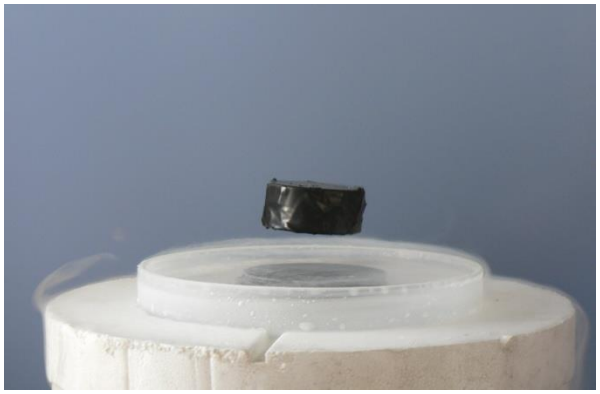
Introduction of Superconductivity



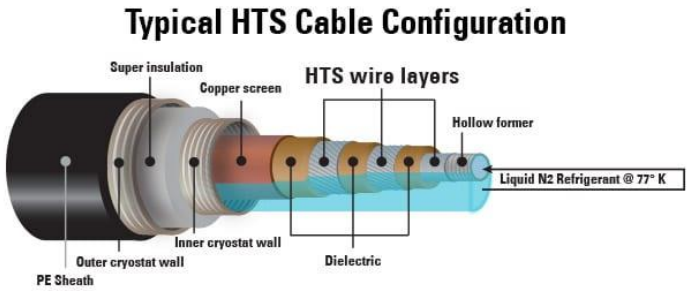
Parth Raval,

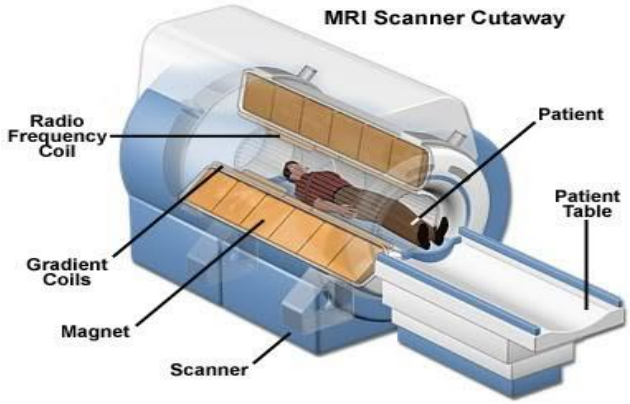
L D College of Engineering,

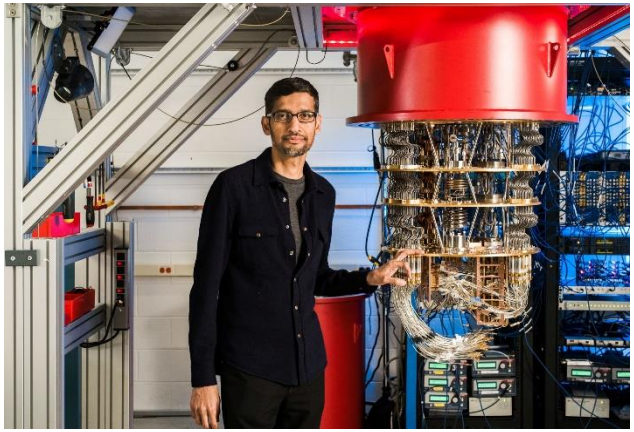
Navrangpura, Ahmedabad

Who studies on first lecture… nah.. Let talk…

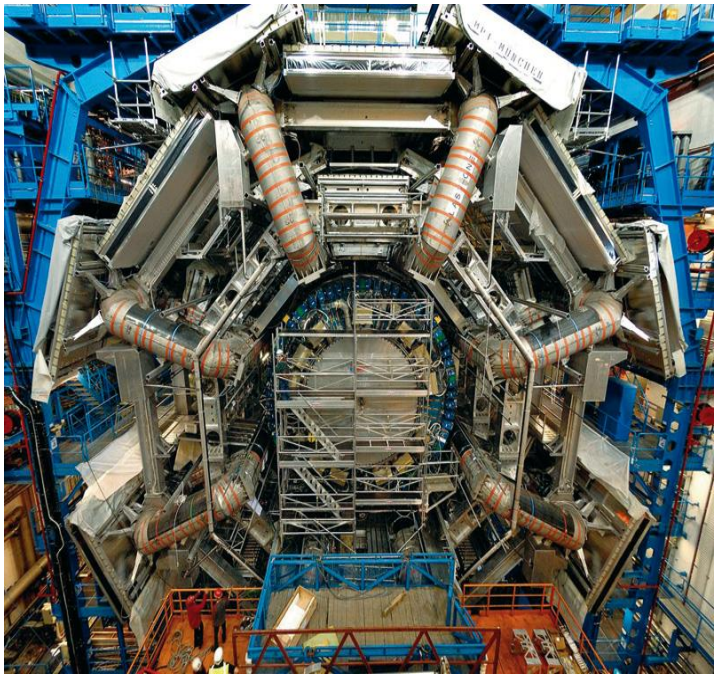
Usage of Our Subject

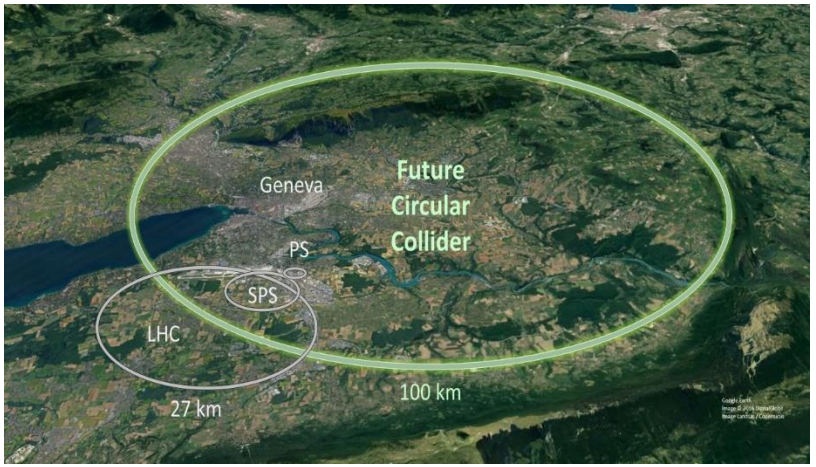






Usage of Our Subject : CERN





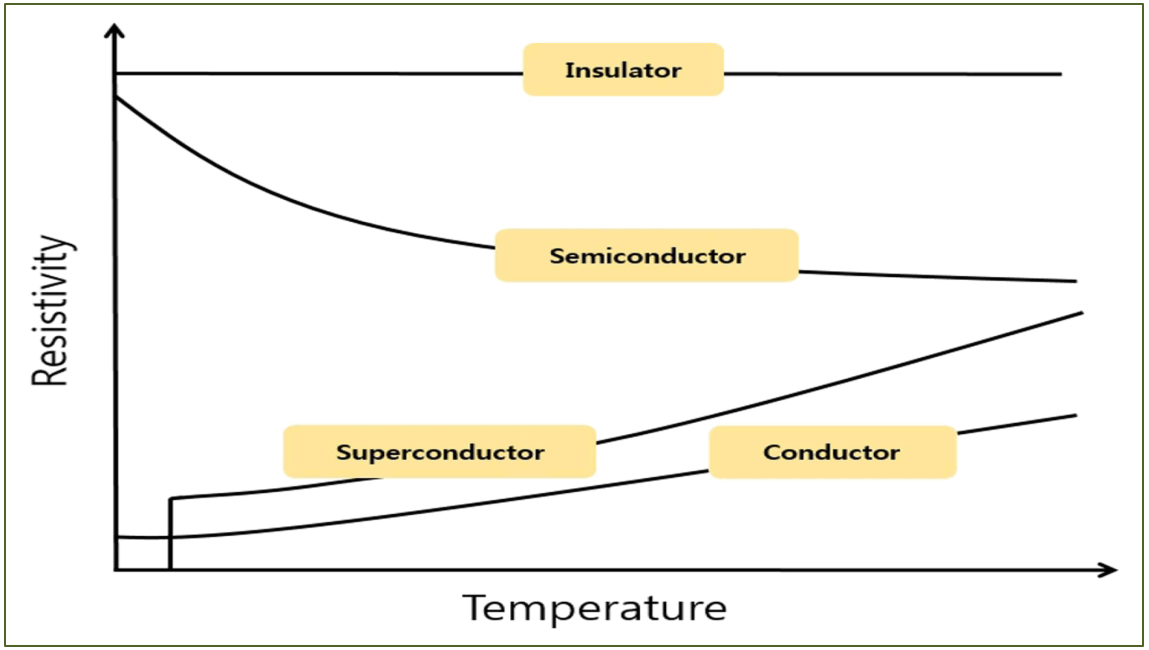
Energy	Defense	Transportation	Industrial	Medical	Science/ Research
• Cables • FCLs • Generators • Transformers • SMES • Fusion Reactors	• Motors • Cables	• Maglev • Motors	• Induction Heaters • Motors • Generators • Magnetic Separation • Bearings	• MRI • Particle Therapy • Current Leads	• HF Magnets • NMR • Accelerators • Neutron and X-ray Scattering • Undulators








Resistivity Vs. Temperature

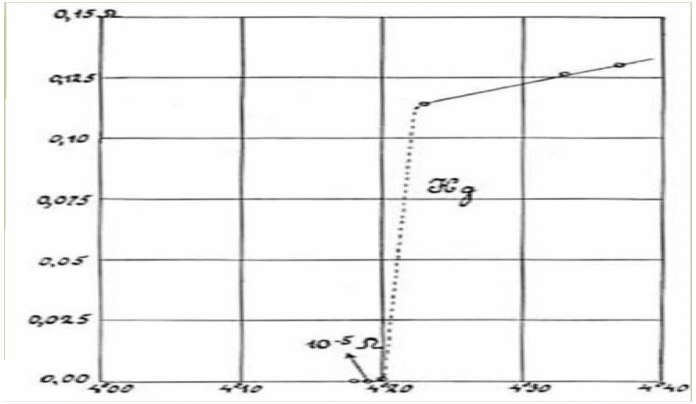


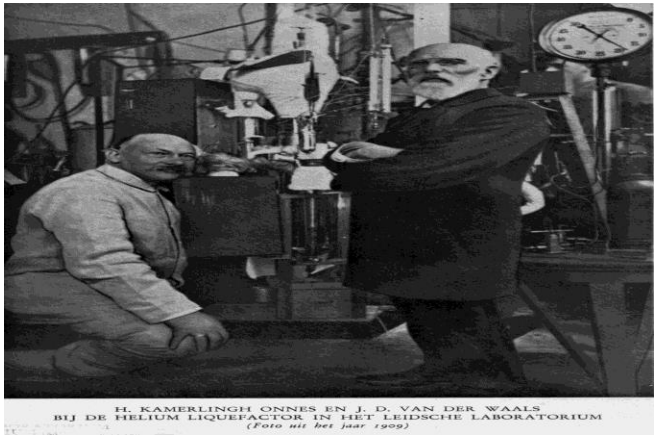
The effect of temperature was point of interest for scientists.

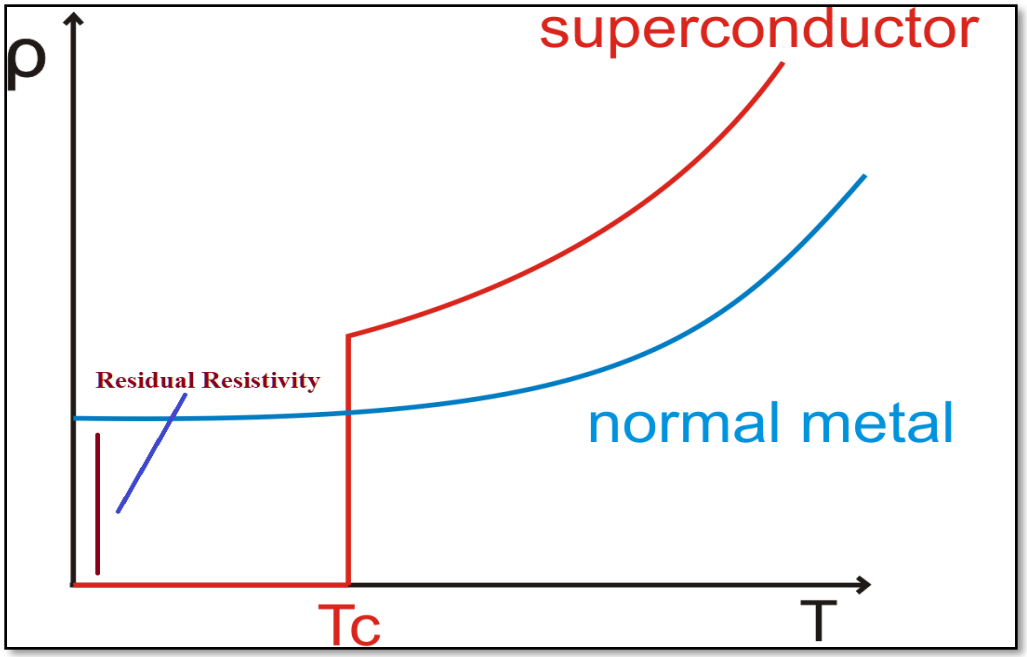
The study was done fro High Temperature as well as low temperature also.

Some interesting observations were recorded for element like Mercury.

H. Onnes and his observations




H. KAMERLINGH ONNES EN J. D. VAN DER WAALS
BIJ DE HELIUM LIQUEFACTOR IN HET LEIDSCHE LABORATORIUM
(Foto uit het jaar 1909)



Basic understanding of metallic conduction must be finite, even at T = 0.
Nevertheless many superconductors, for which resistivity zero exist.

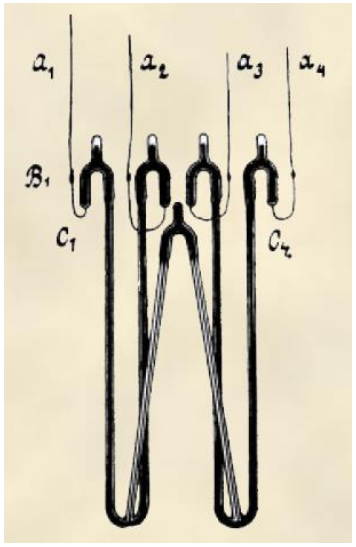
The first one Hg was discovered by Onnes in 1911.

It becomes superconducting for T < 4:2K.

Observations

Type of material	What happens in a wire?	Result
Conductor	 Electrons flow easily (like water through a garden hose)	Collisions cause dissipation (heat)
Insulator	 Electrons are tightly bound no flow (like a hose plugged with cement)	No current flow at all
Superconductor	 Electrons bind into pairs and cannot collide (a frictionless hose)	No collisions No dissipation No heat No resistance

Superconductivity- discovery I



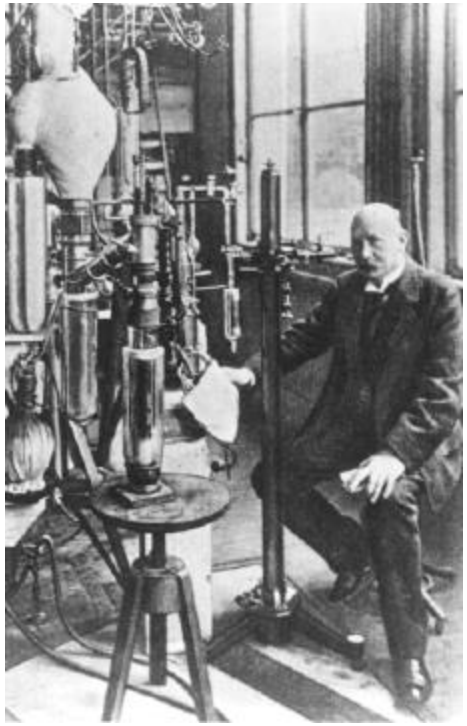
1895 William Ramsay in England discovered helium on the earth
1908 H. Kamerlingh Onnes liquefied helium (boiling point 4.22 K)

Resistivity at low temperatures- pure mercury (could repeatedly distilled producing very pure samples).

- Repeated resistivity measurements indicated zero resistance at the liquid-helium temperatures. **Short circuit was assumed!**
- During one repetitive experimental run, a young technician fall asleep. The helium pressure (kept below atmospheric one) slowly rose and, therefore, the boiling temperature. As it passed above 4.2 K, suddenly resistance appeared.

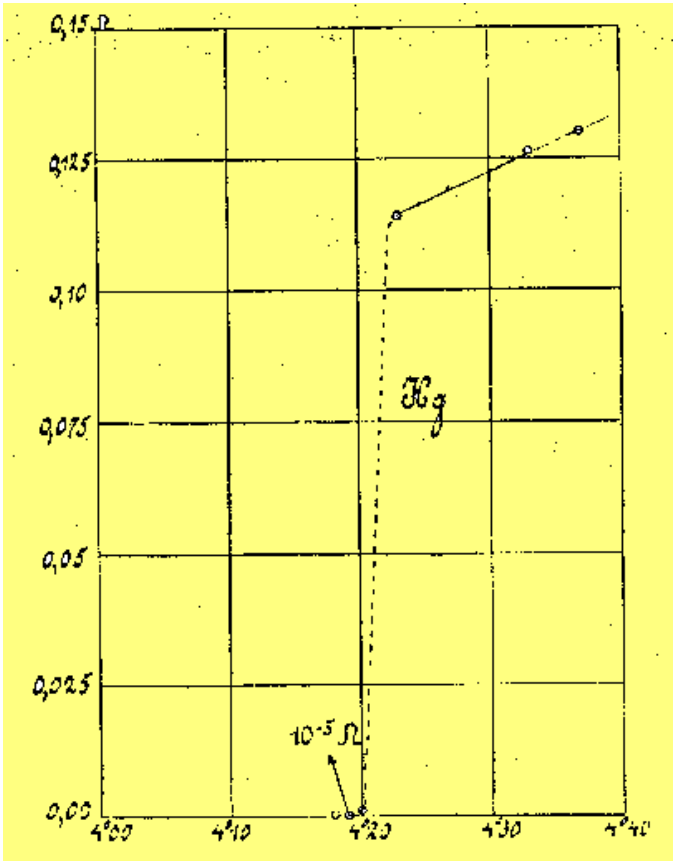
Hg T_C=4.2K

From: Rudolf de Bruyn Ouboter, "*Heike Kamerlingh Onnes's Discovery of Superconductivity*", Scientific American March 1997



Superconductivity- discovery II

- Liquid Helium (4K) (1908). ***Boiling point*** 4.22K.
- Superconductivity in Hg T_C=4.2K (1911)



„Mercury has passed into a new state, which on account of its extraordinary electrical properties may be called the superconducting state"

H. Kamerlingh Onnes 1913 (Nobel preis 1913)

Resistivity R=0 below T_C; ($R<10^{-23}$ Ω·cm, 10^{18} times smaller than for Cu)

Further discoveries

1911-1986: "Low temperature superconductors" Highest T_C=23K for Nb_3Ge

1986 (January): High Temperature Superconductivity $(LaBa)_2\ CuO_4$ T_C=35K

K.A. Müller und G. Bednorz (IBM Rüschlikon) (Nobel preis 1987)

1987 (January): $YBa_2Cu_3O_{7-x}$ T_C=93K

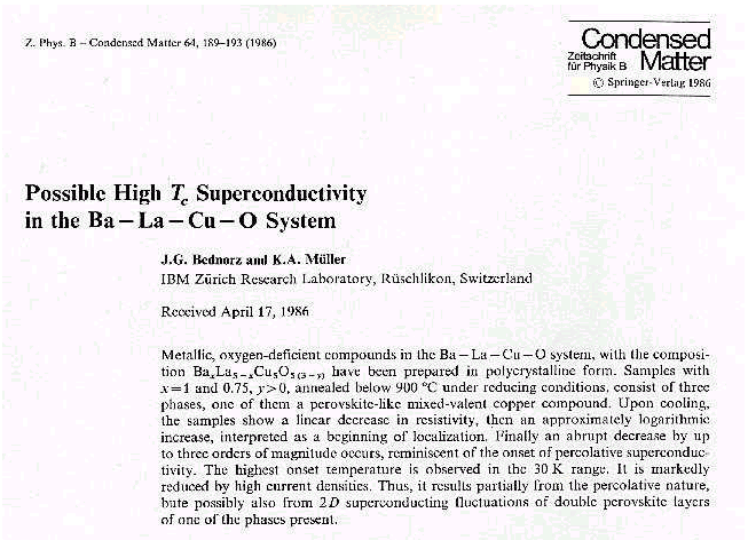
1987 (December): Bi-Sr-Ca-Cu-O T_C=110K

1988 (January): Tl-Ba-Ca-Cu-O T_C=125K

1993: Hg-Ba-Ca-Cu-O T_C=133K

(A. Schilling, H. Ott, ETH Zürich)

Professor Dr. Dr. h. c. mult. Karl Alex Müller (links) und Dr. Johannes Georg Bednorz



Z. Phys. B – Condensed Matter 64, 189–193 (1986)

Condensed Matter
Zeitschrift für Physik B
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Possible High T_c Superconductivity in the Ba – La – Cu – O System

J.G. Bednorz and K.A. Müller
IBM Zürich Research Laboratory, Rüschlikon, Switzerland

Received April 17, 1986

Metallic, oxygen-deficient compounds in the Ba – La – Cu – O system, with the composition $Ba_xLa_{5-x}Cu_5O_{5(3-y)}$ have been prepared in polycrystalline form. Samples with $x=1$ and 0.75, $y>0$, annealed below 900 °C under reducing conditions, consist of three phases, one of them a perovskite-like mixed-valent copper compound. Upon cooling, the samples show a linear decrease in resistivity, then an approximately logarithmic increase, interpreted as a beginning of localization. Finally an abrupt decrease by up to three orders of magnitude occurs, reminiscent of the onset of percolative superconductivity. The highest onset temperature is observed in the 30 K range. It is markedly reduced by high current densities. Thus, it results partially from the percolative nature, bute possibly also from 2*D* superconducting fluctuations of double perovskite layers of one of the phases present.

K. Onnes' experiment

Superconductivity: In 1911, H. Kamerlingh Onnes, working at Leiden University in The Netherlands, thought that his apparatus had broken. After repeated experiments he wrote the following words in his research journal:

at the boiling point of helium, but would fall to inappreciable values at the lowest temperatures which I could reach.

With this beautiful prospect before me there was no more question of reckoning with difficulties. They were overcome and the result of the experiments was as convincing as could be hoped (fig. 8).

No doubt was left of the existence of a new state of mercury in which its resistance has practically vanished.

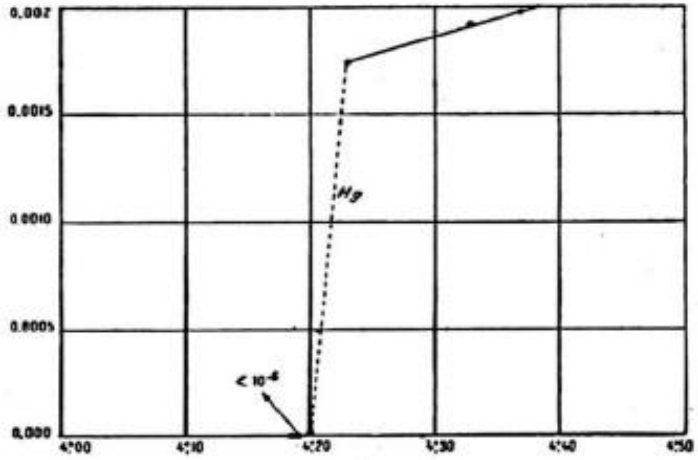

Fig. 8.

Reprinted from Comm. Kamerlingh Onnes Lab., Univ. Leiden (Suppl. 34b, 1913 - Pages 55-70) By Permission

Nobel Prize in 1913.