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Superconductors and its Applications

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Abstract:

Superconductivity allows current to pass through a material with no resistivity at near absolute zero temperature. It also exhibit meissner effect which causes the superconducting material to repel magnetic fields. The application of this technology has been extremely limited due to the high cost of using helium to cool the material to the critical temperature.

Recently, however the inventions of high temperature superconductors are made remarkable discoveries. In the present world, superconductors are being used in almost all the fields such as telecommunication, medical, space, defense etc. In this paper, some of these applications are highlighted along with the most fascinating manifestation of superconductivity- the levitating action.

Introduction

Superconductors, materials that have no resistance to the flow of current, are one of the last great frontiers of scientific discovery.Superconductivity is the passing of electricity through conductors with no loss in power. The resistance of a superconductor is zero[1-9],

$$P = I*I*R = 0$$

Where the power lost in the conductor is equal to the current squared times the resistance R (which is zero)[10-16].

Origins:

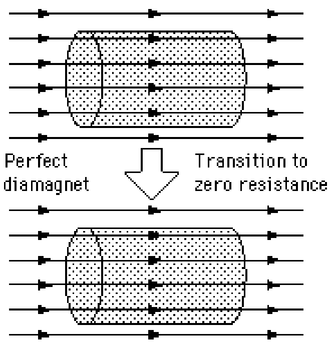
Superconductivity was first discovered in the year 1913 when Dutch physicist H.Kamerlingh Onnes was experimenting with materials at absolute zero temperature. He was measuring the resistance of a mercury crystal as he lowered the temperature and getting the expected curve of decreasing resistance. Unexplicably , however [17-21], at 4° Kelvin, the resistance suddenly went to zero. Later in 1973, a niobium and germanium alloy was found to become super conductive at the record high temperature of 23° K.

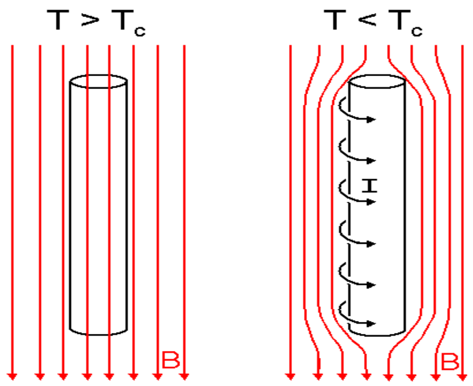
Super conducting technology needed liquid helium to achieve the low temperature, which was expensive to purchase and maintain as it rapidly evaporated[22-29]. But the discovery of high Tc superconductor brought a revolution in the field of science and technology. Liquid nitrogen, which is more easily and cheaply available replaced the liquid helium. The most popular theory explaining superconductivity is the BCS Theory, which states that the electrons move through the superconductors in pairs at low temperature and thus avoid most of the collisions in the conductors which generate unwanted heat. It was explained that the current resistance as a stream of flowing electrons smashing into the fixed crystal lattice of the metal conductor[30-36], which converts the power into, disorganized energy. In superconductivity, it was proposed that the electrons attract each other and travel in pairs – mirror imaging each others actions. When one bangs into the lattice, its partner ricochets, thus regaining the lost energy; the net effect is that no energy is lost in the transmission[37-41].

Critical temperature

A normal material achieves superconductivity only after lowering its temperature below a critical limit. The temperature at which the transition from normal to super conducting state takes place on cooling in the absence of magnetic field is called critical temperature. This transition temperatures vary from material to material apart from zero electreical resistivity[42-46], the following changes also occur.

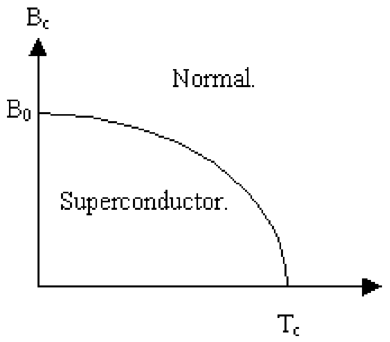
1) When a weak magnetic field is applied to superconducting specimen at a temperature below critical temperature[47-50], the magnetic flux lines are expelled. This phenomenon is called meissner effect or diamagnetism





PERFECT DIAMAGNET SUPERCONDUCTOR

Super conducting state of a material depends on the temperature and the strength of the magnetic field in which the material is placed. Even if the temperature is kept below Tc , and we go on increasing the magnetic strength gradually, a point will be reach where the superconductivity will disappear. This value of magnetic field strength is called critical magnetic



A type 1 superconductor.

field Bo
where Tc is the critical temperature and Bo critical magnetic field.

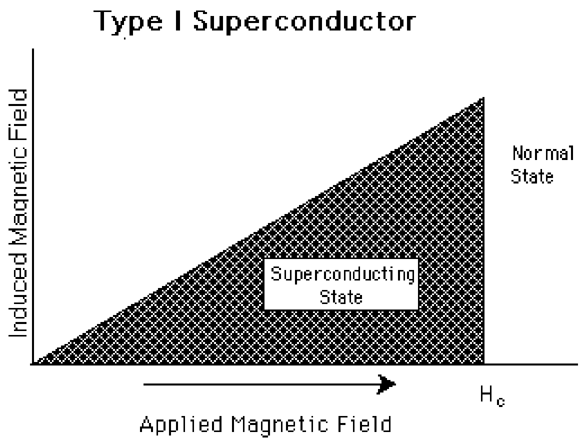


Fig. 10

2) There is a discontinuous change in specific heat.

<u>Types of superconductors</u>:

Superconductors are basically classified into two categories.

1) <u>Type 1 superconductors:</u>

Superconductors exhibiting complete meissner effect i.e., zero electrical resistively below a critical temperature, zero internal magnetic field (meissner effect), and a critical magnetic field above which superconductivity ceases are called type 1 superconductors

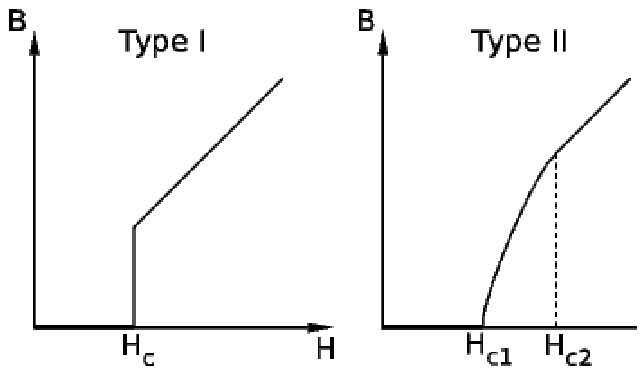
2)Type two superconductors

Type two superconductors unusually exist in a mixed state of normal and superconducting regions. This is sometimes called as vortex state, because vortices of super conducting current surround filaments or cores of normal material.

These do not have a sharp transition change as that of the type 1 superconductors.

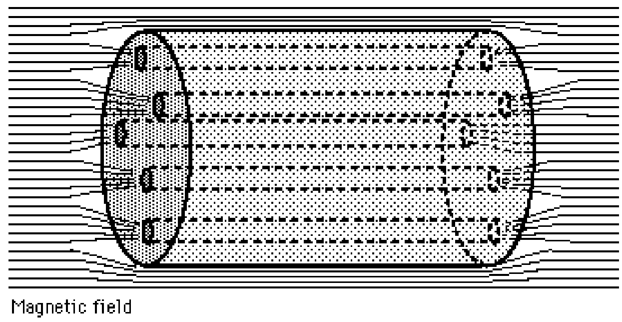
Some of the type 2 superconductors are:

Material	Transition Temp (K)	Critical Field (T)
NbTi	10	15
PbMoS	14.4	6.0
V_3Ga	14.8	2.1
NbN	15.7	1.5
V_3Si	16.9	2.35
Nb_3Sn	18.0	24.5
Nb_3Al	18.7	32.4
$Nb_3(AlGe)$	20.7	44
Nb_3Ge	23.2	38



Mixed –state meissner effect

In type 2 superconductors the magnetic field is not excluded completely, but is constrained in filaments with in the material. These filaments are in the normal state, surrounded by super currents in what is called a vortex state. Such a material can be subjected too much higher external magnetic field and remain superconducting.



Super conductor application

Superconductors have been a boon to the mankind and technocrats. Owing to its unique zero resistivity property, it has got wide spread application in various fields of science and technology. Now a days it’s being used in telecommunication, medical, transportation, defense, space and power transmission. Few of them are described below:

1) Transportation

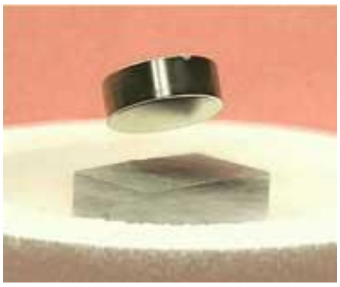
The Meissner effect could be used to levitate trains over their tracks allowing them to reach a speed 0f about 300 mph. In the 21^{st} century this principle could also be applied to cars for those who commute frequently. Heavy objects could be more effieiently moved down assembly lines in factories using superconducting levitation. Frictionless bearing could also be as a result of newly discovered effect which “holds” a magnetic field.

Mechanism for levitation:

Superconductor’s expel magnetic field, and hence repel magnets. This repulsion can be stronger than gravity, which leads to levitation – the most fascinating manifestation of superconductivity.

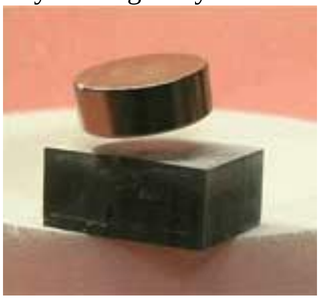
A superconductor is immersed in liquid nitrogen to provide cooling below the critical temperature. A magnet is placed in the air above the superconductor and left there levitating. Nothing but magnetic interaction keeps the magnet from falling down.

The levitating magnet has a preferential position above the superconductor and returns there after a small perturbation by a human finger. When the magnet is pushed hard towards the superconductor, it changes the magnetic field distribution in the superconductor, and a new position becomes preferential.



At room temperature magnetic field lines from the magnet penetrate the superconductor without restraint. After cooling by liquid nitrogen they get trapped by microscopic inhomogeneities in the superconductor. The trapped magnetic lines then serve as invisible threads holding the two objects together at a certain distance

When the superconductor is taken out of the liquid nitrogen, its temperature slowly starts increasing. As a result, the superconducting properties weaken, and the levitation force gradually gives way to the gravity.

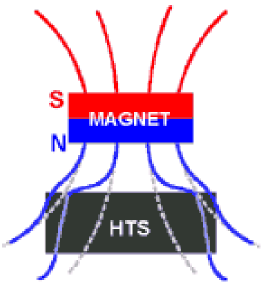


MAGLEV TRAIN

A future application of superconductivity is under development in Japan. To minimize friction, powerful on board superconducting magnets support this train above the tracks, shown below a prototype.

Why repulsion?
Magnetic field is partly excluded from the superconductor. Hence the same repulsion is between a magnet and a diamagnet

Why attraction? The magnetic flux lines that managed to penetrate the superconductor get *pinned* (trapped) there by microscopic in homogeneities. When the magnet is lifted up, the superconductor holds its magnetic lines and follows the magnet. How to help magnetic lines penetrate the superconductor? Place the superconductor close to the magnet already at *high* temperature (movie 3) or push the magnet hard towards the superconductors.



Such a distribution of magnetic field lines is expected for a type-II superconductor with flux pinning, i.e. for all high-temperature superconductors

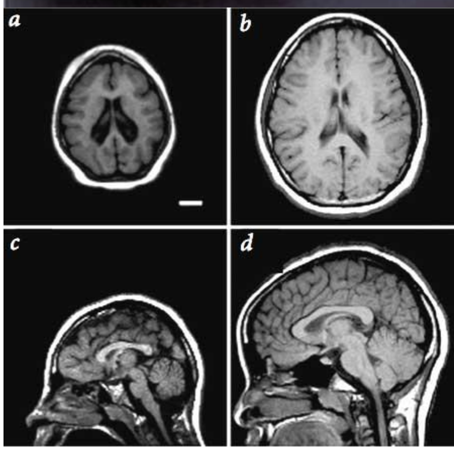
2) **MEDICAL APPLICATION**

MRI (MAGNETIC RESONANCE IMAGE:)

The key feature of superconductor is that it can carry an electrical current for ever with no decay. Millions of people around the world have been surrounded by a super conducting magnet while thousands of MRI machines are in everyday use, each containing tens of kilometers of super conducting wires wound into a persistent current solenoid. The magnet is cooled either by liquid helium or by cryocooler. Once the current has been stored in the superconducting coil, the magnetic field is very stable, decaying by as little as a part per million in a year.

Conventional MRI relays on the fact that protons possess spin and thus a magnetic moment. In the MRI machine a radio frequency pulse of magnetic field induces protons in the patient to process about the direction of the static magnetic field supplied by the super conducting magnet. For the workhorse machine with a field of 1.5tesla, the processional frequency, which is precisely proportional to the field, is about 64 MHz. These precessing magnetic moments induce a radio frequency voltage in a receiver coil that is amplified and stored for subsequent analysis. If the magnetic field were uniform all the protons would possess at the same frequency.

MRI has become a clinical tool of great importance and is used to locate some sites in the brain that are involved in body functions or thought.



3) **IN POWER TRANSMISSION**

Because of the zero resistance property of the super conducting wires, all the electric motors could be improved in efficiency. Communications using electromagnetic waves would get a boost as a high temperature superconductivity coating on the inside of resonators, high frequency generators, surveillance satellites, television, lasers, particle accelerators and radio astronomy products improves performance by reducing power loss. This power loss is inhibitive at higher frequencies, but now, using superconductivity the “wireless” transmission bandwidth increases 167 times as operating frequencies will eventually move from 30GHz to 5Tera Hz(5000GHz).

Electric generators, made more efficient by using super conducting wires, could store their energy in super conducting coils during the night to be used in peak hours during the day. These storage coils would have a current flow without any resistance or voltage source—energy that can be stored and trapped at any time, forever.

$$V=I*R=0 \text{ (Ohm's law)}$$

Where the voltage V is zero the resistance R is zero, and the current I is limited by the properties of the material. Deserts might be covered with huge solar collectors, which feed this coils.

4) DEFENCE APPLICATIONS

Defense applications are also abundant. Super conducting sensors in the cold of space could be used to detect missile launches. Submarines could be tracked using tiny magnetic detectors scattered throughout the seas. And to counter acoustical detection a submarine could propel itself through the water with no moving parts using superconductivity to generate magnetic fields, which would force water through a pipe. Strategic defense initiative laser technology could get its required mega watt energy bursts from super conduction storage units instead of proposed nuclear detonations.

Conclusion

With the discovery of high Tc superconductors a new revolution has started in the field of superconductivity. Now scientists are trying to get the critical temperature as close as possible to the room temperature thus we can use liquid Nitrogen instead of expensive Helium. Now itself some Yttrium compounds are giving a critical temperature as close as 138K. If we are able to make little more improvement then we can see a new world which will run on superconductors

REFERENCE:

1. Ramamoorthy, R., Kanagasabai, V., Kausalya, R., Impact of celebrities' image on brand, International Journal of Pure and Applied Mathematics, V-116, I-18 Special Issue, PP-251-253, 2017
2. Ramamoorthy, R., Kanagasabai, V., Vignesh, M., Quality assurance in operation theatre withreference to fortis malar hospital, International Journal of Pure and Applied Mathematics, V-116, I-14 Special Issue, PP-87-93, 2017
3. Ramya, N., Arthy, J., Honey comb graphs and its energy, International Journal of Pure and Applied Mathematics, V-116, I-18 Special Issue, PP-83-86, 2017
4. Ramya, N., Jagadeeswari, P., Proper coloring of regular graphs, International Journal of Pure and Applied Mathematics, V-116, I-16 Special Issue, PP-531-533, 2017
5. Ramya, N., Karunagaran, K., Proper, star and acyclic coloring of some graphs, International Journal of Pure and Applied Mathematics, V-116, I-16 Special Issue, PP-43-44, 2017
6. Ramya, N., Muthukumar, M., On coloring of 4-regular graphs, International Journal of Pure and Applied Mathematics, V-116, I-16 Special Issue, PP-491-494, 2017
7. Ramya, N., Muthukumar, M., On star and acyclic coloring of graphs, International Journal of Pure and Applied Mathematics, V-116, I-16 Special Issue, PP-467-469, 2017
8. Ramya, N., Pavi, J., Coloring of book and gear graphs, International Journal of Pure and Applied Mathematics, V-116, I-17 Special Issue, PP-401-402, 2017
9. Ramya, P., Hameed Hussain, J., Alteration framework for integrating

quality of service in internet real-time network, International Journal of Pure and Applied Mathematics, V-116, I-8 Special Issue, PP-57-61, 2017

10. Ramya, P., Sriram, M., Tweet sarcasm: Peep, International Journal of Pure and Applied Mathematics, V-116, I-10 Special Issue, PP-231-235, 2017
11. Sabarish, R., Meenakshi, C.M., Comparision of beryllium and CI connecting rod using ansys, International Journal of Pure and Applied Mathematics, V-116, I-17 Special Issue, PP-127-132, 2017
12. Sabarish, R., Rakesh, N.L., Outcome of inserts for enhancing the heat exchangers, International Journal of Pure and Applied Mathematics, V-116, I-17 Special Issue, PP-419-422, 2017
13. Sangeetha, M., Gokul, N., Aruls, S., Estimator for control logic in high level synthesis, International Journal of Pure and Applied Mathematics, V-116, I-20 Special Issue, PP-425-428, 2017
14. Sangeetha, M., Gokul, N., Aruls, S., Image steganography using a curvelet transformation, International Journal of Pure and Applied Mathematics, V-116, I-20 Special Issue, PP-417-422, 2017
15. Saraswathi, P., Srinivasan, V., Peter, M., Research on financial supply chain from view of stability, International Journal of Pure and Applied Mathematics, V-116, I-17 Special Issue, PP-211-213, 2017
16. Saravana Kumar, A., Hameed Hussain, J., Expanding the pass percentage in semester examination, International Journal of Pure and Applied Mathematics, V-116, I-15 Special Issue, PP-45-48, 2017
17. Saravana, S., Arulselvi, S., AdaBoost SVM based brain tumour image segmentation and classification, International Journal of Pure and Applied Mathematics, V-116, I-20 Special Issue, PP-399-403, 2017
18. Saravana, S., Arulselvi, S., Dynamic power management monitoring and controlling system using wireless sensor network, International Journal of Pure and Applied Mathematics, V-116, I-20 Special Issue, PP-405-408, 2017
19. Saravana, S., Arulselvi, S., Clustered morphic algorithm based medical image analysis, International Journal of Pure and Applied Mathematics, V-116, I-20 Special Issue, PP-411-415, 2017
20. Saravana, S., Arulselvi, S., Networks, International Journal of Pure and Applied Mathematics, V-116, I-20 Special Issue, PP-393-396, 2017
21. Saritha, B., Chockalingam, M.P., Adsorptive removal of heavy metal chromium from aqueous medium using modified natural adsorbent, International Journal of Civil Engineering and Technology, V-8, I-8, PP-1382-1387, 2017
22. Saritha, B., Chockalingam, M.P., Adsorptive removal of brilliant green dye by modified coconut shell adsorbent, International Journal of Pure and Applied Mathematics, V-116, I-13 Special Issue, PP-211-215, 2017
23. Saritha, B., Chockalingam, M.P., Photodegradation of eriochrome black-T dye from aqueous medium by photocatalysis, International Journal of Pure and Applied Mathematics, V-116, I-13 Special Issue, PP-183-187, 2017
24. Saritha, B., Chockalingam, M.P., Photodradation of malachite green DYE using TIO<inf>2</inf>/activated carbon composite, International Journal of Civil Engineering and Technology, V-8, I-8, PP-156-163, 2017
25. Saritha, B., Chockalingam, M.P., Synthesis of photocatalytic composite Fe-C/TiO2 for degradation of malachite green dye from aqueous medium,

International Journal of Pure and Applied Mathematics, V-116, I-13 Special Issue, PP-177-181, 2017
26. Saritha, B., Chockalingam, M.P., Removal of heavy X`X`l from aqueous medium using modified natural adsorbent, International Journal of Pure and Applied Mathematics, V-116, I-13 Special Issue, PP-205-210, 2017
27. Saritha, B., Chockalingam, M.P., Degradation of malachite green dye using a semiconductor composite, International Journal of Pure and Applied Mathematics, V-116, I-13 Special Issue, PP-195-199, 2017
28. Sartiha, B., Chockalingam, M.P., Photocatalytic decolourisationof textileindustry wastewaterby TiO2, International Journal of Pure and Applied Mathematics, V-116, I-18 Special Issue, PP-221-224, 2017
29. Sartiha, B., Chockalingam, M.P., Study on photocatalytic degradation of Crystal Violet dye using a semiconductor, International Journal of Pure and Applied Mathematics, V-116, I-18 Special Issue, PP-209-212, 2017
30. Shanthi, E., Nalini, C., Rama, A., The effect of highly-available epistemologies on hardware and architecture, International Journal of Pharmacy and Technology, V-8, I-3, PP-17082-17086, 2016
31. Shanthi, E., Nalini, C., Rama, A., Drith: Autonomous,random communication, International Journal of Pharmacy and Technology, V-8, I-3, PP-17002-17006, 2016
32. Shanthi, E., Nalini, C., Rama, A., A case for replication, International Journal of Pharmacy and Technology, V-8, I-3, PP-17234-17238, 2016
33. Shanthi, E., Nalini, C., Rama, A., Elve: A methodology for the emulation of robots, International Journal of Pharmacy and Technology, V-8, I-3, PP-17182-17187, 2016
34. Shanthi, E., Nalini, C., Rama, A., Autonomous epistemologies for 802.11 mesh networks, International Journal of Pharmacy and Technology, V-8, I-3, PP-17087-17093, 2016
35. Sharavanan, R., Golden Renjith, R.J., Design and analysis of fuel flow in bend pipes, International Journal of Pure and Applied Mathematics, V-116, I-15 Special Issue, PP-59-64, 2017
36. Sharavanan, R., Jose Ananth Vino, V., Emission analysis of C.I engine run by diesel,sunflower oil,2 ethyl hexyl nitrate blends, International Journal of Pure and Applied Mathematics, V-116, I-14 Special Issue, PP-403-408, 2017
37. Sharavanan, R., Sabarish, R., Design of built-in hydraulic jack for light motor vehicles, International Journal of Pure and Applied Mathematics, V-116, I-17 Special Issue, PP-457-460, 2017
38. Sharavanan, R., Sabarish, R., Design and fabrication of aqua silencer using charcoal and lime stone, International Journal of Pure and Applied Mathematics, V-116, I-14 Special Issue, PP-513-516, 2017
39. Sharmila, G., Thooyamani, K.P., Kausalya, R., A schoolwork on customer relationship management with special reference to domain 2 host, International Journal of Pure and Applied Mathematics, V-116, I-20 Special Issue, PP-199-203, 2017
40. Sharmila, S., Jeyanthi Rebecca, L., Anbuselvi, S., Kowsalya, E., Kripanand, N.R., Tanty, D.S., Choudhary, P., Swathy Priya, L., GC-MS analysis of biofuel extracted from marine algae, Der Pharmacia Lettre, V-8, I-3, PP-204-214, 2016
41. Sidharth Raj, R.S., Sangeetha, M., Data embedding method using adaptive pixel pair matching method, International

Journal of Pure and Applied Mathematics, V-116, I-15 Special Issue, PP-417-421, 2017

42. Sidharth Raj, R.S., Sangeetha, M., Android based industrial fault monitoring, International Journal of Pure and Applied Mathematics, V-116, I-15 Special Issue, PP-423-427, 2017
43. Sidharth Raj, R.S., Sangeetha, M., Mobile robot system control through an brain computer interface, International Journal of Pure and Applied Mathematics, V-116, I-15 Special Issue, PP-413-415, 2017
44. Sivaraman, K., Sundarraj, B., Decisive lesion detection in digital fundus image, International Journal of Pure and Applied Mathematics, V-116, I-10 Special Issue, PP-161-164, 2017
45. Sridhar, J., Sriram, M., Cloud privacy preserving for dynamic groups, International Journal of Pure and Applied Mathematics, V-116, I-8 Special Issue, PP-117-120, 2017