles, and nuclei (see Section 4.2, [1]); those are generated due to these particles.

Present study is focussed on to provide the understanding of how in substances at their transition temperature (T_c), resistance-less state, superconducting state, numerous properties, and effects, that the substances exhibit at their transition temperature, are generated.

In the present study, it has also been included to study:

1) Obstacle, that resists the motion of free electrons of the substances at their temperatures $> T_c$, but at their temperatures $\leq T_c$, the obstacle becomes such that the resistance produced by that (obstacle) becomes negligible, and the substances acquire the resistance-less state (see Section 1.1, and for its verification, see Section 1.1.1).

2) Means that orient the directions of motion of all the free electrons of the substances at their temperatures $\leq T_c$ in one direction (see Section 1.2, and for its proof, see Section 1.2.1).

The results of the determination of the purpose why electrons, nucleons, and other particles possess the property of persistent spin motion [see bullets 1), and 2), Section 2] , and of the determination of their unique structures [see bullets i), ii), and iii), Section 2], together with the knowledge of the roles of the determined obstacle (see Section 1.1), and means (see Section 1.2), provide very clear and complete understanding of how in substances at their transition temperature:

1) resistance-less state is generated (Section 1.1);

2) persistent current starts flowing and superconductivity is generated (Section 3);

3) numerous properties and effects, exhibited by superconductors, are generated (Section 4).

The properties and effects exhibited by superconductors, those have been included in the present study, are listed as follows:

i) Why and how entropy of substances decreases at their superconducting state (Section 4.1).

ii) Why and how transition temperature (T_c) varies from substance to substance (Section 4.2).

iii) Why and how substances like copper (Cu), gold (Au), and silver (Ag) do not superconduct even down to very low temperatures (Section 4.3).

iv) Why and how Meissner effect is generated (Section 4.4).

v) Why and how levitation of a magnet above the superconductor occurs (Section 4.5).

vi) Why and how diamagnetism generated in substances at their superconducting state persists, whereas, that generated at their normal state does not persist (Section 4.6).

vii) Why and how: i) the energy of free electrons of the substances is decreased at their superconducting state (Section 4.7.1); ii) the energy of free electrons of the substances goes on decreasing as their temperature decreases below T_c (Section 4.7.2).

viii) Why and how in ferromagnetic substances, superconducting state does not occur (Section 4.8).

ix) Why and how: i) normal state of a substance is restored applying a critical value of an external magnetic field H_c across that substance at that's superconducting state (Section 4.9.1); ii) H_c increases as temperature of the substance decreases below its T_c (Section 4.9.2); iii) H_c varies from substance to substance (Section 4.9.3)

x) Why and how: i) thermal conductivity of a substance is discontinuously increased when superconducting state of the substance is destroyed by the application of an external magnetic field H_c (Section 4.10.1); ii) thermal conductivity of the substance changes continuously between its two phases, and at superconducting phase, thermal conductivity is found to be lower (Section 4.10.2).

xi) Why and how: i) substance absorbs heat when superconductivity of the substance is destroyed isothermally by an external magnetic field (Section 4.11.1); ii) temperature of the substance becomes lower for the adiabatic case (Section 4.11.2)

xii) Why and how specific heat of the substance is discontinuously increased when temperature of the substance is brought down to its T_c (Section 4.12)

xiii) Why and how Josephson's tunnelling is generated (Section 4.13)

Present study includes also how substances, e.g., ferromagnetic substances, which are assumed to be non-superconducting, can be made superconducting (Section 4.8.1).

Currently, to explain superconductivity, several theories have so far been proposed. The first ever phenomenological theory of superconductivity was proposed by Fritz London and Heinz London [2] by correlating the current in a superconductor with a vector potential and using Maxwell equations. Theory explained well the vanishing of resistivity and the occurrence of Meissner effect in metallic superconductors. An expression for London penetration depth λ was given which was confirmed experimentally. Another phenomenological theory was proposed by Ginzberg and Landau (G-L theory) [3] introducing the concept of an order parameter and a temperature dependent coherence length which close to 0 K is similar to the temperature independent Pippard coherence length. The most successful theory, the microscopic BCS theory [4] ultimately came from three physicists Bardeen, Cooper and Schrieffer in 1957. They argued that two electrons with equal and opposite momenta form a bound pair (Cooper pair), a boson, via the exchange of a virtual phonon overcoming the Coulomb repulsion. These pairs condense into a ground state, a gap appears in the energy spectrum and the system turns superconducting. However, there is no evidence of phonon mediation in pair formation in these materials as evidenced from the absence of isotope effect. After many attempts and a long turmoil two theories have found some acceptance. First, is the resonance valence bond (RVB) theory [5] proposed by P.W. Anderson and other is spin fluctuation theory [6] proposed by P. Monthoux.

1.1 Determination of the obstacle

As we know, the photons are emitted from the orbiting electrons of the substances, which go on continuously. Some photons of them remain always in the substances despite absorption of some of photons again in the substances and emission out of some of photons from the surfaces of the substances. The photons remaining in the substances, during their stay/existence in substances, go on travelling here and there inside the substances and collide with their free electrons found in the way of photons, and thus they resist the motions of free electrons of the substances.

When temperature of any substance decreases, thermal energy of that's atoms and hence of that's orbiting electrons goes on decreasing. In this process of decreasing temperature of the substance, a temperature should be obtained when thermal energy of the orbiting electrons of the substance is reduced as much that some of them, e.g. the most strongly bound electrons become unable to excite to any allowed higher energy state. Then, they stop emitting photons. If the reduction in temperature of the substance continues, similarly, the lesser and lesser strongly bound orbiting electrons in succession go on becoming unable to excite, and ultimately, a temperature T_c', see Fig. 2(a), is obtained when all the orbiting electrons become unable to excite and emit photons. Then (i.e. at temperature T_c'), since the production of photons in the substance is stopped completely, the photons present inside the substance are emitted out from the surfaces of the substance. All the photons present inside the substance are not emitted out immediately from the substance, because practically it is not possible. In the beginning, the speed of emitting out happens to be very rapid, and very shortly, at temperature T_c, Fig. 2(a), the photons remaining inside the substance is reduced as much that the speed of their emission out from the substance becomes extremely slow. So, at temperature T_c, because the number of photons remaining in the substance is reduced very much, the resistance produced due to their collisions with free electrons of the substance becomes insignificant.

During span of temperature (T_c'-T_c), because the emission out of photons from the substance happens to be very rapid, resistance of the substance also decreases accordingly (i.e., very rapidly), as shown in Fig. 2(a), and, at temperature T_c, resistance of the substance is reduced to zero. So, at temperature T_c, the substance can be said to be at resistance-less state, and the temperature T_c can be said to be the transition temperature of the substance. (For its verification, see Section 1.1.1.**)**

1.1.1 Evidence to verify that at temperatures $\leq T_c$ of the substance, the number of photons in substance is reduced as much that the resistance produced due to photons is reduced to zero

In case of, e.g., mercury (Hg), as we see in Fig. 2(b) [7], after temperature 4.25° K (Kelvin), the resistance of mercury starts decreasing very rapidly, and at temperature 4.2° K, that reduces to zero, similarly, as has been described above in Section 1.1.

It verifies the truth of that the photons emitted from the orbiting electrons of the substances and remaining in them act as the obstacle that resists the motion of free electrons of the substances at their temperatures $> T_c$, and at their temperatures $\leq T_c$, the number of photons remaining in them is reduced as much that the resistance produced due to their collisions with free electrons of the substance becomes insignificant (i.e., the resistance produced due to photons is reduced to zero).

1.2 Determination of the means

The external magnetic field, placing in which the substances are cooled down to $\leq T_c$, orients the directions of linear velocity v (or of L_s) of the free electrons of the substance, which (v) the electrons obtain because of their persistent spin motion [see bullet 1), Section 2 for detail information], in one direction, according to Lorentz force (for proof of its truth, see Section 1.2.1).

The external magnetic field tries to orient the directions of linear motion (v) of free electrons of the substance at its all the temperatures (i.e., at $\leq T_c$ and $> T_c$) according to Lorentz force. At temperatures $> T_c$, due to presence of photons and their frequent collisions with free electrons of the substance, the orientation of the directions of v of free electrons of the substance fails to persist. However, at temperatures $\leq T_c$, because the number of photons remaining in substance is reduced as much that their collisions with free electrons of the substance become insignificant, the orientation of the directions of v of free electrons of the substance starts persisting.

1.2.1 Proof of that the directions of velocity of free electrons of the substances are oriented and aligned due to the external magnetic field placing in which the substances are cooled down to their transition temperatures

If we take an iron bar and place it in magnetic meridian of the earth's magnetic field, the lines of force of the earth's magnetic field pass through the body of the iron bar. Whereas, if, after magnetizing the iron bar, we place it in the same position of the earth's magnetic field, we find that the lines of force of the earth's magnetic field are now expelled out from the body of the bar, i.e. a change in flux occurs. The expulsion of the lines of force of the earth's magnetic field from the body of the bar occurs because when the bar is magnetized, its lines of force are generated, and according to property of magnetic lines of force, because they neither intersect themselves nor other lines of force, the lines of force of the earth's magnetic field are expelled out from the body of the bar.

In the same manner, the lines of force of the external magnetic field, which were earlier passing through the body of the substance, Fig. 5(a), when persistent current had not started flowing through it, are expelled out from the body of the substance (i.e. a change in flux, or Meissner effect is observed, see Section 4.4 for detail information) when the persistent current starts flowing through the substance, Fig. 5(b), it means, there is generated some magnetic field around the substance, the lines of force of which are oriented and aligned with respect to the direction of lines of force of the external magnetic field such that they stop the lines of force of the external magnetic field to pass through the body of substance. Consequently, the lines of force of the external magnetic are expelled out from the body of substance, as shown in Fig. 5(b). The lines of force, which stop the lines of force of the external magnetic field to pass through the body of the substance, are generated within the substance when persistent current starts flowing through the substance, it means, the magnetic fields which the electrons possess are oriented and aligned such that they (magnetic fields) block the lines of force of the external magnetic field to pass through the substance.

It is, therefore, confirmed that the direction of motion of electron is associated with the plane of its magnetic field, and when the persistent current starts flowing through the substance (i.e., when free electrons of the substance start moving), the directions of velocity (v) of free electrons of the substance are oriented and aligned such that the planes of their (free electrons) magnetic fields block the lines of force of the external magnetic field to pass through the substance.

Note: For further confirmation whether the external magnetic field, placing in which the substances are cooled down to their $\leq T_c$, orients the directions of v of their free electrons in one direction or not, a substance, of which T_c is known, is cooled down to its T_c without keeping it in that external magnetic field. If superconductivity is not generated in substance, the above claim is confirmed.

2 Results of the determination of the purpose why electrons and nucleons possess the property of persistent spin motion, and of the determination of their unique structures

Because the purpose (see Section 2, [1]) why electrons, nucleons, and other particles possess the property of persistent spin motion, provided due to their unique structures, is to generate in them:

1) linear velocities (v) along the directions of their respective L_S, where (v) varies with their frequency of spin motion (ω) (see Section 2.1, [1] for detail information);

2) motional energy E_M [= kinetic energy (E_K) + spin energy (E_S)] and motional momentum p_M [= linear momentum (p_{LIN}) + spin momentum (p_S)] (see Section 2.2, [1] for detail information);

all electrons, nucleons, and other particles are always found in a state of linear motion (v) oriented along their respective L_S directions. The energy (E_M), momentum (p_M), and spin angular momentum (L_S) of electrons, nucleons, and other particles are always conserved during their motion, even when the rate of velocity increase in electrons accelerated by a large voltage (see Bertozzi's experiment [8] for example) starts decreasing after they attain their relativistic velocity, or when electrons move along their elliptical orbits (see Section 2.2, [1] for details.

Moreover, because of the unique structures of electrons, and nucleons (see Section 3, [1]):

i) planes of their magnetic rings and magnetic ring's magnetic fields occur always in a plane perpendicular to the directions of their respective v;

ii) directions of their spin magnetic moments (μ_S) occur always opposite to the directions their respective v;

iii) directions of spin motion of their rings of magnetism and magnetic ring's magnetic fields occur always in clockwise direction (if the direction of their v is opposite to the face of clock).

3 Explanation of how superconductivity is generated

At temperature T_c of the substance, when the number of photons inside the specimen substance is reduced as much that they become unable to resist the flow of free electrons of the specimen due to their collisions with free electrons of the specimen, the directions of linear velocity (v) of the electrons [generated in them due to their persistent spin motion (see bullet 1), Section 2)] are found randomly oriented in all the different directions of the substance because of their frequent collisions with photons, which (photons) were earlier (i.e. at temperatures $> T_c$) present inside the specimen. The external magnetic field, placing in which the substance is cooled down to $\leq T_c$, orients and aligns the randomly oriented directions of v of free electrons of the substance in direction perpendicular to its (external magnetic field's) direction according to Lorentz force (for confirmation of its truth, see Section 1.2.1). As soon as the directions of v of free electrons of the substance are oriented and aligned, the electrons start flowing in that direction, i.e. the persistent current starts flowing through the substance in that direction. This state of substance is its superconducting state.

Once the directions of linear velocity of electrons are oriented and aligned in one direction and they start flowing in that direction, their motion persists and it is not being disturbed even after removing the external magnetic field, unless, if by some means, the photons are generated again in the substance, e.g., applying a magnetic field of strength H_c (see Section 4.9.1 for detail information).

4 Explanation of how the properties, and effects exhibited by substances at their superconducting state are generated

4.1 Explanation of how entropy of the substances decreases at their superconducting state

The decrease in entropy at superconducting state of the substance means, the system becomes more orderly. In other words, the disturbance in the substance is reduced. At temperature T_c, because all the orbiting electrons of the substance stop exciting and emitting photons, and the number of photons remaining in the substance is reduced as much that the resistance produced due to their collisions with free electrons of the substance becomes insignificant and the photons become unable to disturb the alignment of v of free electrons of the substance due to their (photons) collisions with free electrons of the substance, the alignment of v of free electrons of the substance starts persisting, i.e. the system becomes orderly. Therefore, the entropy of the substance is reduced.

4.2 Explanation of how T_c varies from substance to substance

As we know, thermal conductivity of substances varies from substance to substance, and conduction of thermal energy in substances occurs by means of transportation. The transportation of thermal energy is done by thermal energy carriers, i.e., photons, because photons are interpreted as bundles or quanta of radiation energy [9], and the radiation energy produces both the effects of heating and lighting.

Suppose thermal conductivity of substance $S_1 >$ thermal conductivity of substance S_2. It means, at same temperature, thermal energy can be conducted more easily and effectively in substance S_1 as compared to that in substance S_2. It can be possible only if, in substance S_1, more number of photons is available as compared to that in substance S_2, which means, at same temperature T, in substance S_1, its more number of orbiting electrons are excited and emit more number of photons as compared to that in substance S_2. The excitation of more number of orbiting electrons in substance S_1 can be possible if the orbiting electrons of substance S_1 are comparatively loosely bound in their respective atoms than the orbiting electrons in their respective atoms of the substance S_2.

Therefore, if we take substances, e.g., S_1, S_2, S_3 of successively decreasing thermal conductivity, more number of orbiting electrons in substance S_1 shall be loosely bound as compared to that in substance S_2, more number of orbiting electrons in substance S_2 shall be loosely bound as compared to that in substance S_3. If we start decreasing temperature of all these substance equally, the temperature T', at which suppose all the orbiting electrons of the substance become unable to excite and emit photons, shall be obtained earliest in substance S_3, and latest in substance S_1, i.e., T' for substance S_3 shall be $> T'$ for substance S_2, and T' for substance S_2 shall be $> T'$ for substance S_1. Thus, the temperature T' varies from substance to substance, and it decreases as thermal conductivity of the substances increases. Now, since T' is the temperature at which all the orbiting electrons of the substance become unable to excite and emit photons, T' is same as T'_c (see Section 1.1). Hence, T'_c varies from substance to substance, and decreases as thermal conductivity of the substances increases.

Further, because of decreasing order of thermal conductivity in substances S_1, S_2, S_3, at temperature T'_c, the number of photons found present inside the substance S_1 are happened to be more than the number of photons found present inside the substance S_2, the number of photons found present inside the substance S_2 are happened to be more than the number of photons found present inside the substance S_3. Therefore, as temperature of the substances decreases below their respective T'_c, the slope of straight line AB [Fig. 1(a)], and T_c vary from substance to substance, and decrease as thermal conductivity of the substances increase.

4.3 Explanation of why and how substances like copper, gold, and silver do not superconduct even down to very low temperatures

Substances like copper (Cu), gold (Au), and silver (Ag), which are very good conductors of electric current, do not superconduct even at temperatures down to 0.05 K. These substances are since very good conductors of heat also, and as thermal conductivity of substances increases, their T'_c and T_c decrease (see Section 4.2), therefore, T_c for Cu, Au, and Ag are happened to be very low, probably as much low that, even down to temperature 0.05 K, their T'_c and T_c are not obtained.

AN IMPORTANT NOTE: To obtain high temperature superconductors, substances of low thermal conductivity should be tried, or alloys, containing substances of low thermal conductivity, should be tried.

4.4 Explanation of how Meissner effect is generated

At temperatures $\leq T_c$ of the substance, when the directions of linear velocity v of its free electrons are oriented and aligned and consequently the persistent current starts flowing (i.e., superconducting state is generated, see Section 3), because of properties which the electrons obtain due to their unique structure (see Section 3.1, [1]): 1) the planes of their magnetic rings and magnetic ring's magnetic fields are subsequently aligned in a plane perpendicular to the directions of their respective v [see bullet i), Section 2]; 2) the directions of their spin magnetic moments (μ_S) are aligned opposite to the directions of their respective v [see bullet ii), Section 2]; and 3) the directions of spin motion of their magnetic rings and magnetic ring's magnetic fields are aligned in clockwise direction (if the direction of their v is opposite to the face of clock) [see bullet iii), Section 2].

Further, at temperatures $\leq T_c$ of the substance, when its free electrons start flowing (i.e., persistent current starts flowing), because they flow through inter-lattice passages of the substance, through every inter-lattice passage, the electrons flow in the form of number of queues. Their flow in such a manner (i.e., in the form of number of queues through every inter-lattice passage) can be assumed as, through every inter-lattice passage, the electrons are moving in the form of a beam, as shown in Fig. 3. Because the directions of v, and μ_s, and the planes of magnetic rings and magnetic ring's magnetic field etc. of the electrons are oriented and aligned, every inter-lattice beam (flowing through inter-lattice passage) obtains all the properties which the electron beams possess (e.g., electromagnetism, magnetic moment, magnetic field that possesses direction and occurs in a plane perpendicular to the direction of flow of electrons through the beam, see Section 3, [10]). The magnetic fields generated around inter-lattice beams interact, as shown in Fig. 3, in the same manner as magnetic fields around electrons interact, as shown in Fig. 2 [10], and explained in Section 3, [10]. Due to interaction between magnetic fields of inter-lattice beams:

1) A force of attraction is generated between all the inter-lattice beams, in the same manner as a force of attraction is generated between all the electrons of an electron beam against the repulsive Coulomb force generated between electrons due to similar charge on them (see Section 3, [10]). Thus, ultimately a force of attraction is generated between all the free electrons flowing through the substance and they are bound together.

2) A magnetic field is generated around and along the length of the substance which possesses direction (anticlockwise, if the electrons are moving towards the face of clock, or clockwise, if the persistent current is flowing towards the face of clock, as shown in Fig. 4) and occurs in a plane perpendicular to the direction of flow of current through the substance, as shown in Fig. 4. [In Fig. 4, the direction of current has been shown by two long arrows along the length of the substance.]

Moreover, because the electron beam possesses electromagnetism, which happens to be diamagnetism, and magnetic moment of electromagnetism of the beam occurs along the direction of alignment of μ_S of the electrons of the beam (see Section 3, [10] for detail information), due to magnetism of inter-lattice beams, the substance obtains magnetism (which obviously happens to be diamagnetism), and the magnetic moment of the magnetism thus obtained by the substance occurs along the direction of alignment of the directions of magnetic moment of the inter-lattice beams.

Thus, the substance starts behaving as a magnetic dipole, in the same manner as an electric current carrying close loop behaves as a magnetic dipole (see Section 6.2, [10]). Consequently, the magnetic lines of force of the external magnetic field, which were earlier (i.e. at temperatures $> T_c$) passing through the body of the substance, Fig. 5(a), when no persistent current had started flowing through the substance, are now expelled out from the body of the substance, Fig. 5(b), and a change in flux, i.e., the Meissner effect [11] is observed

4.5 Explanation of why and how levitation of a magnet above the surface of superconductor occurs

Above the upper surface of the magnetic dipole, obtained as the consequence of flow of persistent current through the substance (see Section 4.4), if a magnet is laid down, the magnet experiences a force of repulsion, if their similar poles lie facing to each other, and the magnet is levitated above the surface of the dipole provided the mass of magnet is such that the repulsive force on it may levitate it. If their opposite poles lie facing to each other, the magnet experiences a force of attraction, and it is not levitated.

Currently, it is claimed that the levitation of magnet takes place if the superconductor is a high temperature superconductor. The reason behind this claim may be that the magnet, which is levitated, probably happens to be heavy, and in high temperature superconductors, due to occurrence of superconducting state in them at high temperature, their free electrons possess more energy and hence more velocity that causes increase in persistent current flowing through them. The increase in persistent current increases the strength of magnetic field generated around them, and that (increase in strength of magnetic field) increases the force of repulsion on the magnet and the magnet is levitated.

4.6 Explanation of why and how the diamagnetism generated in substances at their superconducting state persists, whereas, that generated at their normal state does not persist

In substances at their temperatures $\leq T_c$, when persistent current starts flowing and the substances obtain the superconducting state, since the number of photons remaining in substances is reduced as much that their collisions with free electrons of the substances becomes insignificant (see Section 1.1), the diamagnetism generated in substances (see Section 4.4) persists.

However, in substances at their temperatures $> T_c$ (i.e., at their normal state), since the number of photons existing in them happens to quite large, due to their frequent collisions with free electrons of the substances, the alignment of the directions of v, and subsequently the alignments of: i) the planes of magnetic rings and magnetic ring’s magnetic fields; and ii) the directions of μ_S of their free electrons; which (alignments) are caused due to the external magnetic field applied to magnetize the substances, or caused due to an electric voltage applied across the ends of the substances (see Section 4, [10], are happened to be weak. Consequently, all the alignments are being destroyed very shortly when the external magnetic field or the electric voltage is removed. Thus, the diamagnetism generated in substances at their normal state does not persist and very shortly that disappears.

4.7 Explanation of why and how the energy of free electrons of the substances is decreased at their superconducting state, and that decrease goes on increasing as their temperature decreases below their T_c

4.7.1 Why and how the energy of free electrons of the substances is decreased at their superconducting state

In substances at their temperatures $\leq T_c$, when persistent current starts flowing and the substances obtain the superconducting state, due to interaction between magnetic fields of inter-lattice beams, a force of attraction is generated between all the inter-lattice beams, and ultimately between all the free electrons flowing through the substance and they are all bound together (see Section 4.4 for detail information). Due to this binding, the energy of free electrons of the substances at their superconducting state is reduced. Consequently, an energy gap is obtained between electrons of the substances at their superconducting state and the electrons of the substances at their normal state.

4.7.2 Why and how the decrease in energy of free electrons of the substances goes on increasing as their temperature decreases below their T_c

As temperature of the substance decreases below its T_c, due to decrease in: 1) thermal energy of free electrons of the substance, thermal agitation of free electrons of the substance against the binding force, which is generated between them due to interaction between their magnetic fields and binds them together (see Section 4.4), goes on decreasing; and 2) the number of photons, remaining in the substance, goes on decreasing (see Section 1.1); the binding force among electrons goes on increasing continuously. Consequently, the decrease in energy of free electrons of the substances goes on increasing as their temperature decreases below their T_c.

4.8 Explanation of why and how in ferromagnetic substances, superconducting state does not occur

As we observe that, when a current carrying close loop or a coil, which behaves like a magnetic dipole, is suspended freely between two magnetic poles of an external magnetic field, the loop/coil is rotated such that its south and north poles may lie towards the north and south poles respectively of the external magnetic field. The angle of rotation of the loop/coil depends upon: i) the strength of current flowing through the loop/coil, ii) the strength of the external magnetic field, and iii) how much the loop/coil is free to rotate.

The electronic orbits of the substances since also behave like magnetic dipoles, if it (specimen substance) is placed in an external magnetic field, its electronic orbits are also rotated, and their rotations depend upon: i) how much the orbits are free to rotate, ii) the strength of the external magnetic field, and iii) the rate of flow of electrons in their respective orbits. In accordance as the orbits of the specimen are rotated, the specimen acquires magnetism.

In ferromagnetic substances, the electronic orbits are probably so arranged in different planes and with different magnitudes of binding in their respective atoms such that when they (ferromagnetic substances) are placed in an external magnetic field, their orbits are rotated/oriented as much and in such a way that the resultant magnetism generated in them due to their orbital rotations are obtained to be quite strong.

Therefore, when a specimen of ferromagnetic substance is cooled down placing it in an external magnetic field, magnetism is generated in it due to rotation of its electronic orbits. However, the direction of magnetic moment of magnetism thus generated in ferromagnetic specimen due to orientation of its electronic orbits, lies along the direction of the external magnetic, whereas, the direction of magnetic moment of the magnetism generated in ferromagnetic specimen due to orientation of the planes of magnetic rings of the free electrons of the specimen, lies in direction perpendicular to the direction of the external magnetic field. Since the former magnetism generated in the specimen happens to be quite strong, and it is generated in the specimen at normal temperature (i.e., at temperatures $> T_c$) of the specimen as soon as the specimen is put in the external magnetic field, whereas, the later magnetism is generated in the specimen at superconducting state of the specimen (i.e., after cooling down the specimen to temperatures $\leq T_c$), the former magnetism does not let the planes of magnetic rings of the free electrons to get oriented and aligned. Then v of free electrons of the specimen are also not oriented and aligned and consequently the free electrons of the specimen fail to flow persistently through the specimen. Hence, in ferromagnetic substances, superconducting state does not occur.

In non-ferromagnetic substances too (which superconduct), their electronic orbits are rotated as the consequence of application of the external magnetic field across them, but the rotations of their electronic orbits are probably happened to be such that the resultant magnetisms generated due to rotations of their electronic orbits, happens to be insignificant or insufficient in producing an effective obstruction in orientation of the planes of magnetic rings of their free electrons.

4.8.1 Ferromagnetic substances can be made superconducting

By some means, if the directions of v of the free electrons of the ferromagnetic specimen can be oriented and aligned without keeping the ferromagnetic specimen in an external magnetic field, the ferromagnetic specimen can be made superconducting. That means can be as follows:

We take the ferromagnetic substance in form of a rod and connect its two ends through an electric circuit containing a battery and an ammeter. When an electric current is allowed to flow through the rod, the directions of motion (v) if its free electrons are oriented and aligned along the direction of their flow (see Section 4.4, [10] for its confirmation). If this rod is cooled down and an increase in current is observed in the ammeter at some temperature, it means the resistance of the rod is reduced to zero, i.e., the ferromagnetic substance can super conduct.

Now, instead of taking the ferromagnetic substance in form of a straight rod, we take the substance in form of a rod which is turned in form of a close loop and its two ends are coupled by a weak link, which (weak link) can consist of a thin insulating barrier (see Section 4.13 for detail). When an electric current is allowed to flow through this loop, due to possession of E_M and p_M by the electrons [see bullet 2) of Section 2], they transmit through the thin insulating barrier (see Section 4.13 for its confirmation) and the electric current starts flowing through the whole loop. Now this loop is cooled down, and as soon as an increase in current in the ammeter of the circuit is observed, it means T_c of the substance has reached and the resistance of the substance has reduced to zero. If the electric circuit is now removed, the persistent current continues flowing.

An important note: The above method (Section 4.8.1) can be applied in obtaining superconducting state in superconducting substances too, if this method is more economic and convenient than obtaining superconducting state keeping the substances in an external magnetic field.

4.9 Explanation of how: 1) the normal state of a substance is restored applying a critical value of an external magnetic field H_c across it at its superconducting state; 2) H_c increases as temperature of the substance decreases below its T_c; and 3) H_c varies from substance to substance

4.9.1 How the normal state of a substance is restored applying a critical value of an external magnetic field H_c across it at its superconducting state

Restoration of normal state of a substance applying an external magnetic field H_c across it at its superconducting state means, due to application of field H_c, the generation of photons in the substance is restarted. The Zeeman effect [12] confirms the generation of photons as the consequence of application of an external magnetic field. Because, in normal Zeeman Effect, it is observed that, when a strong magnetic field is applied across a source of light, a single spectral line is split into three lines, which mean, as the consequence of application of a strong magnetic field, there starts emitting two more photons, i.e., total three photons of three different frequencies instead of emission of a single photon of a single frequency. (How photons are emitted as the consequence of application of an external magnetic field, see Section 4.10.1.) The emission of two additional photons as the consequence of application of a strong magnetic field confirms that, due to application of field H_c, the generation of photons in the specimen is restarted.

The discontinuously increase in thermal conductivity of a substance, when its superconducting state is destroyed by the application of an external magnetic field H_c, also confirms the truth of generation of photons as the consequence of application of an external magnetic field H_c (see Section 4.10.1 for detail information).

4.9.2 How H_c increases as temperature of the substance decreases below its T_c

As temperature of a substance decreases below its T_c, because: 1) the emission of photons from the substance [which (emission) becomes very slow after T_c and goes on slowing, see Section 1.1) continues, and consequently the number of photons remaining in the substance goes on decreasing continuously; and 2) the binding force between electrons generated due to interaction between their magnetic fields (see Section 4.4) goes on increasing (because, as temperature of the substance decreases, thermal energy, and hence thermal agitation of its free electrons goes on decreasing, that causes an increase in binding force between electrons); the need of number of photons to destroy the alignment of free electrons of the specimen, goes on increasing. So, to fulfill this need, H_c of increasing magnitude is needed. Hence, the magnitude of H_c goes on increasing as temperature of the specimen decreases below its T_c.

4.9.3 How H_c varies from substance to substance.

Because the thermal conductivity of substances varies from substance to substance, if at same temperature we provide same amount of thermal energy to substances, e.g., S_1, S_2, S_3 of successively decreasing thermal conductivity (as mentioned in Section 4.2), in substance S_1, because its orbiting electrons are happened to be maximum loosely bound, maximum number of photons are emitted from that, and in substance S_3, because its orbiting electrons are happened to be minimum loosely bond, minimum number of photons are emitted from that. Similarly, at same temperature T_c, if we apply an external magnetic field of same strength H_c to restore normal states of substances S_1, S_2, S_3, in substance S_1, maximum number of photons shall be emitted, and in substance S_3, minimum number of photons shall be emitted. Therefore, in substance S_1, to make emission of required number of photons to restore its normal state, the external magnetic field of minimum strength shall be needed, and in substance S_3, to make emission of required number of photons to restore its normal state, the external magnetic field of maximum strength shall be needed. Thus, to restore normal state of substances, external magnetic field of different strength is needed in different substance, i.e., H_c varies from substance.

4.10 Explanation of why and how: 1) thermal conductivity of a substance is discontinuously increased when superconducting state of the substance is destroyed by the application of an external magnetic field $\mathrm{H_c}$; 2) thermal conductivity of substances changes continuously between their two phases, and at superconducting phase, it is found to be lower

Thermal conductivity of superconductors undergoes a continuous change between their two phases and is usually lower in the superconducting phase. For example, at 2° K, thermal conductivity of Tin (for which $T_c = 3.73\,K$) has value $34\,W\,cm^{-1}\,K^{-1}$ for the normal phase and $16\,W\,cm^{-1}\,K^{-1}$ for the superconducting phase [13]. However, it changes discontinuously when superconducting state of substances is destroyed by the application of an external magnetic field H_c.

4.10.1 Why and how thermal conductivity of a substance is discontinuously increased when its superconducting state is destroyed by the application of an external magnetic field H_c

To destroy superconducting state of a substance, when H_c is applied across the substance, the electronic orbits of the substance, which (orbits) behave as magnetic dipoles, are rotated (see Section 4.8 for detail information). How much and in which planes the different orbital magnetic dipoles are rotated, accordingly, the change in magnetic flux of different orbits are caused due to magnetic lines of force of the external magnetic field H_c. The orbital magnetic dipoles, of which the similar magnetic poles lie towards the similar pole of H_c, their magnetic flux are decreased, and the orbital magnetic dipoles, of which the similar magnetic poles lie towards the opposite pole of H_c, their magnetic flux are increased. The orbital magnetic dipoles, of which magnetic flux are increased, their area (A) are increased, and therefore, in order to conserve their magnetic moment M (= $i\,A$, where i is current flowing along the orbit due to flow of its electron along it), there i are decreased, i.e., velocity of electrons along them are decreased. The orbital magnetic dipoles, of which magnetic flux are decreased, their area (A) are decreased, and therefore, in order to conserve their M, there i are increased, i.e., velocity of electrons along them are increased. The change in velocity of orbiting electrons means, their energy are changed, i.e., they are excited. When they are excited, they acquire elliptical orbits (see Section III C, [14]), and during their elliptical orbital motions, they are expanded and suddenly compressed down (see Section, III I, [14]), and as the consequence of their sudden compression, the radiation energy which is filled in them during their expansion, are emitted from them collectively in form of photons. Further, how many times an orbiting electron expands and is compressed down during its one orbital motion, same numbers of photons are emitted from that orbiting electron. (For detail and complete information, see Section III, [14])

When photons are emitted from the orbiting electrons of the substance, due to their:

1) collisions with persistently flowing electrons of the substance, persistent flow of electrons of the substance is broken down, and thus, normal state of the substance is restored;

2) presence in the substance, thermal conductivity of the substance is discontinuously increased.

Note: Due to the external magnetic field, placing in which the substance is cooled down to its T_c, too the electronic orbits of the substance may be rotated and their (orbits) electrons may be excited, but, as the strength (H) of this magnetic field happens to be quite weak as compared to H_c, no significant amount of rotation of the orbits and hence excitation of their (orbits) electrons happens to be possible such that the photons may be emitted from their electrons.

4.10.2 Why and how thermal conductivity of substances changes continuously between their two phases, and at superconducting phase, it is found to be lower

Bringing down temperature of a substance to its T_c when superconducting state of the substance is obtained, because the disappearance of photons from the substance occurs continuously, quite rapidly in the beginning, and very shortly, that becomes very slow (see Section 1.1), thermal conductivity of the substance undergoes a continuous change between its (substance) two phases.

Further, at $\leq T_c$ (i.e., at superconducting phase) of the substance, because the number of photons remaining in the substance is reduced very much, thermal conductivity of the substance becomes lower at its superconducting phase.

4.11 Explanation of latent heat of transition

When superconductivity of a substance is destroyed isothermally (i.e. at constant temperature) by a magnetic field, the specimen absorbs heat from the atmosphere in the form of latent heat. For the adiabatic case (constant heat), the specimen’s temperature becomes lower. When the substance restores its superconducting state, reducing isothermally the magnetic field, the superconductor gives up that latent heat of transition.

4.11.1 Why and how the substance absorbs heat when superconductivity of the substance is destroyed isothermally by an external magnetic field

When superconductivity of a substance is destroyed isothermally by a magnetic field, photons are produced in the substance, and due to their collisions with persistently flowing free electrons of the substance, persistent flow of free electrons of the substance is broken down (see Section 4.9.1). The photons are produced in the substance as the consequence of expansion and sudden compression of its orbiting electrons (see Section 4.10.1). When the orbiting electrons of the substance expand, they need some energy for their expansion which is derived by them from the thermal energy of the substance. Consequently, a loss in heat of the substance occurs. Therefore, to compensate that loss in heat, some heat is absorbed by the substance from the atmosphere, which (absorption) occurs in the form of latent heat.

If the field is reduced isothermally and the substance restores its superconducting state, the heat energy, which was absorbed earlier by the substance from the atmosphere in the form of latent heat, is now given up by the substance.

4.11.2 Why and how temperature of the substance becomes lower for the adiabatic case

When temperature of the substance is not maintained constant, i.e. adiabatic case, due to absorption of heat energy by the orbiting electrons of the substance for their excitation from the heat energy of the substance, temperature of the substance is lowered down.

4.12 Explanation of why and how specific heat of the substance is discontinuously increased when temperature of the substance is brought down to its T_c

Because the orbiting electrons of the substances derive some part of heat energy for their excitation from the heat energy subjected to increase internal energy of the substances, the heat energy left in the substances to increase their internal energy E_{int} is reduced (for its verification, see Ref. [15]). Consequently, specific heat $C_v = dE_{\text{int}} / dT$ of the substances at their normal state is found to be decreasing at their lower temperatures (see Ref. [15] for detail information).

When temperature of the substance is brought down to its T_c, during that bringing, because thermal energy of the substance decreases continuously, more and more orbiting electrons go on becoming unable to excite and emit photons because of non-availability of sufficient amount of thermal energy for their excitation, and at temperature T_c', when all the orbiting electrons of the substance become unable to excite and emit photons (see Section 1.1), a lot of thermal energy, which would have been absorbed by the orbiting electrons of the substance for their excitation at different temperatures during cooling of the substance if the orbiting electrons of the substance had found that to be sufficient for their excitation at those temperatures, is found available in the substance to increase its internal energy. Due to this lot of thermal energy, the internal energy (E_{int}) of the substance is increased abruptly, and hence, the specific heat $C_{\text{v}}\,(= dE_{\text{int}} / dT)$ of the substance is also increased abruptly. Consequently, specific heat of the substance is increased discontinuously when temperature of the substance is brought down to its T_c', or T_c. [As we see (Section 1.1.1), for Hg, $T_c' = 4.25^{\circ}$ K, and $T_c = 4.2^{\circ}$ K are happened to be very close to each other, and currently, there is no concept of T_c', therefore, T_c' and T_c can be considered as same.]

4.13 Why and how the Josephson's tunnelling is generated

The Josephson's tunneling [16] is the phenomenon of super-current across two superconductors coupled by a weak link. The weak link can consist of a thin insulating barrier known as S-I-S (superconductor-insulator-superconductor), or S-N-S (a short section of no-superconducting metal), or S-s-S (a physical construction that weakens the superconductivity at the point of contact).

Why and how the phenomenon of supercurrent across the weak link occurs, that is as follows:

When an electric voltage is applied across both the ends of this system (two superconductors coupled by a weak link), the directions of linear velocity of the free electrons of both the superconductors are oriented and aligned along the direction of flow of the free electrons, according to their property [see bullet 1) of Section 2], and, according to their property [see bullet 2) of Section 2], because they possess E_M and p_M, they transmit through the weak link and an electric current starts flowing through the circuit. (To verify that the electrons can transmit through the weak link because of possessing E_M and p_M, see Section 3.3, [17].) If this system is cooled down to T_c, because then the number of photons remaining in the superconductors is reduced as much that they (photons) become unable to resist the flow of free electrons through the superconductors, the resistance of both the superconductors are reduced to zero, and consequently, an increase in current in the ammeter is observed. Now, if the battery is shunted out from the circuit, the current continues flowing.

5 Discussion

In current theories, proposed to explain superconductivity, no account of the role of: 1) photons (Section 1.1); 2) external magnetic field keeping in which the substances are cooled down to their T_c (Section 1.2); and 3) properties which the electrons obtain because of their unique structure (Section 2); has been taken. Instead, in current theories, e.g., in BCS theory [4], for which it is claimed that it provides better quantum explanation of superconductivity and accounts very well for all the properties exhibited by the superconductors, it has been assumed that, at temperature T_c of the substance, when an electron approaches a positive ion core, the core suffers attractive Coulomb interaction and that sets the core in motion and consequently the lattice is distorted. Can it logically and practically ever be possible that an ion core, which is obtained as the consequence of ejection of electron(s) from a neutral atom and happens to be approximately $1.84A\times10^3$ (where A is the mass number, and $1.84\times10^3 = m_n / m_e$ where, m_n and m_e respectively are the mass of nucleon and electron) times massive than an electron, is attracted by an electron? Can that attraction set the ion core in motion? Can the motion of core distort the lattice, which is a regular periodic array of number of atoms?

Further, the above assumptions contradict two well-observed facts:

1) Due to attractive Coulomb interaction between electrons and ion cores of the substance, if its ion cores are set in motion and consequently its lattices are distorted, then disturbance and hence disorderness in substances should be increased, that means, entropy of the substances should be increased. While on the contrary, entropy of the substances decreases.

2) Due to setting of ion cores into motion and consequently distortion of lattices of the substance, resistance of the substance should be increased. While on the contrary, resistance of the substance reduces to zero.

Furthermore, the concept of Cooper pairs, their formations, and flow of persistent current due to flow of Cooper-pairs through the substances too give rise to several very basic and fundamental questions. For example, at temperature T_c of the substances:

1) How and from where do the Cooper pairs obtain their initial linear velocity with which they start flowing?

2) How is their linear velocity maintained for indefinitely long time against the gravitational force, which acts on them continuously during their flow?

3) How are the directions of motion of all the Cooper pairs oriented and aligned in one direction (along the direction of flow of persistent current)?

4) Are the Cooper pairs broken and the electrons are separated from their respective pairs when a critical value of an external magnetic field (H_c) is applied across the substances to restore their normal states? If yes, then how does it happen so? Moreover, if not then how does the persistent current stop flowing?

6 Conclusion

As we know, properties of a person depend upon his physical and mental structures, and a work performed by him depends upon his properties, and condition(s) under which the work is performed. In the same manner, properties of electrons, nucleons, and other particles should depend upon their structures, and the phenomena, properties of their systems, and structures of their systems, generated due to them, should depend upon their properties, and conditions under which the phenomena, properties of their systems, and structures of their systems are generated. Therefore, if a theory is developed to explain the phenomena generated due to them, properties and structures of their systems generated due to them, that theory should be developed taking into account their properties [e.g., see bullets 1), and 2), and bullets i), ii), and iii) of Section 2], and condition(s) under which, for example: 1) presence of photons in substances, which colliding with free electrons of the substances produce resistance in their flow, in significant amount at their normal state (see Section 4, [10]); 2) presence of photons in substances in insignificant amount at their superconducting state (see Section 1.1); 3) no presence of photons in electron, proton etc. beams, and nuclei; the phenomena, properties of their systems, and structures of their systems are generated due to them. Otherwise, the developed theory, e.g., electromagnetic theory, quantum wave theory, and current quantum field theories, cannot be true. Consequently, if the rigorous mathematical proofs of the electromagnetic theory, quantum wave theory, and current quantum field theories are examined, in them, numerous logically and practically unbelievable assumptions have been accepted (see Section 1, [17] for quantum wave theory, and Sections 3.1.1, and 3.3.1, [18] for quantum field theories) in order to arrive at the desired results. Further, despite accepting numerous logically and practically unbelievable assumptions, the quantum wave theory fails to explain numerous phenomena, e.g., see Section 1, [17], and electromagnetic theory and current quantum field theories fail to explain, for example: 1) all the properties and two possible effects listed in Section 3.2, [18]; 2) property (see Section 1.1), and several properties of the list of Section 4; 3) all the properties listed in Section 3.4, [18]; and 4) structures of deuterons, alpha particles, and nuclei.

Acknowledgement

The author would like to thank his respected teacher, Prof. Ashok Kumar Gupta, who is a retired Professor in Physics with Allahabad University, Allahabad (U.P.), India, for his valuable and continuous moral support, encouragement, timely discussion, sincere advice, and help.

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FIGURE CAPTIONS

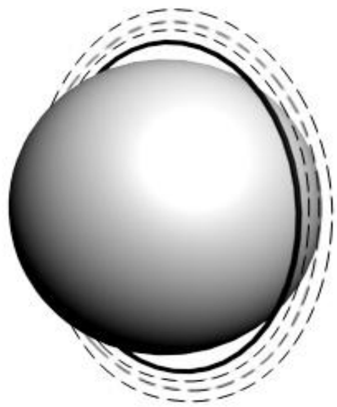
Fig. 1 (a) The spherical ball, dark solid-line circle, and concentric broken-line circles represent respectively the charge, magnetism, and magnetic field of an electron. (b) Transverse cross-sectional view of an electron where the ball of charge is indicated by a dark, thick, and solid-line circle, magnetism by a dark, thin, and solid-line circle, and magnetic field by broken-line circles with arrows to show the directions of their spin motion.

Fig. 2 (a) The nature of variation of resistance of the substances with their temperature near their transition temperature. (b) Variation of resistance of mercury with its temperature near its transition temperature.

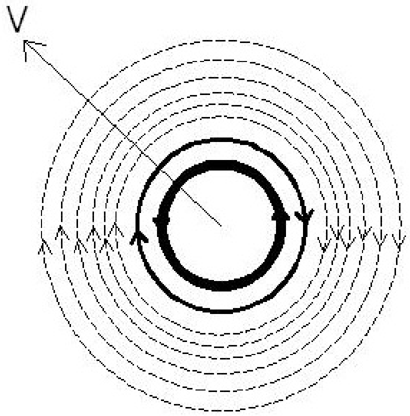
Fig. 3 Transverse cross-sectional view of interaction between magnetic fields generated around the inter-lattice electron beams which are passing through the inter-lattice passages of the specimen substance, where the lattices have been shown by small solid dark discs.

Fig. 4 Longitudinal view of the magnetic field generated around and along the length of the specimen, taken in the form of a close loop and carrying persistent current i.

Fig. 5 The magnetic lines of force of the external magnetic field passing through the body of the specimen, taken in the form of a close loop and no current are flowing through it. (b) Ejection of the magnetic lines of force from the body of the specimen when the persistent current i start flowing through the specimen.

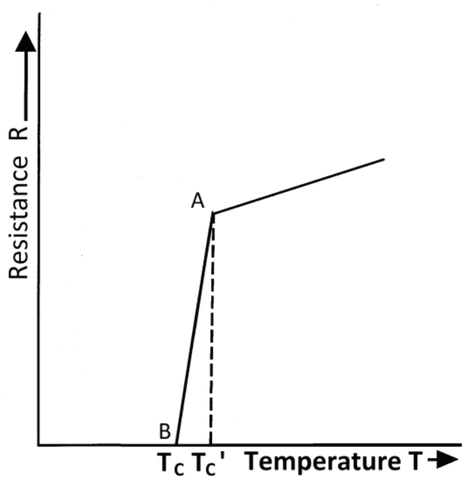


(a)

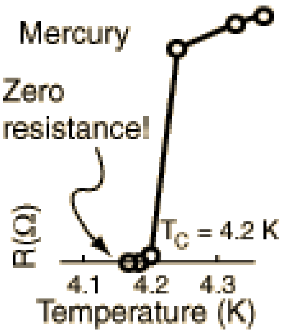


(b)

Fig. 2


Resistance R
A
B
T_C T_C'
Temperature T

(a)


Mercury
Zero
resistance!
R(Ω)
T_C = 4.2 K
4.1
4.2
4.3
Temperature (K)

(b)

Fig. 2

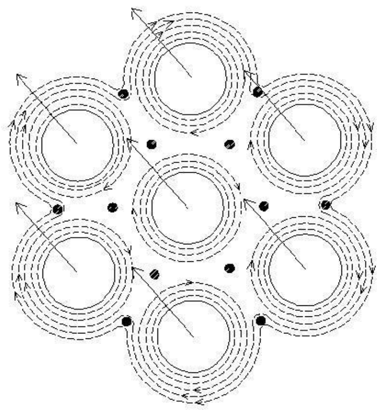


Fig. 3

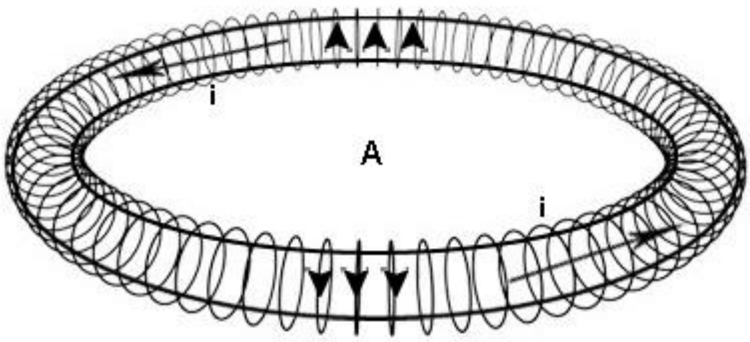
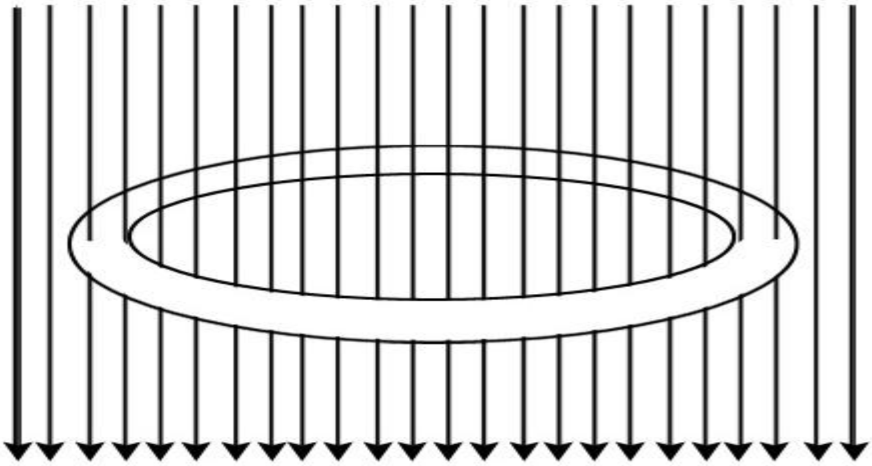
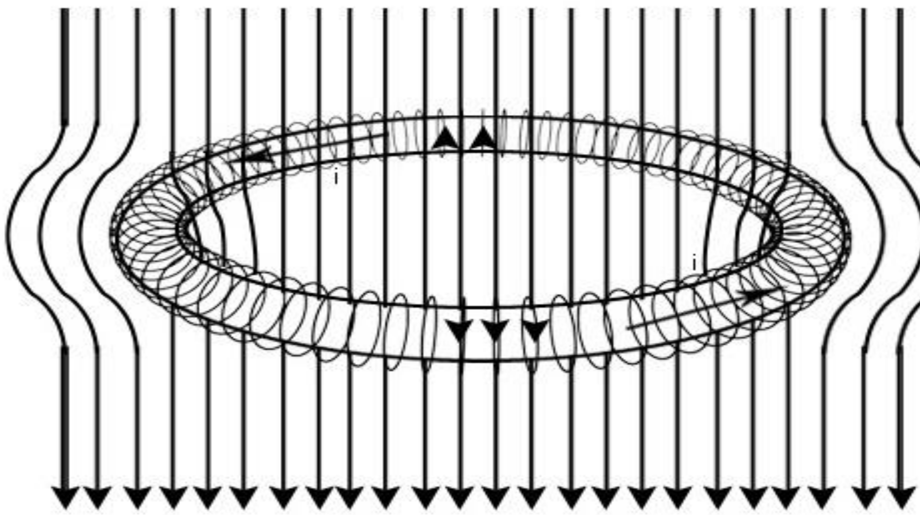


Fig. 4



(a)



(b)

Fig. 5