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Mechanism of superconductivity

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Abstract

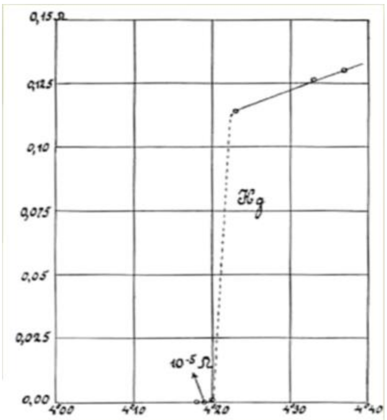
Superconductivity is a solid-state physics phenomena that happens in some materials at a particular critical temperature (commonly referred to as Tc). The absence of any magnetic field in the inside of a superconducting material is distinguished by its endlessly high electrical conductivity. This so-called superconductivity has proven crucial in many fields of science. The theory of superconductivity and its mechanism is explained in this paper in a straightforward manner.

Keywords: Super conductors, super conductivity, phonon mechanism, excitation mechanism

Introduction

A number of alloys and their mixtures loses their resistance entirely at very low temperature and they altogether permits the current to easily flow within the interior of these materials. This phenomenon observed by Kammerling Onnes in 1911 when Mercury was cooled in liquid Helium to find out what happens to resistance of Mercury at low temperatures. Though the resistivity was supposed to disappear gradually, to their surprise the resistance of Hg dropped abruptly to unmeasurable values at 4.2 Kelvin [1]. This phenomenon of zero resistance state in Hg was called superconductivity. The temperature (in zero magnetic field) at which resistance quickly falls to zero is known as critical temperature T_c. The critical temperature for numerous superconducting elements varies from fewer than 0.1 K to almost 10 K.

Figure 1 The resistance versus temperature graph showing resistive drop in Hg at 4.2 K



There are two "flavours" of superconductors:

- Type I Superconductors
- Type II Superconductors

Type I Superconductors

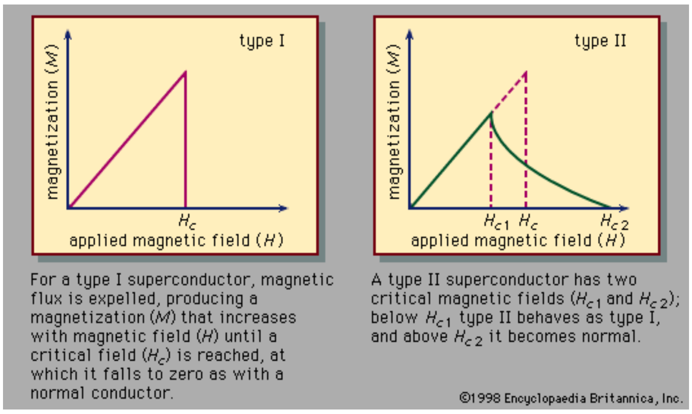
The Type I category superconductors indicates some conducting nature and this category generally consists of metalloids and metals at room temperature. This type of category is kept in incredible cold or very low temperature to facilitate unimpeded electron flow required in accordance with to minimize molecular vibrations sufficiently, that so called as BCS theory. In order to help each other to overcome molecular obstacles, BCS theory suggested pairing up of electrons in "Cooper pairs"- much like of drafting racing cars on racing track each other in order to go faster . This process of coupling due to the sound packets formation with the crystal lattice's flexing is called phonon-mediated. Type 1 superconductors can also be classified by their characteristic properties to be discovered first, to be "soft" superconductors, and to become superconductive it needs the coldest temperatures. They show "perfect" diamagnetism which is nothing but is the ability of a magnetic field to repel completely and a very sharp transition to a superconducting state. Along with critical transition temperature (Tc) of Type 1 superconductors, and below this temperature each superconducts. Surprisingly, silver, gold, and copper, these three are best metallic conductors, and also they do not rank among the superconductive elements.

Type II Superconductors

The Type 2 category superconductors consists mainly alloys and metallic compounds, except for the elements Vana-Review Paper ATOMIC PHYSICS 2 Niobium(Nb), Technetium(Tc) & they have high Tc from Type 1 superconductors with a mechanism that is still not understood completely. However recent research suggesting this may be possibly due to holes of hypo charged oxygen in the charge reservoirs.

When placed in an external magnetic field, Type II superconductors lose their superconductivity gradually, rather than quickly or abruptly. When a Type II superconductor is placed in a magnetic field, it gradually loses its superconductivity, as shown in the graph of intensity of magnetization (M) vs applied magnetic field (H). At lower critical magnetic fields (Hc1), Type II superconductors begin to lose their superconductivity, and at higher critical magnetic fields (Hc2), they totally lose their superconductivity (Hc2). Vortex state or intermediate state is the state that exists between the lower critical magnetic field (Hc1) and the upper critical magnetic field (Hc2). Sperconductor of the type 2 becomes conductor after the upper critical temperature.

Figure 2. Type 1 and type 2 superconductors



Mechanisms of Superconductivity

Phonon Mechanism of Superconductivity

Bardeen, Cooper and Schrieffer propose a basic theory that explains the microscopic origin of electrical conduction. Consistent with them, electrical conduction was associated with the existence of a sure try of electrons, every lepton in try having equal however opposite spin and momentum, traveling through the lattice[3]. The pairs, called Cooper pairs, area unit sure by associate electron-phonon interaction. The lepton try wave perform is symmetrical s-wave sort. The electrons in these states aren't any longer needed to adapt the Fermi-Dirac Statistics. The paired charge carriers act over substantial distances to supply a coherent state. Every Cooper try needs a sure minimum energy to be displaced, and if the thermal fluctuations within the lattice area unit smaller than this energy the try will flow while not dissipating energy. Once associate lepton moves through the system, it creates a depression within the atomic lattice through lattice vibration called phonon. If period of time of the lattices robust enough, another lepton will constitute period of time created by initial lepton –therefore referred as water-bed result become sturdy enough, Cooper pairs convert the creation of holes behind the electrons and also the traditional conductor through a limitless offer of electrons by creation of Cooper pairs. The BCS theory accounted for several of the experimental observations like the existence of associate energy gap 2(0) between the superconducting and traditional electrons with a foreseen worth on the point of three kBTc at absolute zero. The worth of gap constant 2(0)/kBTc decides the strength of lepton phonon coupling in superconductors. Once the coupling is robust, this magnitude relation will increase monotonically. To induce high- Tc from electron-phonon coupling, one desires sturdy coupling, however if the coupling is robust enough to give terribly high Tc, then it's conjointly sturdy enough to cause lattice stability. The BCS theory has been found to satisfactorily describe all super- conducting phenomena in weak coupled superconductors like Zn, Ga, Cd etc, that have 2« EF. The high-Tc cuprates follow BCS theory in some aspects such as persistent current, Josephson tunnelling and vortex lattice development. This theory explains the magnetic flux through a superconducting ring is amount as a result of the superconducting ground state involves pairs of electrons. electrical conduction is well explained by BCS theory in alkali doped *C*60 and *MgB*2. However, this theory conjointly implies that the forces binding the copper pairs were terribly feeble, therefore they would be ripped apart by thermal vibrations at something alternative than extremely low temperatures and so electrical conduction won't occur higher than 30K. Several of the properties of high-*Tc* superconductors like little or no atom shift, short coherence length, unprecedently high transition temperature, electrical and magnetic anisotropies etc. were markedly totally different from typical superconductors. Therefore, BCS theory seems to be inadequate for top *Tc* – superconductors.

Excition Mechanism of Superconductivity

The first exciton model, was planned by W.A. very little for organic superconductors and by Ginzburg and Kirzhnitz for bedded systems[5]. During this model, it had been necessary to assume the existence of 2 teams of electrons: one in every of them is expounded to physical phenomenon band, wherever the superconducting pairing happens by exchange by excitons that square measure excitations within the second cluster of virtually localized electrons. The search for superconducting in organic material were stirred up to a major degree by the concept of very little regarding the possibility of high- Tc electrical conduction is the excitonic mechanism of the Cooper pairing of negatron in long conducting chemical compound chains containing lateral molecular branches- polarizers. In this mechanism, the effective attraction between electrons at the Fermi surface is iatrogenic by the exchange of excitons, instead of phonons. The excitation mechanism is in essence not restricted to one dimensional structure. Ginzburg has mentioned the likelihood of excitonic electrical conduction in two dimensional systems. One of the most attractions of the planned exciton mechanism is that the apparent risk of upper transition temperatures. Throughout this model, the metal electrons flow at the Fermi surface tunnel into the semiconductor gap and wherever they flow with virtual excitons, in direct analogy there is a web attractive interaction among the electrons with the phonon mechanism superconductivity. For the purpose of read of the entire-electron interaction, there is study of the electrical conduction in a metal-semiconductor system's exciton mechanism. The Exciton mechanism of electrical conduction in a metal-semiconductor system is studied from the purpose of read of the entire electron-electron interaction. There's no experimental proof for the existence of the excitonic mechanism of electrical conduction as a result of high energy building block excitonic excitations cannot make sure the binding of electrons in pairs.

Magnetic Mechanism of Superconductivity

Magnetic Mechanism of superconductivity during this mechanism, the pairing is completed exchange by spin excitations magnons. Magnon could be a similar particle that is that the quantum synonyms of a spin wave of excitation in an exceedingly magnetically ordered system. It involves the interaction between the physical phenomenon electrons caused by each the exchange by acoustic phonons and a further interaction associated with the exchange by spin waves (magnons). It starts with a superconducting material within the anti-ferromagnetic state, during which neighbouring electrons have spins of opposite orientation. Once the fabric is doped by the addition of another part, holes area unit created that conjointly carry a spin. every hole desire to spin parallel to the negatron, however it conjointly wishes to delocalized-spread its wavefunction to alternative sites[5]. However, it sees magnetic attraction electrons whose spins area unit aligned parallel with it at these alternative sites. Its spin is tipped, in order that the negatron will have a good alignment of its spin with the magnetic attraction electrons. This causes a spin polarization cloud to create, attracting a second negatron and forming a combine. The interaction is mediate by polarizing spin degrees of freedom. It was shown that the electrical conduction and magnetic attraction will co-exist in constant special regions. High-Tc superconductors reveal robust magnetic fluctuations within the region of doping which may be accountable for the pairing. In magnon pairing mechanism of electrical conduction in cuprates, a physical phenomenon negatron (oxygen p like) tends to repolarize the near copper d spins into native magnetic attraction order. As this gas negatron moves on, it tends to de- part behind a wake with ferromagnetically paired copper spins. As a second physical phenomenon negatron is scattered into the wake of initial negatron since there's already magnetic attraction polarization of the copper spins. The internet result is the enticing interaction accountable for electrical conduction.

Anderson created a trial to elucidate the Cooper pairing in hot temperature superconductor by the participation of magnetic excitations. The Anderson model is based mostly on the conception of magnetic ordering. This mechanism ensures the connexons of carriers in pairs with remunerated spin, the thus referred to as spinon. Rising in holes is observed when doping of high-Tc superconductors compounds takes place, this hole arising process may differentiate the type of complexes with spinon–holons. The pairing of holons basically explains electrical conduction i.e., using double charge there is creation of spinless bosons. That is, the pairing of carriers within the Resonance Valence Bond (RVB) model is completed thanks to the exchange of magnons. At vasoconstrictor, the paired holons kind a superconducting atmospheric phenomenon, Anderson planned a reverberating valence bond description of physical phenomenon during which the powerfully coupled vest pairs move regarding as bosons in- stead of as a standard easy hole physical phenomenon of AN magnetic attraction system. He advised that this robust pairing model would make a case for the electrical conduction of the cuprates and expected a gapless superconductor. This Anderson model is sort of completely different from the magnon pairing model, wherever there's a hole in the gas there's, an outsized gap, and enticing pairing involving triplet coupling. He gave a 2-D model, thus referred to as "Luttinger liquid" model. within the Luttinger liquid, the spins and charges area unit carried singly by particles referred to as 'spinons' and 'holons' sever ally.The spinons area unit fermions with spin 1/2 and 0 charge whereas holons area unit bosons having zero spin and a charge of e. Scattering of holons and spinons is proportional to spinondensity of states that is linear in T.

Conclusion

However, experts are divided as far as such equipment applications will be found. Because many difficulties persist with large-scale addition of JJ circuits-particularly for high-density recollection- semiconductor investigators interrogated by OTA question whether LTS JJ technology[10]. The availability of thin film materials and single crystal bulk and high quality polycrystalline has make it possible to made reliable measurement of physical properties of material that are important for the application of technology. the superconducting materials area unit usually terribly advanced and multi layered that makes in theory modelling totally different.

REFERENCES

H. K. Onnes, Communications from the Physical Laboratory of the University of Leiden (1911).

W. Meissner and R. Ochsenfeld, Naturwissenschaften 21, 787 (1933).

J. R. Gavaler, Appl. Phys. Lett. 23 (1973) 480

S. N. Putilin, E. V. Antipov, O. Chmaissem, and M. Marezio, Nature 362 (1993) 226.

A. Schilling, M. Cantoni, J. D. Guo, and H. R. Ott, Nature 363 (1993) 56.

C. W. Chu, L. Gao, F. Chen, Z. J. Huang, R. L. Meng, and Y. Y. Xue, Nature, 365 (1993) 323.

M. Nuñez-Regueiro, J.-L. Tholence, E. V. Antipov, J.-J. Capponi, and M. Marezio, Science 262 (1993) 97.

M. B. Maple, Y. Dalichaouch, J. M. Ferreira, R. R. Hake, B. W. Lee, J. J. Neumeier, M. S. Torikachvili, K. N. Yang, H. Zhou, R. P. Guertin, and M. V. Kuric, Physica B 148 (1987) 155.

T. P. Orlando, K. A. Delin, S. Foner, E. J. McNiff, Jr., J. M. Tarascon, L. H. Greene, W. R. McKinnon, and G. W. Hull, Phys. Rev. B 36 (1987) 2394.

S. Jin, T. H. Tiefel, R. C. Sherwood, M. E. Davis, R. B. van Dover, G. W Kammlott, R. A. Fastnacht, and H. D. Keith, Appl. Phys. Lett. 52 (1988) 2074.

R. Hawsey and D. Peterson, Superconductor Industry, Fall, 1996; and references cited therein.

K.H. Hock, H.Nickisch, H.thomas, Helv. Phys. Acta 1983, 56, 237-244.