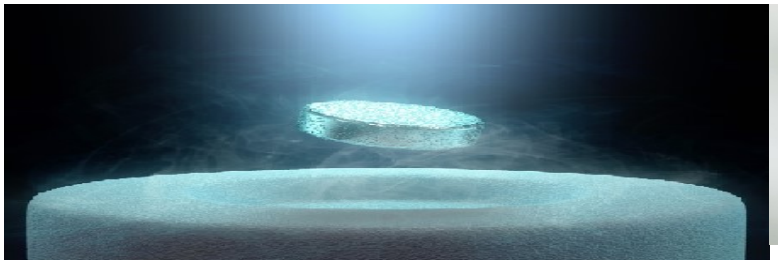
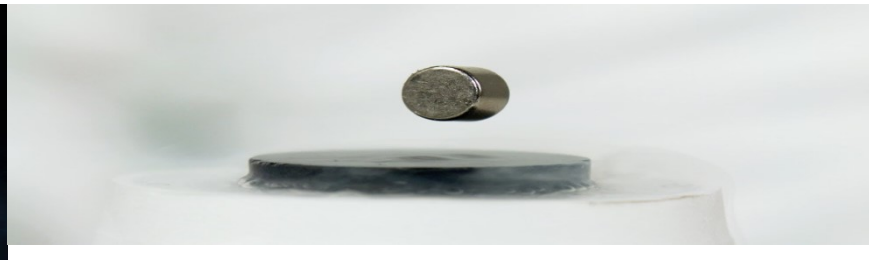
AMIRAJ
COLLEGE OF ENGINEERING & TECHNOLOGY

Topic: Superconductor





Subject : Physics **Code : 3110018**	**Prepared By:** **Dr. Sonal Mathur** **(H&As. Department ACET)**	AMIRAJ COLLEGE OF ENGINEERING & TECHNOLOGY

What is Superconductor?

Some materials loose their resistivity when they are cooled down below a certain temperature. This Phenomenon is called as superconductivity and these materials are called as superconductors.

Discovery

Superconductivity was discovered by Heike Kamerlingh Onnes in 1911.

He was awarded the Nobel prize in Physics in 1913 for his low-temperature research.

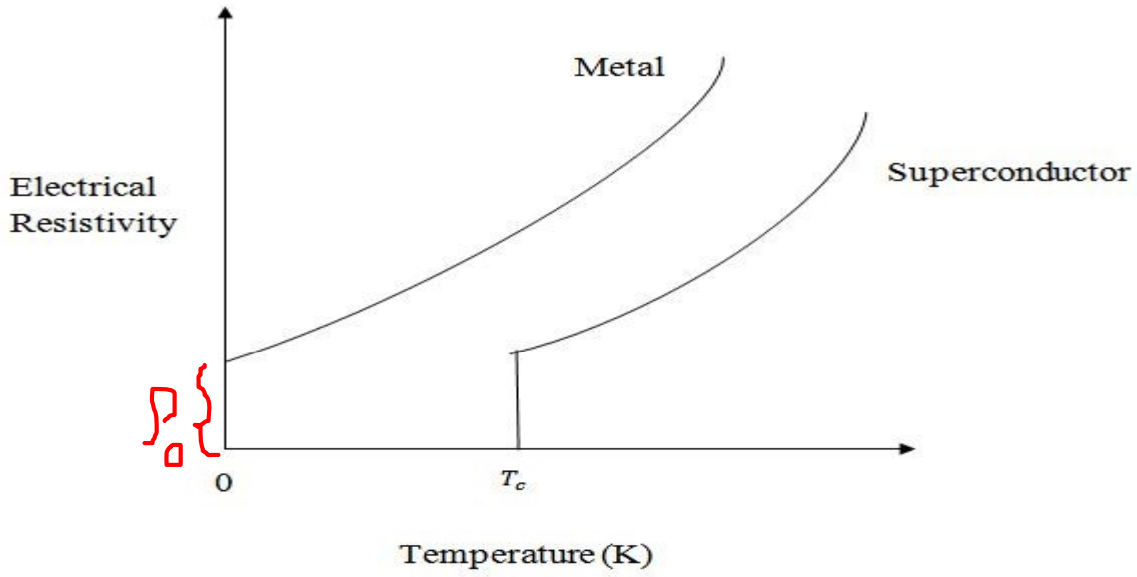
He found that when pure mercury (Hg) was placed in liquid helium, then mercury(Hg) lost its resistivity at 4.2 K. It was found to be 10^{-5} Ω cm.

Critical temperature

- The temperature at which these materials loose their resistivity is called critical temperature (T_c)

Do all good conductors behave as superconductors?

- Some materials like gold and silver are good conductors at normal temperature but they do not show superconductivity. When these materials are cooled down below a certain temperature then some resistivity still remain in those materials. This is called Residual resistivity (ρ_0).
- Whereas ceramics which are insulators show superconductivity.



Resistivity v/s Temperature for superconductor and normal conductor

Properties of Superconductors

Some important properties are given below:

- Electrical Resistance
- Persistent current
- Effect of magnetic field
- Meissner effect
- Critical Current
- Isotopic effect
- Impurity effect
- Pressure effect

Electrical Resistance

- The Resistivity of superconductors drops to 10^{-7} Ωm at critical temperature so we can say that virtually it drops to zero.

- Thus ideally current can flow for infinite time through a loop of superconducting material

Persistent Current

- When current flows through a superconductor then it persist in the material even after the removal of source.

- It is because of zero resistivity of material. This current is called as Persistent current.

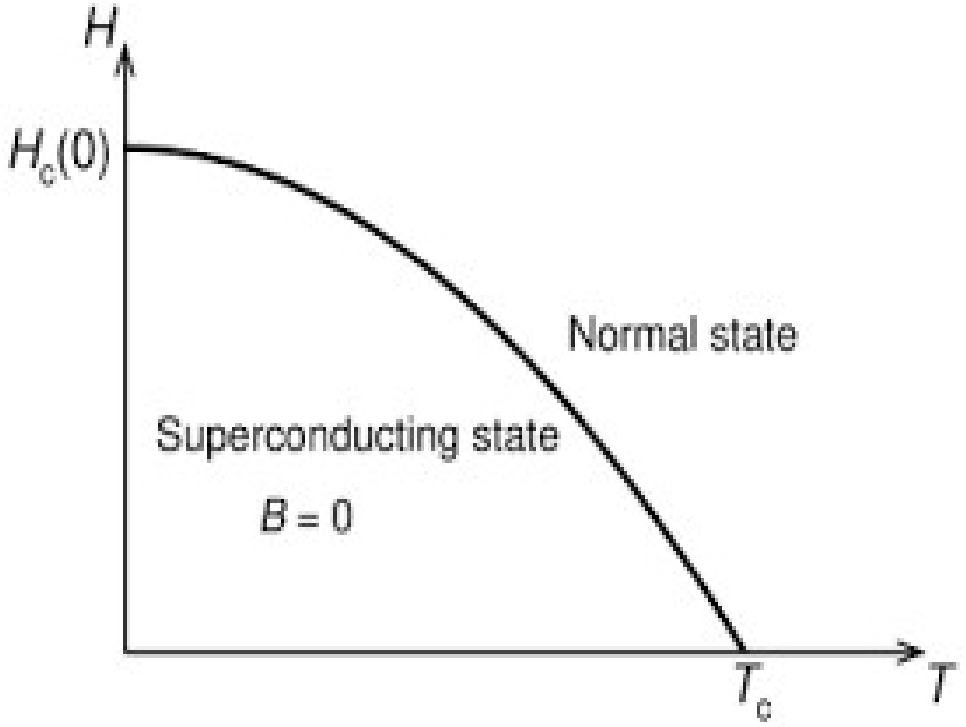
Effect of Magnetic Field

- In 1913, Kamerlingh Onnes found that when a superconductor is kept in an external magnetic field then as magnetic field increases, the superconductivity decreases and at particular value of magnetic field, called critical magnetic field, the superconductivity destroys.
- This critical magnetic field depends upon temperature .

This temperature dependence is given by the Tuyn's equation

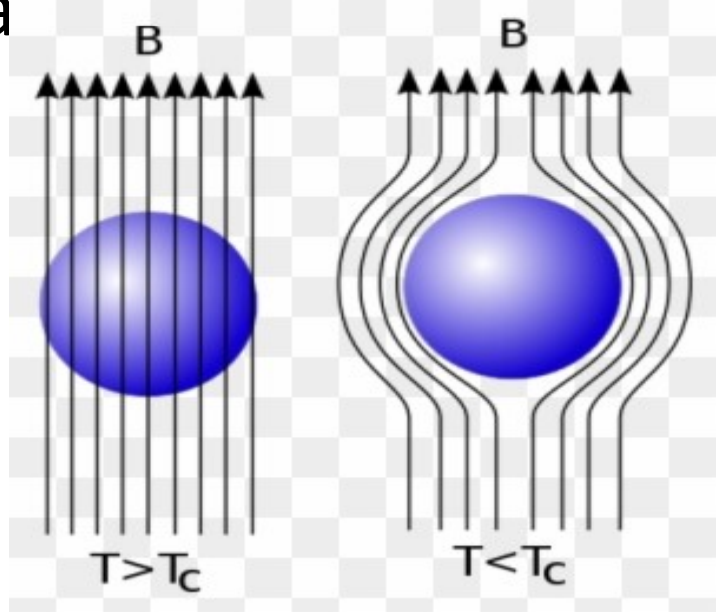
$$H_c(T) = H_c(0) [\ 1-(T/T_c)^2]$$

Where, $H_c(T)$ = critical magnetic field at temperature T K
$H_c(0)$ = Critical magnetic field at temperature 0 K
T_c= critical Temperature



Meissner Effect

- When superconductor is placed in an external magnetic field then it expels all the magnetic field lines from it.
- This effect is called Meissner effect



Critical Current (I_c)

- When heavy current pass through the superconductor then at particular value of current, called critical current, the critical magnetic field also increases.
- It destroys the superconductivity, this effect is called as silsbee effect.
- For a cylindrical wire of radius r, the critical current is given by $I_c = 2\pi r H_c$.

Isotopic effect

- According to observation it was found that the critical temperature also varies with isotopic mass.
- This relation is given by $T_c \alpha (1/ \sqrt{M})$

Where M= Isotopic mass

Impurity effect

- Impurity also affect the superconductivity.
- As impurity in the material increases, critical temperature decreases.
- For example: Pure mercury shows superconductivity at 4.2 K, but impure mercury shows superconductivity below 4.2K.

Pressure effect

- Some materials show superconductivity when they are placed under pressure.

- For example: Cesium does not show superconductivity but when it is placed under pressure of 110 kbar then it shows superconductivity.

THANK YOU