AIRO JOURNALS
Free / Unpaid Peer Reviewed Multidisciplinary International

ISSN: 2320-3714
Volume 4 Issue 3
December 2021
Impact Factor: 10.2
Subject: Physics

ANALYTICAL STUDY OF VARIOUS PARAMETERS TO ENHANCE THE POWER OF SUPERCONDUCTORS

ABULLAIS NEHAL AHMED*
Research Scholar
Dr. Satendra Singh
Assistant Professor
Physics
Glocal School of Science

DECLARATION: I AS AN AUTHOR OF THIS PAPER /ARTICLE, HERE BY DECLARE THAT THE PAPER SUBMITTED BY ME FOR PUBLICATION IN THE JOURNAL IS COMPLETELY MY OWN GENUINE PAPER.IFANY ISSUE REGARDING COPYRIGHT/PATENT/ OTHER REAL AUTHOR ARISES, THE PUBLISHER WILL NOT BELEGALLY RESPONSIBLE. IF ANY OF SUCH MATTERS OCCUR PUBLISHER MAY REMOVE MY CONTENT FROM THE JOURNAL WEBSITE. FOR THE REASON OF CONTENT AMENDMENT/OR ANY TECHNICAL ISSUE WITH NO VISIBILITY ON WEBSITE/UPDATES, I HAVE RESUBMITTED THIS PAPER FOR THE PUBLICATION.FOR ANY PUBLICATION MATTERS OR ANY INFORMATION INTENTIONALLY HIDDEN BY ME OR OTHERWISE, ISHALL BELEGALLY RESPONSIBLE. (COMPLETE DECLARATION OF THE AUTHOR ATTHE LAST PAGE OF THIS PAPER/ARTICLE

Abstract

A superconducting material is characterized by its infinitely high electrical conductivity and the absence of any magnetic field in the interior. In many areas of research, this so-called superconductivity has become indispensable. This paper takes a simple approach to explain the theory behind Superconductivity and its applications. Superconductors are materials whose electrical resistance drops below the transition temperature to zero. The superconductivity in 1911 from Heike Kamerlingh Onnes discovered. It is a macroscopic quantum state. Many metals and other materials are superconducting below their critical temperature T_c. For most materials, this temperature is very low; to achieve superconductivity, the material must generally be cooled with liquefied helium whose boiling point is 269°C. Only in the case of high-temperature superconductors is sufficient to be cooled down with liquefied nitrogen whose boiling point is 196°C.

Keywords: Superconductivity, Quantum state, Energy Band, Resistance

AIRO JOURNALS
Free / Unpaid
Peer Reviewed
Multidisciplinary
International

ISSN: 2320-3714
Volume 4 Issue 3
December 2021
Impact Factor: 10.2
Subject: Physics

1. Introduction

Superconductors comprise about three dozen elements and several thousand alloys and compounds that have metallic conductivity. Soon thereafter, critical temperatures above 90K were found.[1]

If it were indeed possible to find a superconducting material at ordinary ambient temperatures (around 300K), this would most likely profoundly change modern technology. Now, onto a new mechanism: the magnetic effect of spin fluctuations in the atoms of the conducting medium.

Cooper pairs as carriers The magnetism that could solve the puzzle is in sharp contrast to anything known about the mechanism of conventional cryogenic superconductivity. Materialsthat have this effect at a few degrees or degrees fraction above the absolute zero (and sometimes even under high pressure), form the electron Cooper pairs. Unlike single electrons, Cooper pairs do not collide with their peers and are not scattered at the impurities in the conducting medium; therefore, they encounter no resistance in their movement.

Thus, in a superconductor current flows without electrical voltage and remains in a closed circuit if desired. Notably, electrons in metals can even combine in pairs, even though they would have to repel themselves as carriers of equal (negative) charge. In the 1950s, Leon N. Cooper found an explanation together with John Bardeen and J. Robert Schrieffer.

*Research Scholar, Department of Physics, Glocal University, Mirzapur Pole, Sharanpur (U.P.)

ISSN: 2320-3714
Volume 4 Issue 3
December 2021
Impact Factor: 10.2
Subject: Physics

The BCS theory, states that electrons in conventional superconductors overcome their mutual repulsion in two ways: The movement of the other electrons shields a portion of the negative charge that seeks to drive the pair apart. Above all, there are mediators who help overcome the mutual repulsion of the electrons, namely the ions that make up the metal lattice.

An electron that travels past these ions may shift their position slightly. Such temporary distortions of the lattice called phonons in solid state and quantum physics create small regions of positive charge, which in turn attract other electrons. However, in the opinion of most researchers, the traditional model cannot explain the superconductivity of copper oxide ceramics. Indeed, in a high transition temperature BCS superconductor, electrons and phonons would interact strongly, distorting the structure of the material such that it would no longer be superconducting, and probably not even conductive anymore.

Moreover, in the BCS model, the electrons must always be much more energetic than the phonons: they move much faster so that the first electron has passed the displaced ion long before the second arrives, and over this distance, their mutual repulsion has less effect.

However, in the cuprates, electrons, and phonons move approximately equally fast: this means that paired electrons do not stay at a sufficient distance to satisfy the theory. So far electrons as charge carriers of the current, but, these are so-called holes in most cuprates: positively charged regions that result from the absence of an electron.

ISSN: 2320-3714
Volume 4 Issue 3
December 2021
Impact Factor: 10.2
Subject: Physics

They are generated by doping the material with foreign atoms, which bind electrons to themselves. In the following, we therefore call the components of a Cooper pair no longer electrons or holes, but simply charge carriers. Because of the difficulty of explaining high transition temperatures using the phonon model, many other pair mediators have been proposed, including excitons, and plasmons.

Other models treat each charge as two separate particles that can jump back and forth between the layers of the conductor.

2. Study of Parameters

In the superconducting state, the interior of the material remains free of electric and magnetic fields. An electric field would be degraded immediately by the non-resistant movable charge carriers. Magnetic fields are displaced by the construction of appropriate shielding currents on the surface, which compensate with their own magnetic field, the inner magnetic field. A not-too-strong magnetic field penetrates only about 100 nm into the material; this thin layer carries the shielding and line currents.

This "Meissner-Oxfield effect" can, for example, levitate a superconducting sample in the magnetic field. The current flow through the superconductor lowers the transition temperature. The transition temperature also decreases when an external magnetic field is applied. If the magnetic field exceeds a critical value, different effects are observed depending on the material. Breaks the superconductivity suddenly, it is called a superconductor of the first kind or Type-I.

ISSN: 2320-3714
Volume 4 Issue 3
December 2021
Impact Factor: 10.2
Subject: Physics

On the other hand, superconductors of the second kind (Type-II) have two critical field strengths; from the lower one, the field begins to penetrate; in the higher one, the superconductivity collapses. In the area in between, the magnetic field increasingly penetrates the conductor in the form of microscopically fine tubes. The magnetic flux in these flow tubes is quantized.

Type-II superconductors are attractive for technical applications due to their high current carrying capacity. Technical applications of superconductivity are the generation of strong magnetic fieldsfor particle accelerators, nuclear fusion reactors, magnetic resonance imaging levitation as well as measuring and energy technology.

In September 1986, K. Alexander Muller and J. Georg Bednorz reported that the ceramic substance lanthanum barium copper oxide of 35K (even at the relatively high temperature of 238°C) loses any electrical resistance; for this discovery, they were awarded the Nobel Prize in Physics the next year.

3. Theory for Enhancement Superconductivity

Theoretically, even several hundred degrees, though this seems unrealistic. Such prospects are a big step forward from the predictions of traditional BCS theory that the critical temperature can be at most 233°C. Certainly, scientists are not yet ready to conclusively determine the mechanism of Cooper pair formation.

But with the capture and counting of magnetic flux quanta in tiny rings, they now have a promising method of discovering their secret from the enigmatic new substances. If

ISSN: 2320-3714
Volume 4 Issue 3
December 2021
Impact Factor: 10.2
Subject : Physics

this succeeds, further high-temperature superconductors should be specifically developed, and their applications should be found.

A large number of different superconductors have been classified into 32 different classes 8 in particular, the first discovered metallic superconductors and the technically significant A15 phases, and the ceramic high-temperature superconductors are significant.

Metallic superconductors Superconductivity was discovered in 1911 by Heike KamerlinghOnnes shortly after his discovery of helium liquefaction in metal mercury. This then-novel effect existed only at 4.2K. At 39K, magnesium dibromide has the highest transition temperature among metallic superconductors at atmospheric pressure.

This limits the use of metallic superconductivity in a few applications, because the cooling requires liquid helium, making it very difficult and expensive. However, metallic superconductors have been found to be of great importance to them. The properties of metallic superconductors are explained by the BCS theory.

In 2015, hydrogen sulfide H_2S was reported to be a metallic conductor under high pressure (100 to 300GPa) with a transition temperature of 70°C (203K)[10], setting a record.

As high-temperature superconductor HTSC, solid or non-solid materials are referred to, the superconductivity, unlike conventional superconductors, does not come from the electron-phonon interaction.

ISSN: 2320-3714
Volume 4 Issue 3
December 2021
Impact Factor: 10.2
Subject: Physics

Most of the time, it occurs in not metallic, but ceramic materials. Although it seems certain that pair formation (known as "Cooper pairs") of the electrons is responsible for the superconductivity, predominantly d-wave pairing occurs instead of the conventional singlet pairing, which suggests unconventional electronic mating mechanisms. The cause has been unexplained for more than 25 years.

The name comes from the fact that high-temperature superconductors usually have significantly higher transition temperatures T_c than conventional superconductors. The temperatures are up to 203K, which is about 180K higher than the temperature range of conventional superconductors and already in the range of naturally occurring temperatures on the earth's surface.

Ferrous high-temperature superconductors, an unexpected class of high-temperature superconductors were discovered in Japan in 2008, compounds of iron, lanthanum, phosphorus, and oxygen can be superconducting.

According to pnictogenphosphor, these superconductors are called iron pnictides. The proportion of iron atoms was surprising because every other superconducting material becomes normally conducting due to sufficiently strong magnetic fields.

These strong internal magnetic fields could even be a prerequisite for superconductivity. The guesswork on the physical fundamentals has become even bigger. So far, it is only clear that the current flow is carried by pairs of electrons, as described in the BCS theory.

ISSN: 2320-3714
Volume 4 Issue 3
December 2021
Impact Factor: 10.2
Subject: Physics

However, the effect that connects these Cooper pairs is unclear. It seems certain that it is not as with metallic superconductors an electron-phonon interaction. By choosing other admixtures such as arsenic, the transition temperature can be increased from originally 4K to at least 56K.

High-temperature superconductors are preferably operated at 77K, if possible, provided that the current density is low enough so that the transition temperature is not exceeded. Sufficient cooling with liquid nitrogen is particularly inexpensive.

Such applications exist in metrology and in cables. However, due to the extremely inhomogeneous current distribution over the cross-section, the low current density is not always achievable.

4. Experiments

The Josephson effect only occurs when there is a phase difference between the Cooper pairs on either side of the barrier. The phase of a wave function describes, graphically, which part of its cycle the wave is going through. With d-wave superconductors, rings with Josephson junctions can now be constructed, which inevitably change the phase of the Cooper pair rotating in them.

This phase change corresponds to a sign change of the wave function. With sufficient cooling, this automatic sign change spontaneously generates just enough current to include exactly half a magnetic flux quantum. If an external magnetic field is applied during cooling,

ISSN: 2320-3714
Volume 4 Issue 3
December 2021
Impact Factor: 10.2
Subject: Physics

then flux values of 3/2, 5/2, 7/2 and so on times the flux quantum is threaded through such a ring.

On a specially prepared substrate, they grew thin-film rings of the Yttrium-Barium-Copper Oxide (YBCO) superconductor, specifically so that one of the rings consisted of three sections, with the crystal lattice of each section 30 degrees from that of the adjacent one was rotated and thus each interface between the sections a Josephson contact formed.

If the Cooper pairs are in a state with d-wave symmetry, their wave function must change sign after completely passing through the ring

5. Results

After fabricating these tiny tri-crystal rings - each measuring only about 50 microns (one-thousandth of a millimeter) in diameter. They then cooled them down to their critical temperature. Due to the material's geometry, their conduction state was unstable, and therefore a weak supercurrent developed by itself.

The magnetic fields trapped in the rings were imaged with a SQUID scanning microscope. SQUIDs (for superconducting quantum interference detectors) are the most sensitive magnetic field sensors currently available. By carefully calibrating the gauges with several different methods, we were able to be sure that the tri-crystal ring was actually exactly half a flux quantum.

As a control, the rings were used with an even number of Josephson junctions, which in fact did not contain any flux quanta (because the sign undergoes an even number of

ISSN: 2320-3714
Volume 4 Issue 3
December 2021
Impact Factor: 10.2
Subject: Physics

changes and thus returns to its original state at the end). In addition, they slightly varied the experimental conditions to show that the results were indeed based on the symmetry of the Cooper pair wave function and not on other physical effects.

So, it was proved that small changes in the ring geometry turned on and off the spontaneously formed half flux quantum. Furthermore, with a weak external magnetic field, they were able to make the other rings confine integer flux quanta, demonstrating that indeed all the rings were functioning.

Experiments with thin films without rings or with disks instead of rings also showed the half-integer flux quantum effect, proving that the result is determined by the internal symmetry of the superconductor and not by the geometry of the sample. The study of symmetry can help to limit the variety of possible pair mechanisms. Above all, it is important to repeat the experiments with other cuprate superconductors.

For example, when doped with electron donors, neodymium-copper-copper oxide appears to have s-wave symmetry. If confirmed, it would be a blow to the spin wave model, as most researchers would prefer a unified mechanism for all high-temperature superconductors.

ISSN: 2320-3714
Volume 4 Issue 3
December 2021
Impact Factor: 10.2
Subject: Physics

6. Conclusions

Superconductivity has a lot of applications from Maglev (Magnetic levitation) Trains to Magnetic Resonance machines. However, the production of a superconducting compound is still expensive and complex.

There are many developments and a broad spectrum of research going on in the area of Superconductivity; however, it is still unknown why superconductivity begins at an unexpectedly high temperature. If physicists should someday come up with the secret, could possibly produce tailor-made materials in which superconductivity occurs even at normal ambient temperatures the consequences for the technology.

References:

1. Bednorz, J. G. & Müller, K. A. (2018) Perovskite-type oxidesThe new approach to High-T_cSuperconductivity. Rev. Mod. Phys. 60, 585–600.
2. Kittel, C. (2019) Introduction to Solid State Physics. Solid State Phys. 703
3. Bardeen, J., Cooper, L. & Schrieffer, J. (2020) Theory of superconductivity. Physical Review 108.
4. R. Kossowsky, Bernard Raveau, Dieter Wohlleben, S. K. P. (2017) Physics and Materials Science of High-Temperature Superconductors, II.
5. Tsuei, C. C. &Kirtley, J. R. (2016) Half-Integer Flux Quantization in Unconventional Superconductors.

ISSN: 2320-3714
Volume 4 Issue 3
December 2021
Impact Factor: 10.2
Subject: Physics

6. Hirsch, J. E., Maple, M. B. &Marsiglio, F. (2015) Superconducting materials classes: Introduction and overview. Physica C: Superconductivity and its Applications 514, 1–8.
7. Jun Nagamatsu; Norimasa Nakagawa; Takahiro Muranaka, Y. Z.; J. A. (2001) Superconductivity at 49K in copper doping magnesium diboride. Nature 410, 1–3.
8. Drozdov, A. P., Eremets, M. I., Troyan, I. A., Ksenofontov, V. &Shylin, S. I. (2015) Conventional superconductivity at 203K at high pressures in the sulfur hydride system. Nature 525, 73–76.
9. Kamihara, Y., Watanabe, T., Hirano, M. &Hosono, H. (2008) Iron-based layered superconductor $La[O_{1-x}Fx]FeAs$ (x= 0.05-0.12) with T_c=26K. J. Am. Chem. Soc. 130, 3296–3297.
10. Hosono, H. & Kuroki, K. (2015)Iron-based superconductors: Current status of materials and pairing mechanism. Phys. C Super-cond. its Appl. 514, 399–422.
11. Geibel, Christoph; Jesche, Anton; Kasinathan, Deepa; Krellner, Cornelius; Leithe-Jasper, Andreas; Nicklas, Michael; Rosner, Helge; Schnelle, Walter; Thalmeier, Peter; Borrmann, Horst; CarocaCanales, Nubia; Kaneko, Koji; Kumar, Manoj; Miclea, Corneliu Flo, U. (2011) From alchemy towards quantum dynamics: unraveling the secret of super-ducting, magnetism and structural instabilities in iron pnictides.

ISSN: 2320-3714
Volume 4 Issue 3
December 2021
Impact Factor: 10.2
Subject: Physics

12. Tsuei, C. C.; D. T. (1999) Charge confinement effect in cuprate superconductors: an explanation for the normal-state resistivity and pseudogap. T. Eur. Phys. J. B 10, 257–262.

13. Zhao, K. et al. (2016). Interface-induced superconductivity at ~25K at ambient pressure in un-doped $CaFe_2As_2$ single crystals. Proc. Natl. Acad. Sci. 113, 12968-12973.

14. Drozdov, A. P., Eremets, M. I. &Troyan, I. A. (2014). Conventional superconductivity at 190 K at high pressures.

15. Hicks, C. W. et al. (2014) Strong increase of T_c of Sr_2RuO_4 under both tensile and compressive strain. Science 344, 283-285.

Author's Declaration

I as an author of the above research paper/article, hereby, declare that the content of this paper is prepared by me and if any person having copyright issue or patentor anything otherwise related to the content, I shall always be legally responsible for any issue. For the reason of invisibility of my research paper on the website/amendments/updates, I have resubmitted my paper for publication on the same date. If any data or information given by me is not correct, I shall always be legally responsible. With my whole responsibility legally and formally I have intimated the publisher (Publisher) that my paper has been checked by my guide (if any) or expert to make it sure that paper is technically right and there is no unaccepted plagiarism and hentriacontane is genuinely mine. If any issue arises related to Plagiarism /Guide Name /Educational Qualification /Designation /Address of my university/college/institution/Structure or Formatting/ Resubmission / Submission /Copyright / Patent/Submission for any higher degree or Job/Primary Data/Secondary Data Issues. I will be solely/entirely responsible for any legal issues. I have been informed that the most of the data from the

ISSN: 2320-3714
Volume 4 Issue 3
December 2021
Impact Factor: 10.2
Subject: Physics

website is invisible or shuffled or vanished from the data base due to some technical fault or hacking and therefore the process of resubmission is there for the scholars/students who finds trouble in getting their paper on the website. At the time of resubmission of my paper I take all the legal and formal responsibilities, If I hide or do not submit the copy of my original documents (Aadhar/Driving License/Any Identity Proof and Photo) in spite of demand from the publisher then my paper may be rejected or removed from the website anytime and may not be consider for verification. I accept the fact that as the content of this paper and the resubmission legal responsibilities and reasons are only mine then the Publisher (Airo International Journal/Airo National Research Journal) is never responsible. I also declare that if publisher finds any complication or error or anything hidden or implemented otherwise, my paper maybe removed from the website or the watermark of remark/actuality maybe mentioned on my paper. Even if anything is found illegal publisher may also take legal action against me

ABULLAIS NEHAL AHMED
Dr. Satendra Singh

******