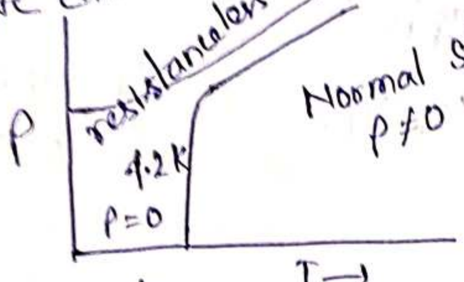
Superconductivity

1908 Kamerling onnes

He-gas → boiling point

Liq. H → 4.2 K

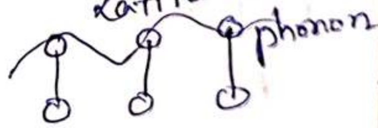
1911 → He discovered superconducting state in Hg



Hg

1931 → Noble pize for study of low temp properties of metal.

Superconducting state or resistanceless state.



$$\rho = \rho_0 + A\left(\frac{T}{\theta_D}\right)^4 \int_0^{\theta/T} \frac{x^5\,dx}{(e^x-1)(1-e^{-x})} + \rho_{mag} \rightarrow (\text{Magnetic scattering term})$$

ρ_0 ↙ Impurity scattering

$A\left(\frac{T}{\theta_D}\right)^4$ ↙ e-phonon scattering term

Integral ↘ Bloch-Gruneisen Integral

1957 → BCS Theorem
- B → Barden → (Transistor)
- C → cooper
- S → schreiffer

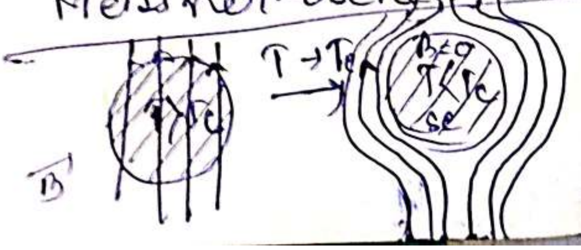
Barden, Britain, Schokley — Transistor P-N-P 1947

MRT → Superconducting Magnet

TO KOMOK

1) High field magnet
2) SMES
3) Magnetic Levitation
   High Speed train running 400 - 500 KM/hour
4) Superconducting switches
5) Josephin tunneling - SQUID

Meissner-Oschenfield Effect:



expansion of Magnetic flux line.

i) $\rho = 0$ ii) $B = 0$ These two properties are independent.

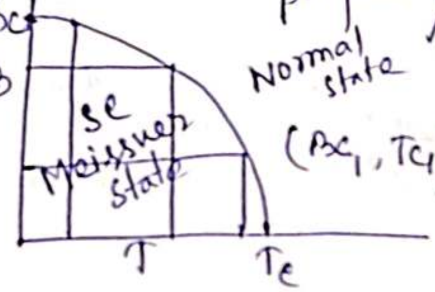
$E = \rho J$ $\rho = 0 \Rightarrow E = 0$ $E = 0$

SC property is a special property where $B = 0$

$\vec{\nabla} \times \vec{E} = 0$

$-\frac{\partial B}{\partial t} = 0$

$B = \text{const}$



Hg = 4.2 K
$B = 0$

Element	Tc (K)
Al	1.2
Cd	0.5
Ga	1.1
In	3.4
Pb	7.2
Nb	9.3
Tc	8.2
Sn	3.7
V	3.3
Nb_3Ge	23
Nb_3Sn	18.1
Nb_3Al	17.5
$Nb_3Al_{0.8}Ge_{0.2}$	20.1

Low Tc Material → Type-I superconductor

1987 Bednortz and Mueller → High Tc Superconductor
Type-II Superconductor.

High Tc Material	Tc (K)
$(LaBa)_2CuO_4$	38 K
$YBa_2Cu_3O_{7-\delta}$	90 K
$Bi_2Sr_2Ca_2Cu_3O_{10+\delta}$	110 K
$Tl_2Ba_2Ca_2Cu_3O_{10+\delta}$	130 K
H_2S (155 GPa)	210 K
LaH_{10} (170 GPa)	250 K

C-H-S (267 GPa) – 270 K

$B=0 \quad \vec{B} = \mu_0(\vec{H}+\vec{M}) = \mu_0\vec{H}\left(1+\frac{M}{H}\right) = \mu_0 H(1+\chi)$

$= \mu H = \mu_0 \mu_r H$

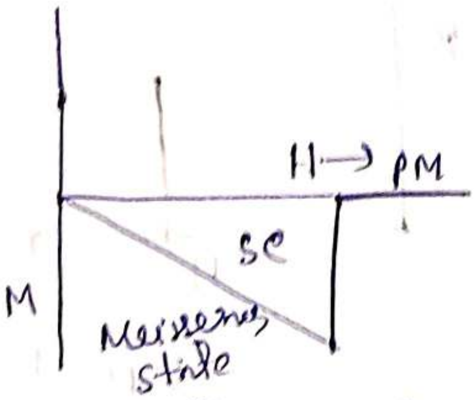
$0 = H + M$

$M = -H$

$\chi = \frac{M}{H} = -1$

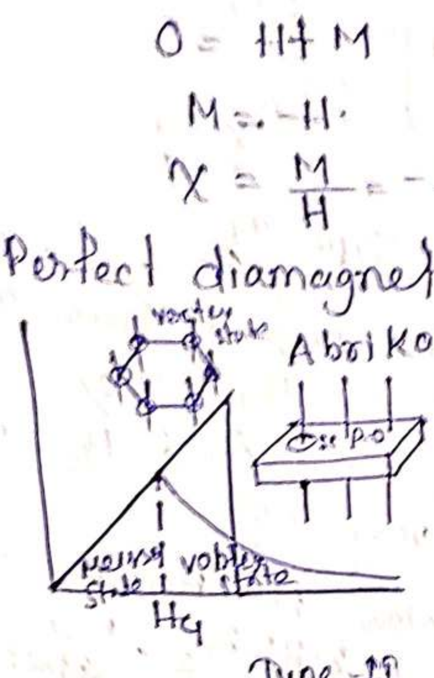
$\chi = -10^{-5}$

Perfect diamagnet



Type -I SC

Abrikosov flux lattice



Type-II