SUPERCONDUTTIVITÀ

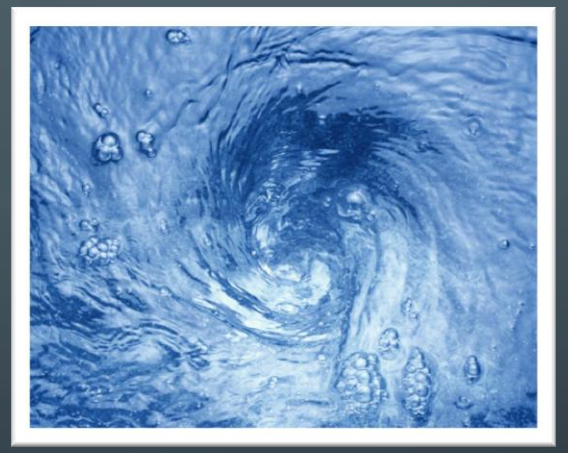
Uno spettacolare stato della materia

Casazza Gioele – Censi Erika – Cinque Gianmaria – Cocan Sebastian –
Coppola Luca – Cuomo Mario – Cusato Mattia – Malandruccolo Andrea

Gruppo di lavoro G
a cura di
Dr. Daniele Di Gioacchino – Dr. Fernando Gozzi

STATI DELLA MATERIA

solido

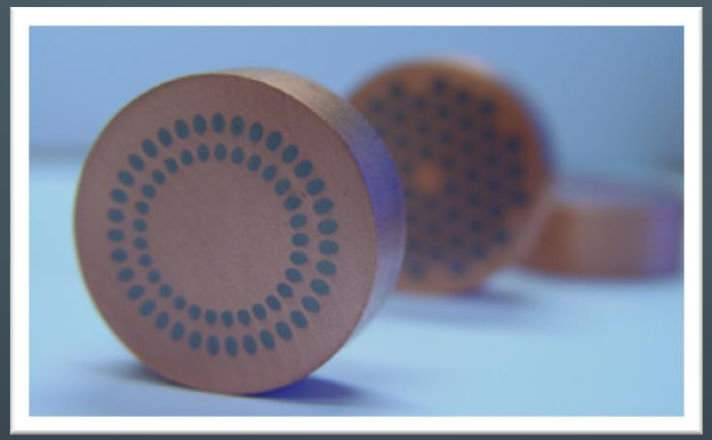


liquido

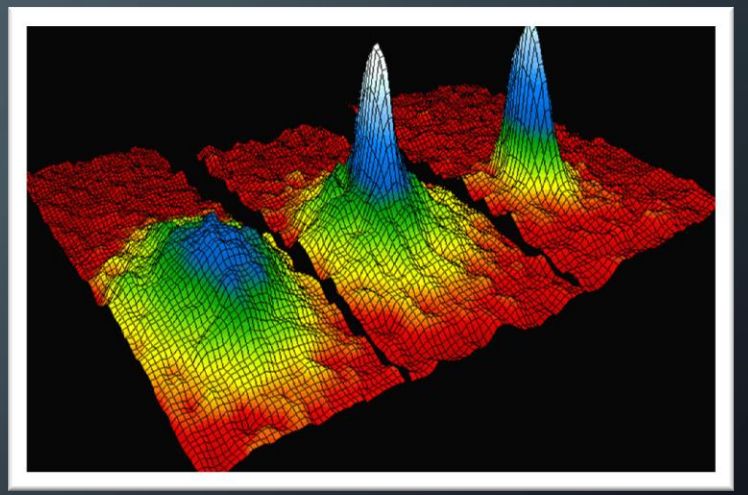
aeriforme

ALTRI STATI DELLA MATERIA

Plasma



Superconduttore



Condensato Bose-Einstein

SUPERCONDUTTIVITÀ

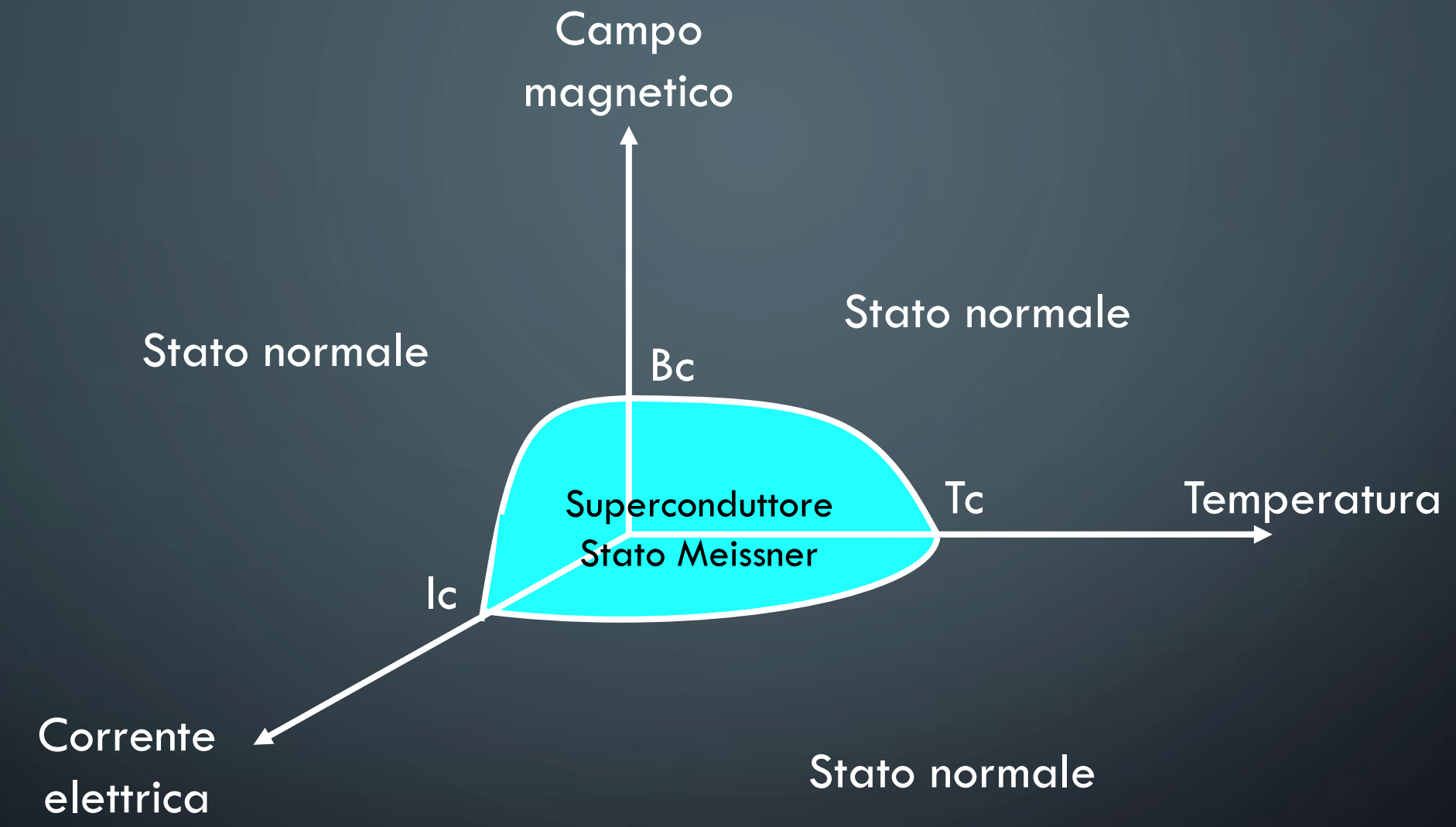
Stato con effetto quantistico macroscopico

CARATTERISTICHE

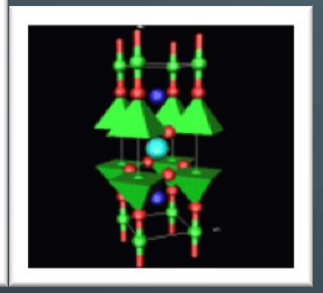
Basse temperature → Tc (temperatura critica)

Resistenza nulla → Ic (corrente critica)

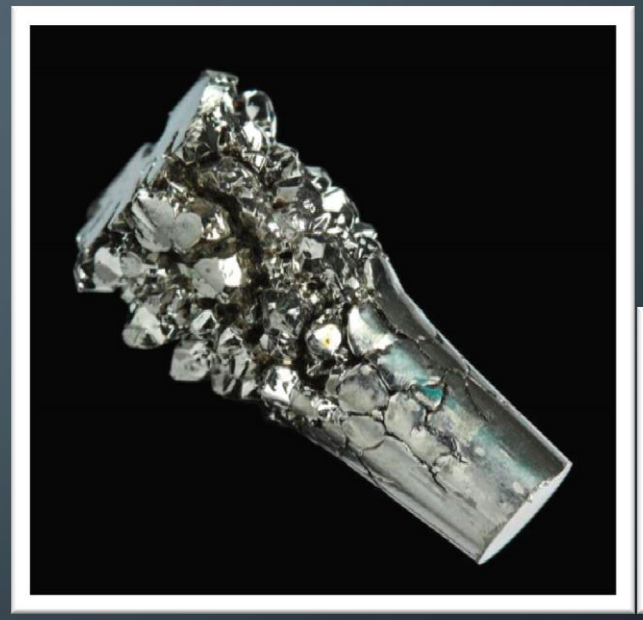
Espulsione (effetto Meissner)/esclusione campo magnetico → Bc (campo magnetico critico)

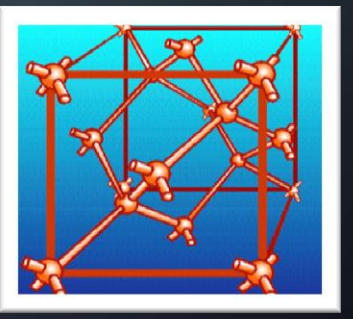

Campo magnetico
Stato normale
Stato normale
Bc
Superconduttore
Stato Meissner
Tc
Temperatura
Ic
Corrente elettrica
Stato normale

TIPI



ceramici



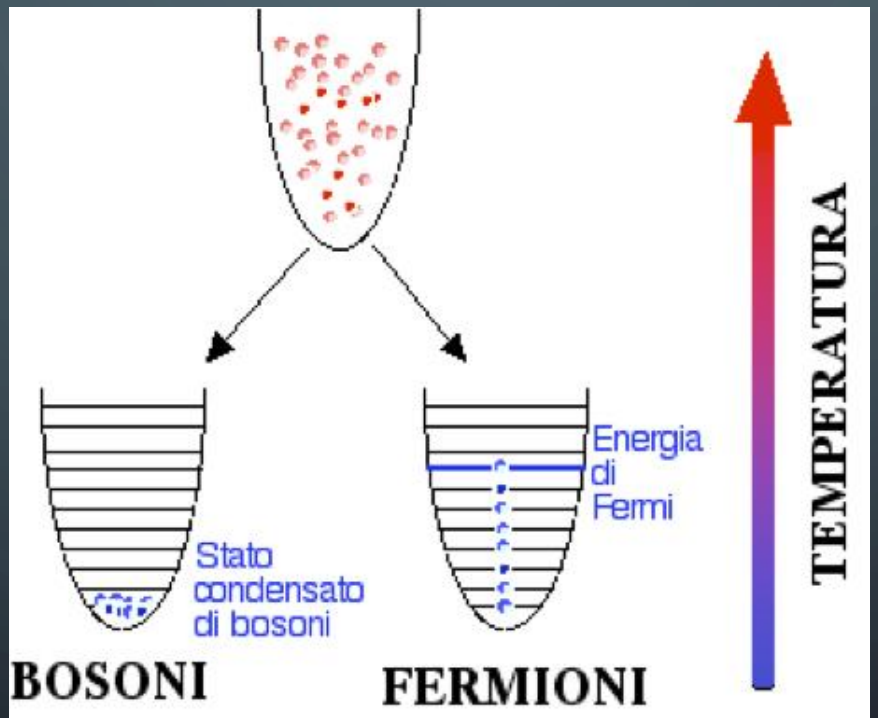


metallici

Resistenza nulla ⇌ Comportamento microscopico

Bosoni

- Spin intero
- Simmetria
- Statistica di Bose-Einstein



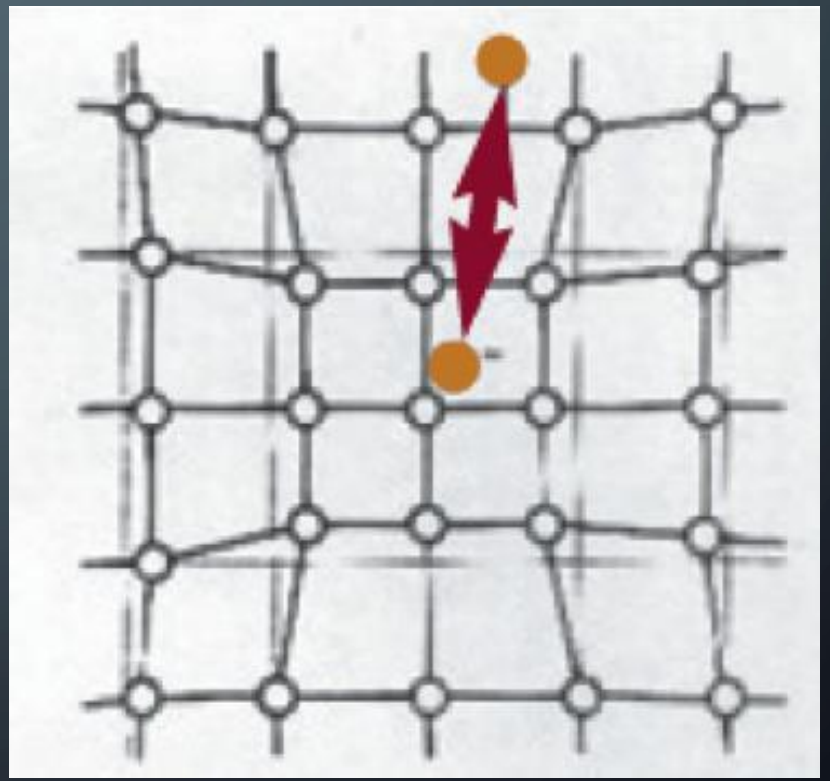
Il diverso comportamento in funzione della temperatura di un sistema di Bosoni e di Fermioni.

Fermioni

- Spin semi-intero
- Asimmetria
- Statistica di Dirac-Fermi
- Principio di Pauli

TEORIA BCS

Bardeen Cooper Scheiffer



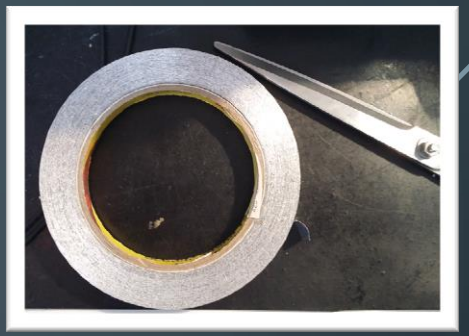
Criogenia

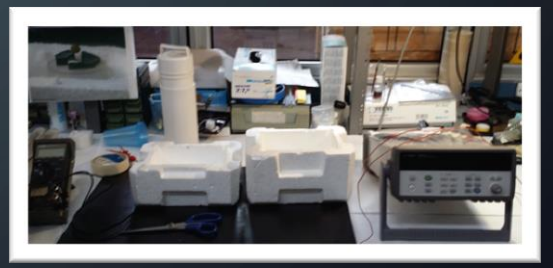
Elettromagnetismo

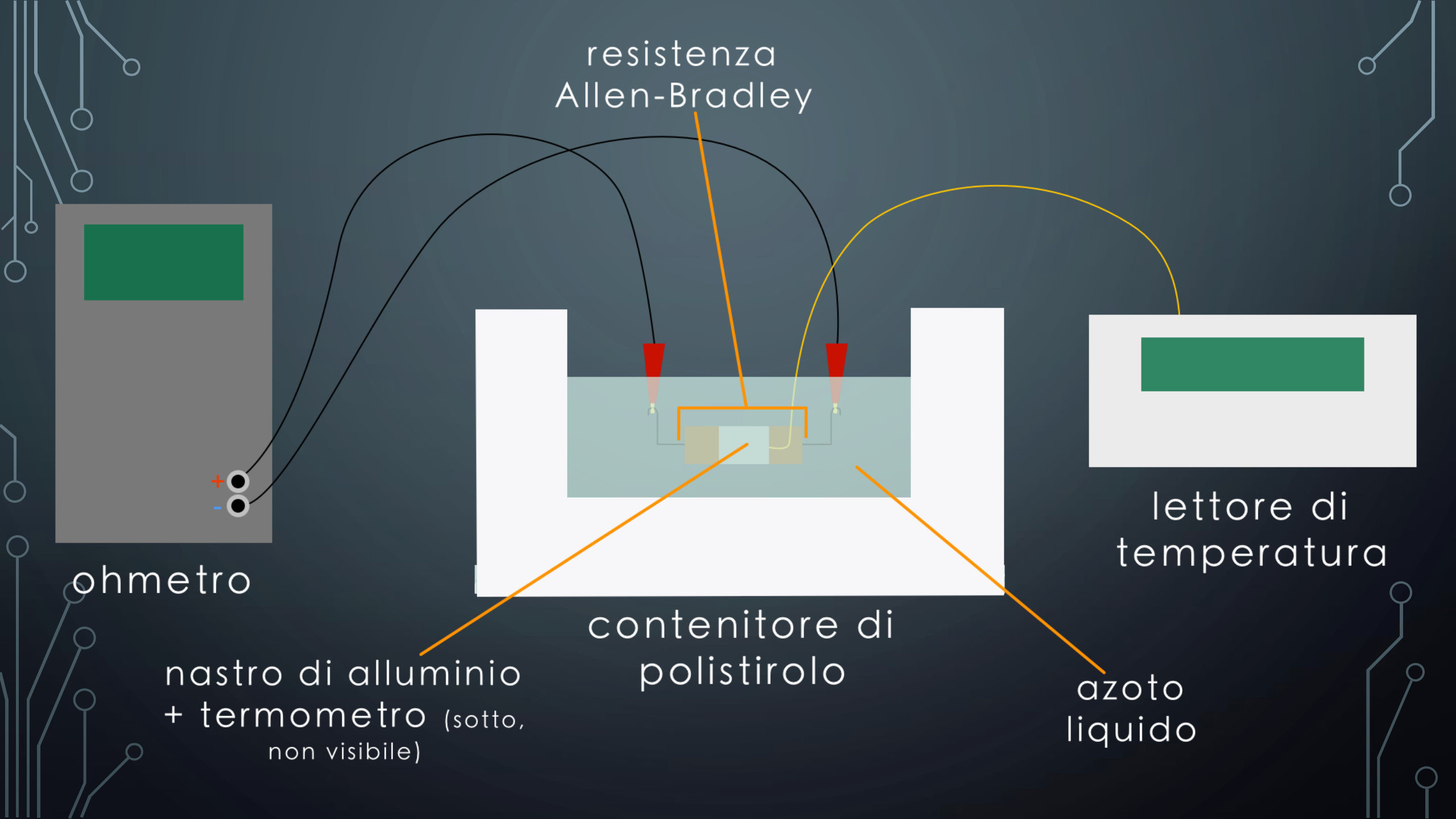
Meccanica quantistica

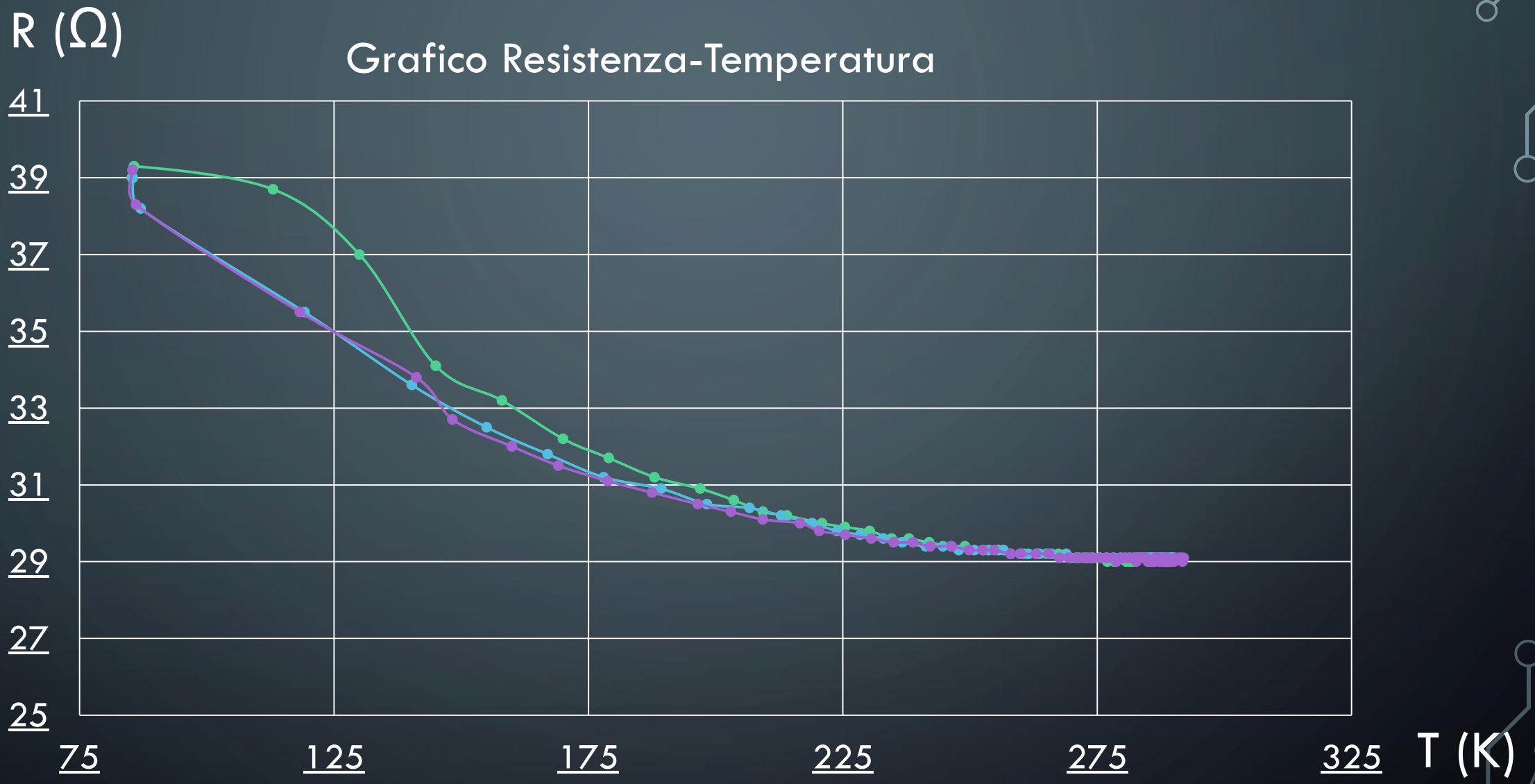
1° ESPERIMENTO

Scopo: osservazione della variazione della resistenza in funzione della temperatura



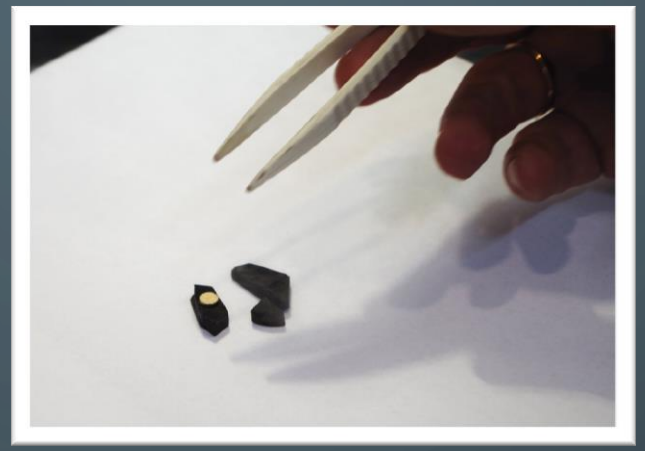


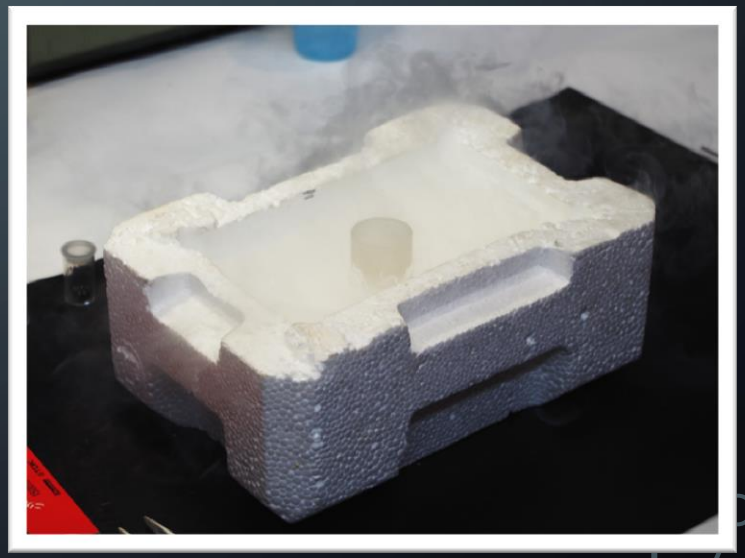

resistenza
Allen-Bradley
+
-
ohmetro
lettore di
temperatura
contenitore di
polistirolo
nastro di alluminio
+ termometro (sotto,
non visibile)
azoto
liquido

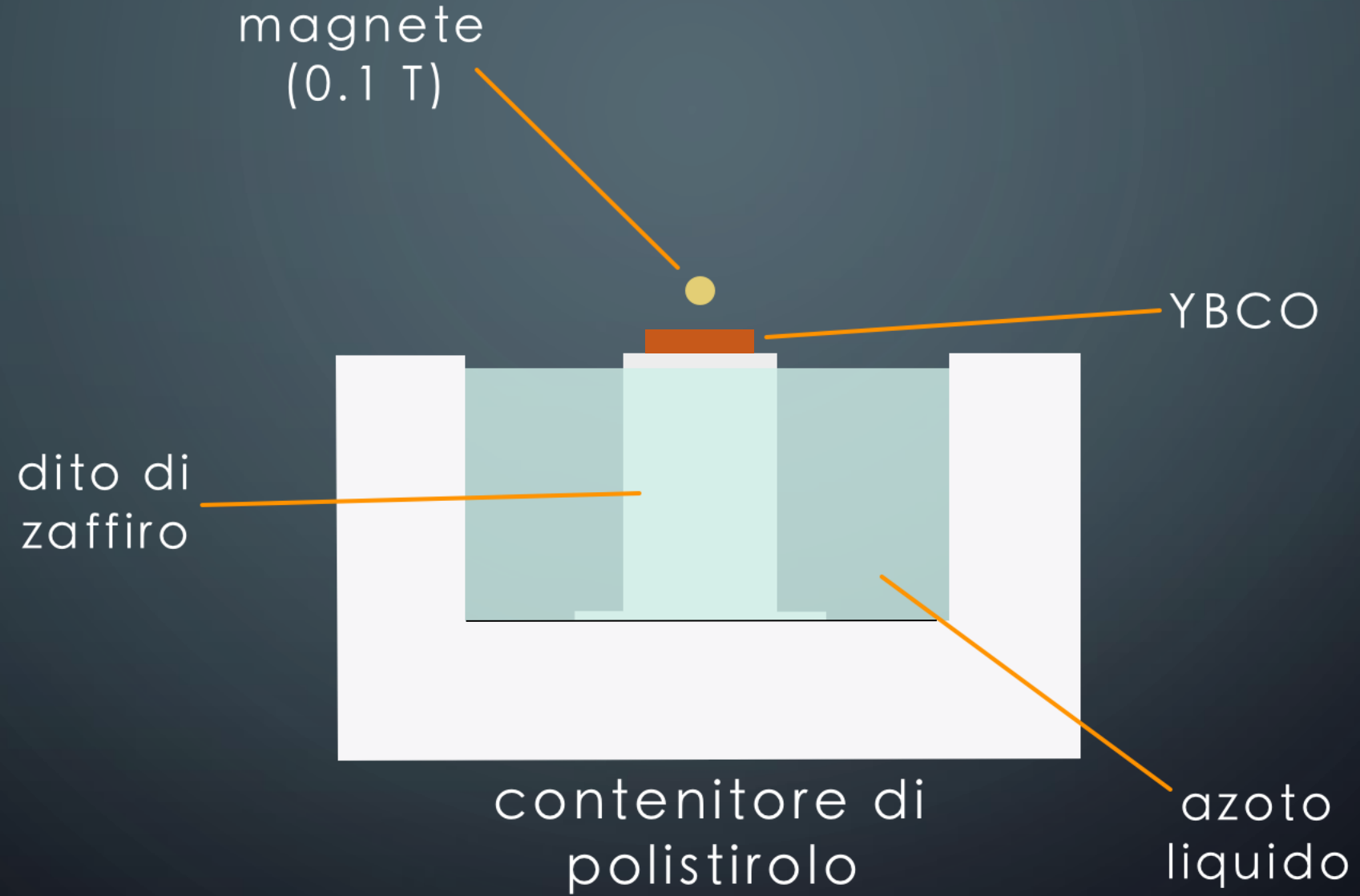

R (Ω)
Grafico Resistenza-Temperatura
41
39
37
35
33
31
29
27
25
75
125
175
225
275
325
T (K)

2° ESPERIMENTO

Scopo: dimostrazione effetto Meissner

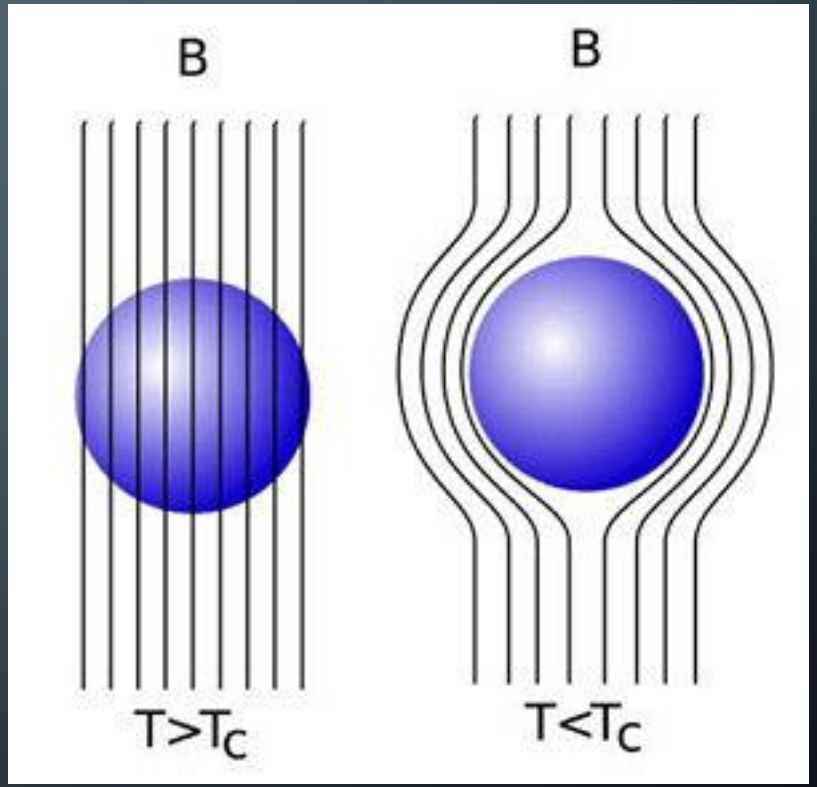





magnete
(0.1 T)
YBCO
dito di
zaffiro
contenitore di
polistirolo
azoto
liquido

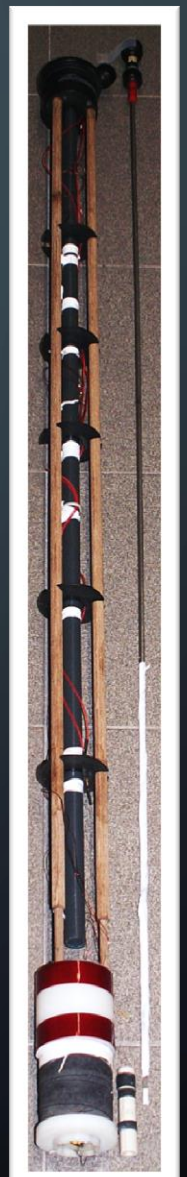
Effetto Meissner

Espulsione campo magnetico



3° esperimento

Scopo: misurazione suscettività magnetica in funzione della temperatura

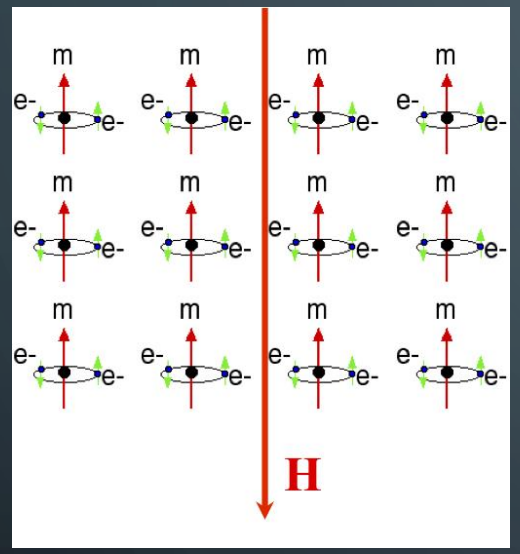


SUSCETTIVITÀ MAGNETICA

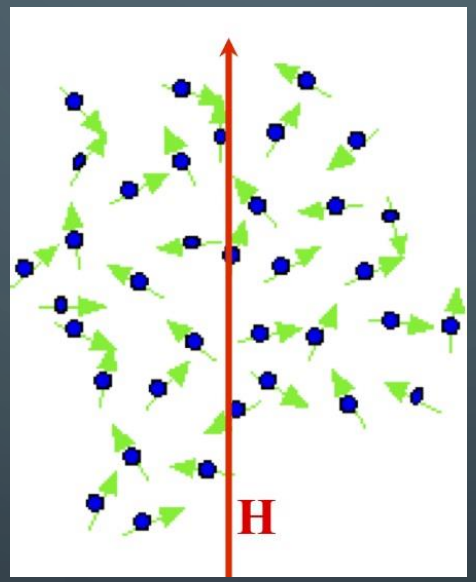
L'azione magnetica nelle sostanze viene definita dalla suscettività → Risposta magnetica di una particolare sostanza ad un campo magnetico esterno

$$X = \frac{M}{H}$$

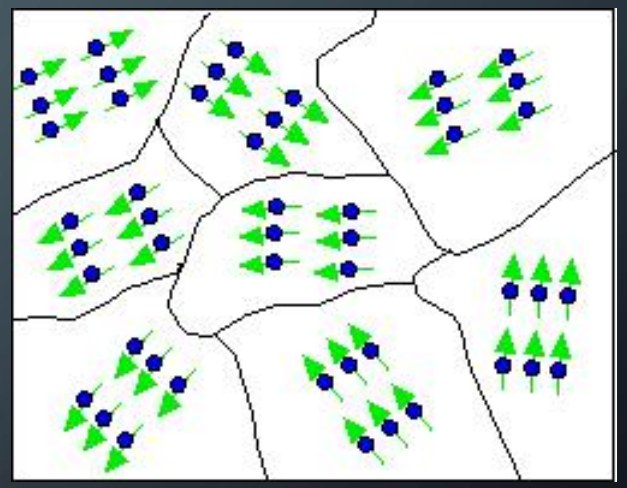
TIPI DI MAGNETISMO



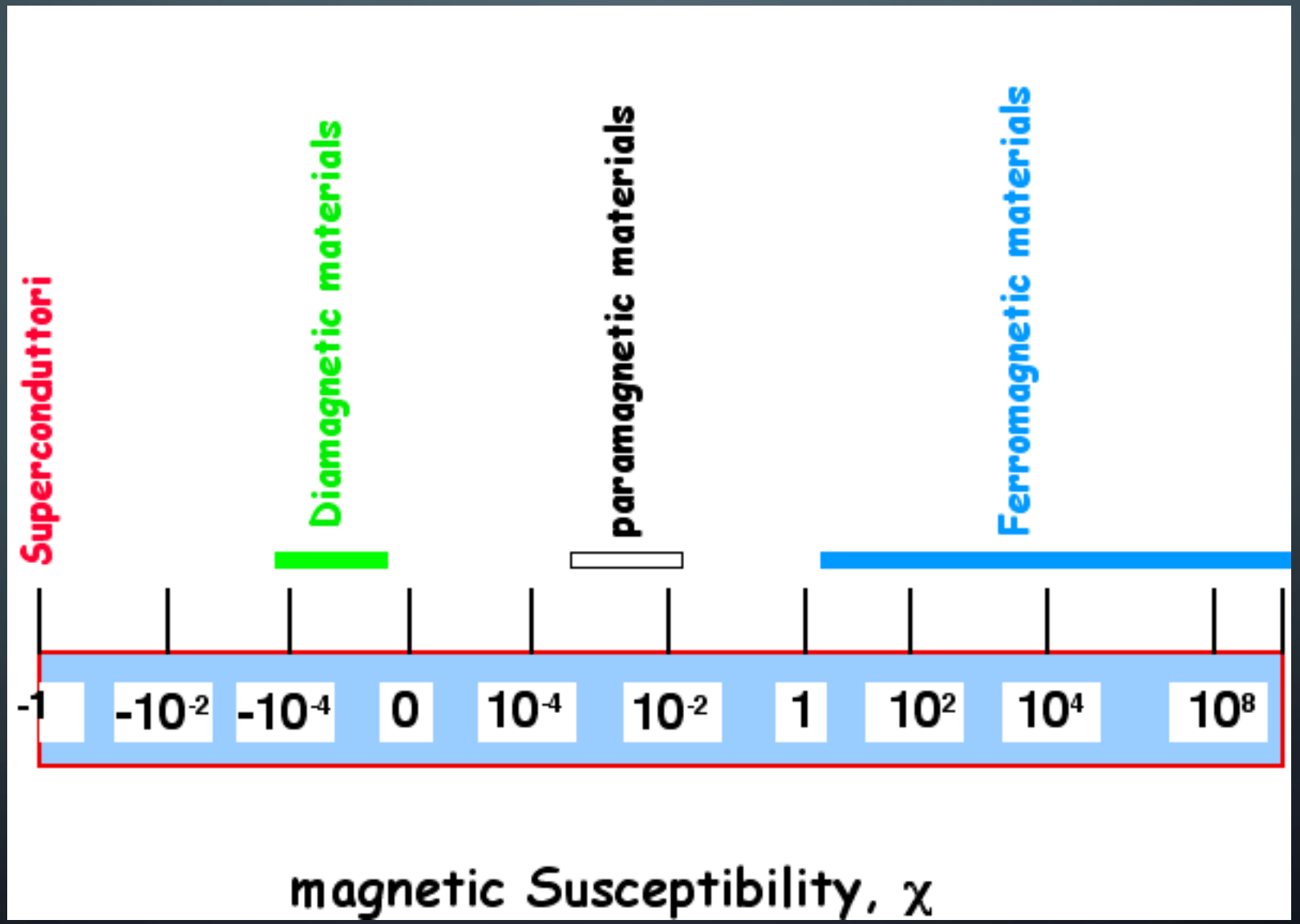
diamagnetismo

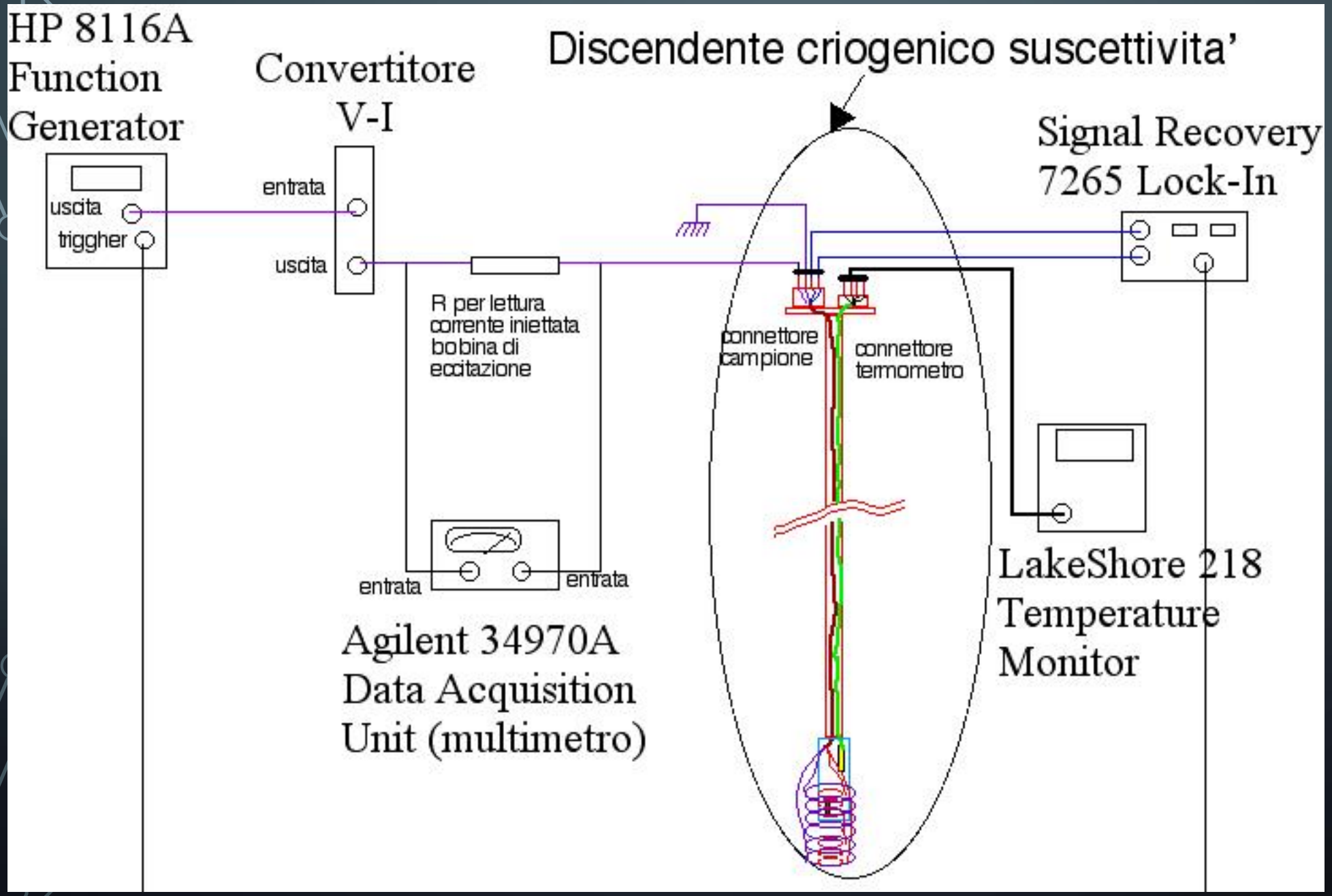


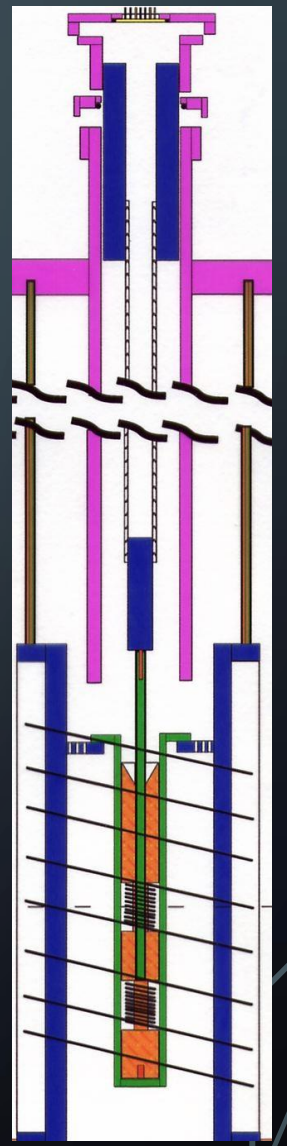
paramagnetismo

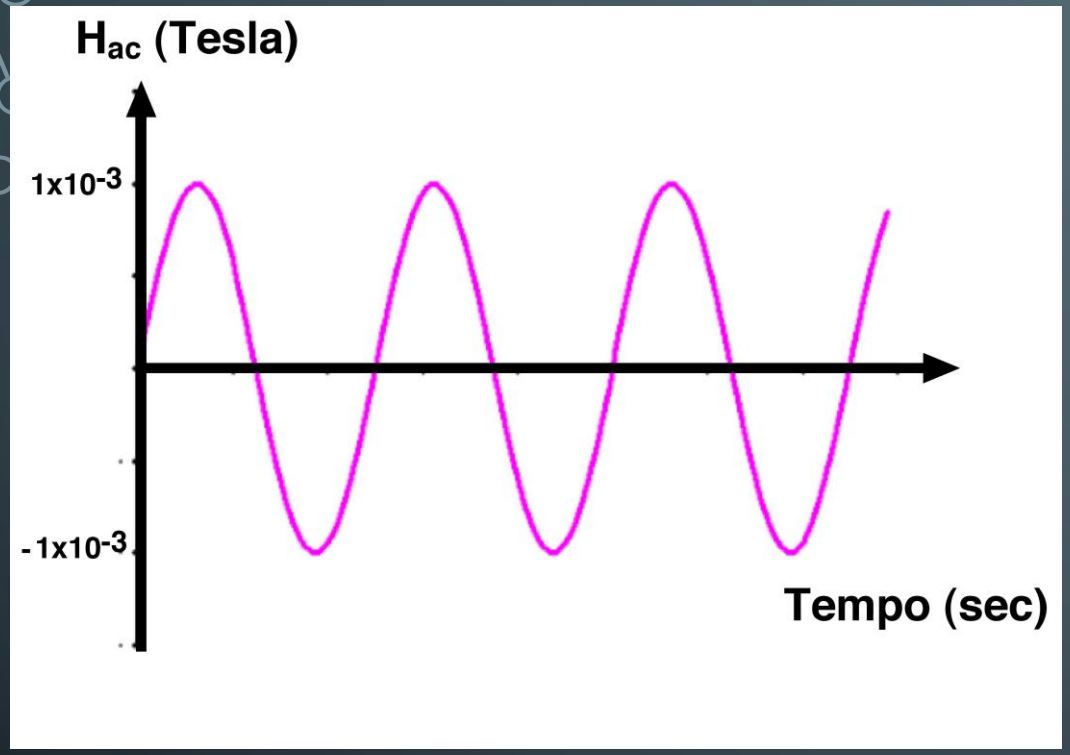


ferromagnetismo

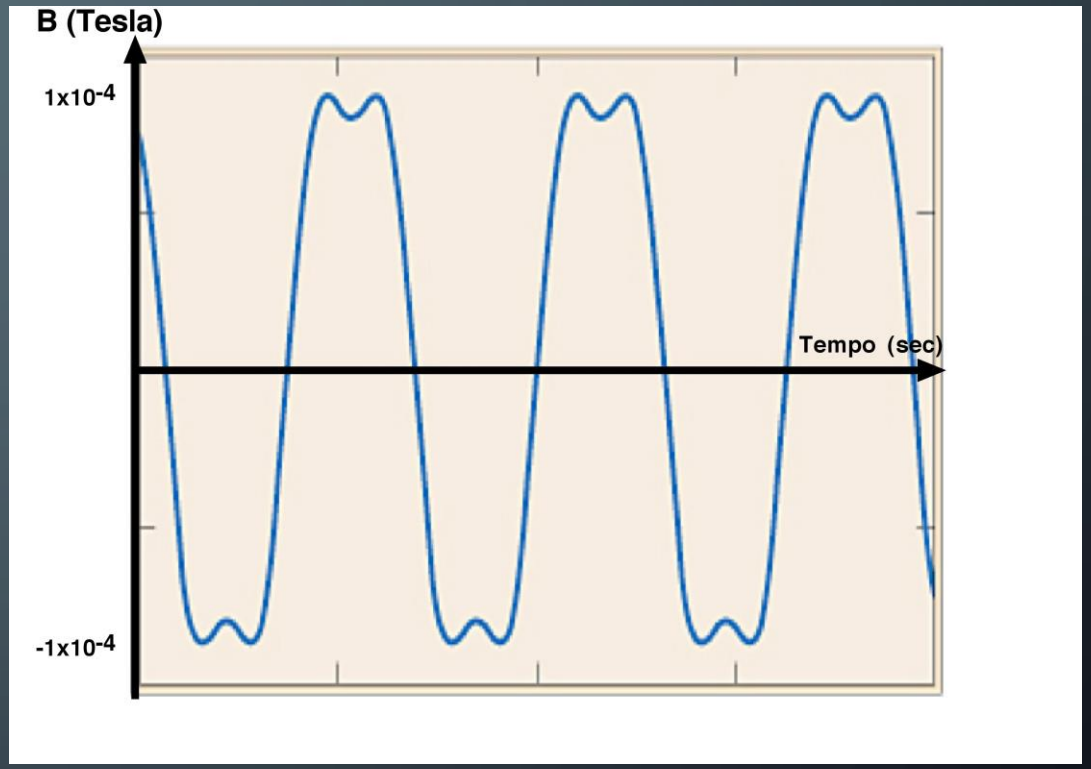

Superconduttori
Diamagnetic materials
paramagnetic materials
Ferromagnetic materials
-1
-10-2
-10-4
0
10-4
10-2
1
102
104
108
magnetic Susceptibility, χ


HP 8116A
Function
Generator
uscita
trigger
Convertitore
V-I
entrata
uscita
R per lettura
corrente iniettata
bobina di
eccitazione
entrata
entrata
Agilent 34970A
Data Acquisition
Unit (multimetro)
Discendente criogenico suscettivita'
connettore
campione
connettore
termometro
Signal Recovery
7265 Lock-In
LakeShore 218
Temperature
Monitor



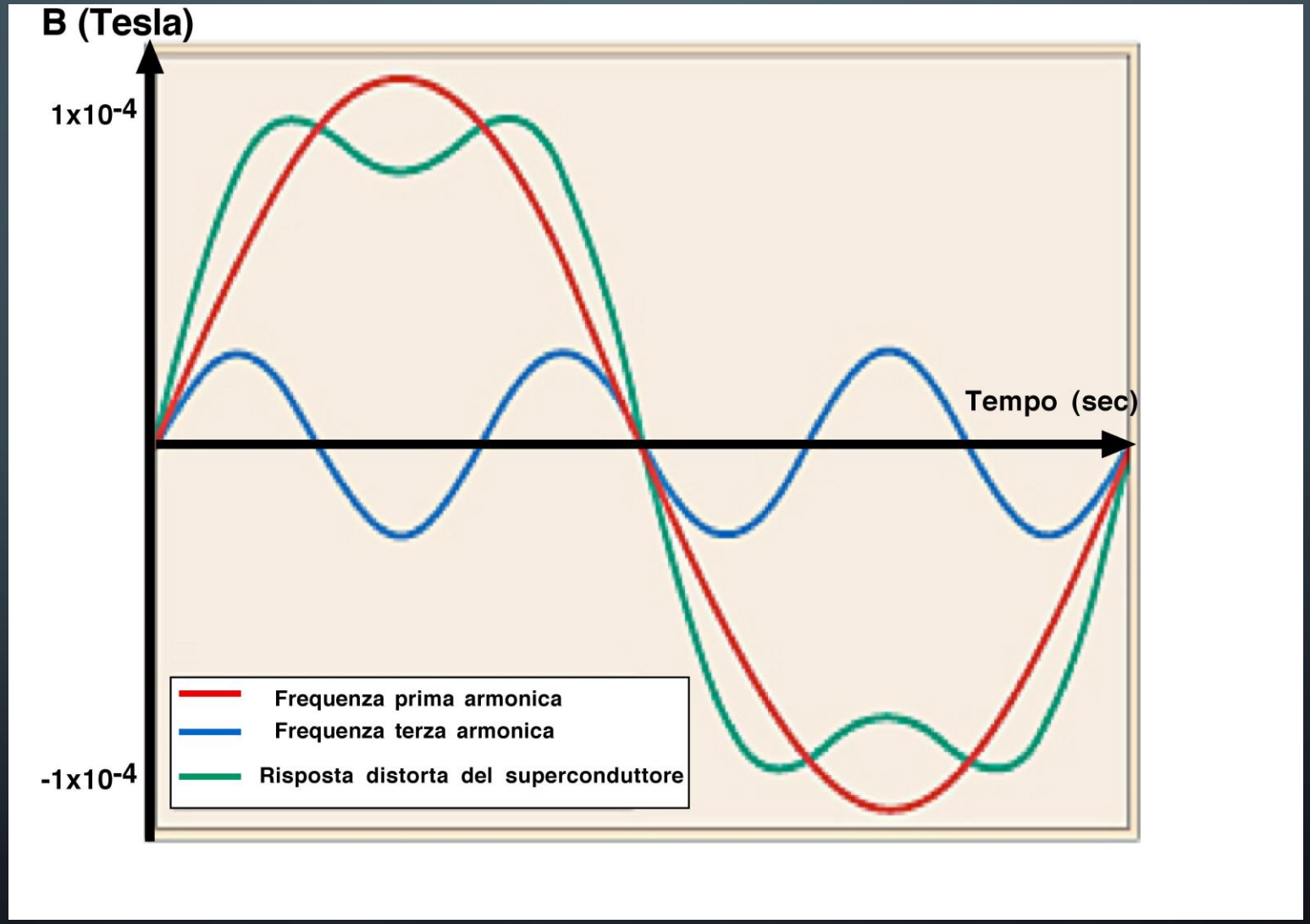


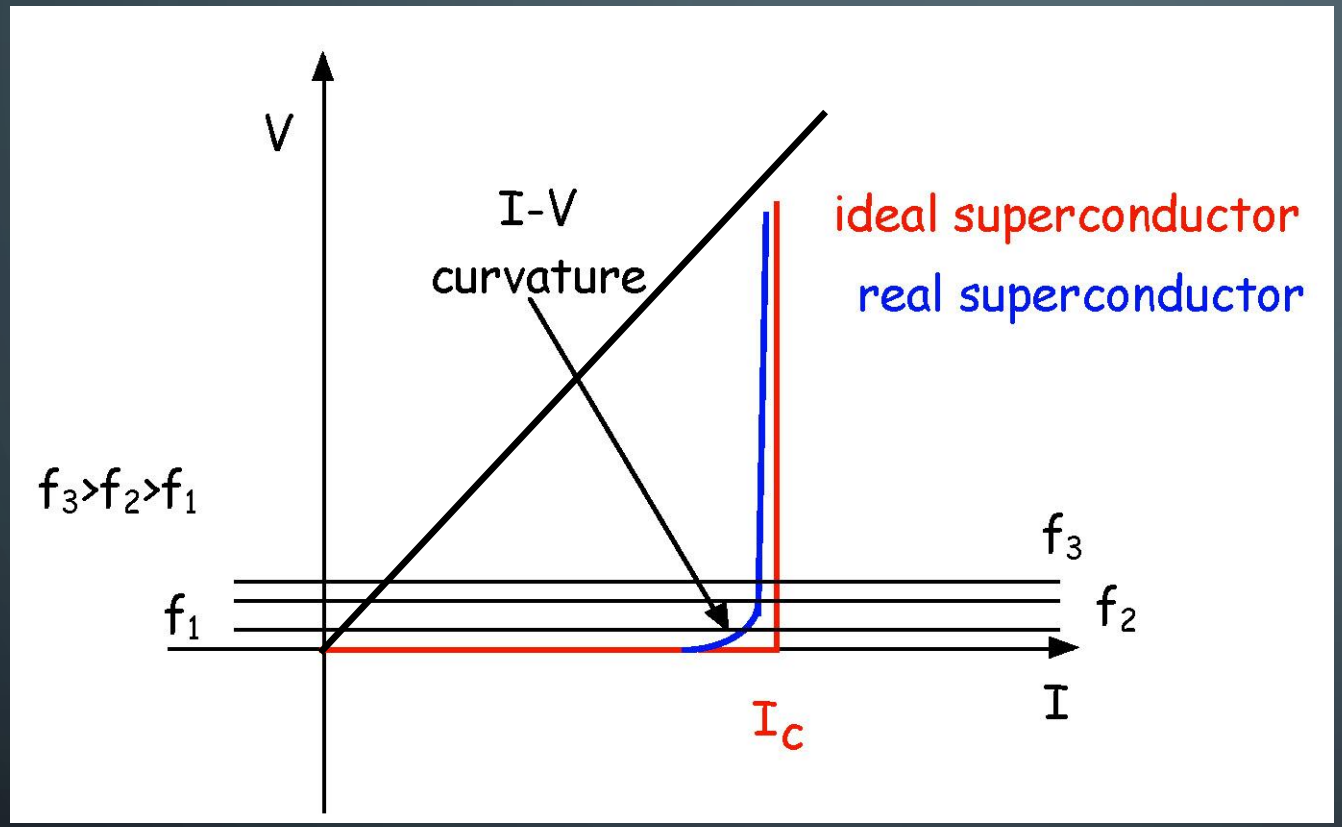
Segnale di eccitazione



Segnale di risposta

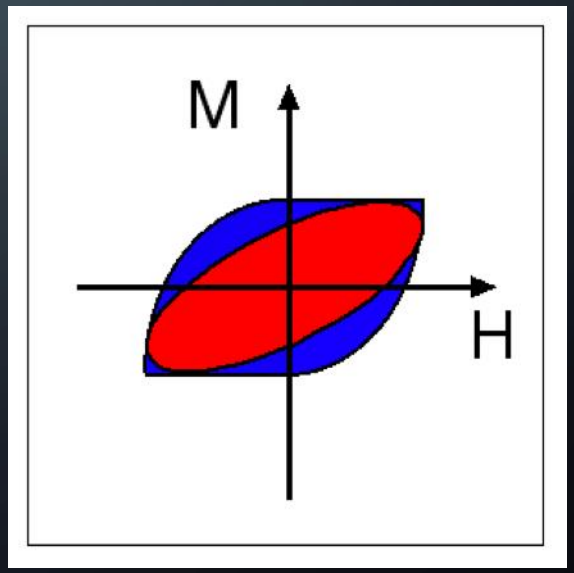
Sviluppo in serie di Fourier

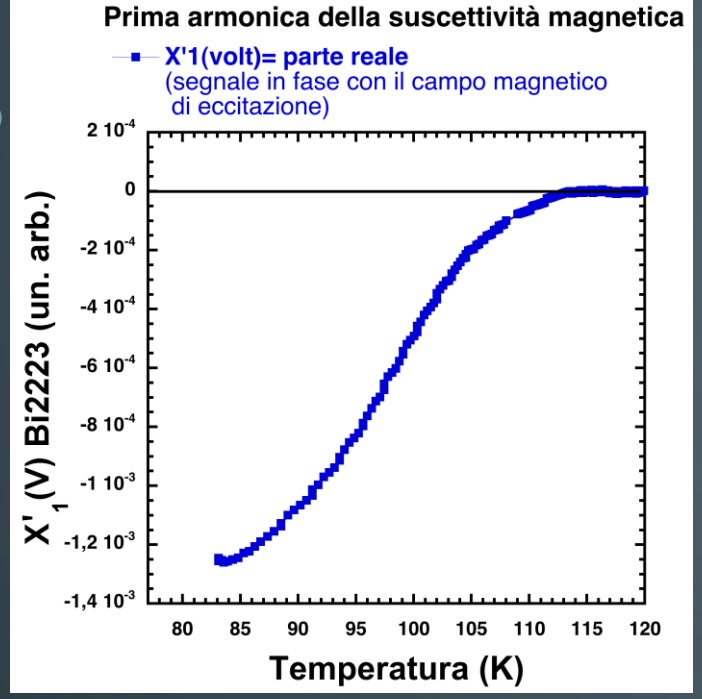


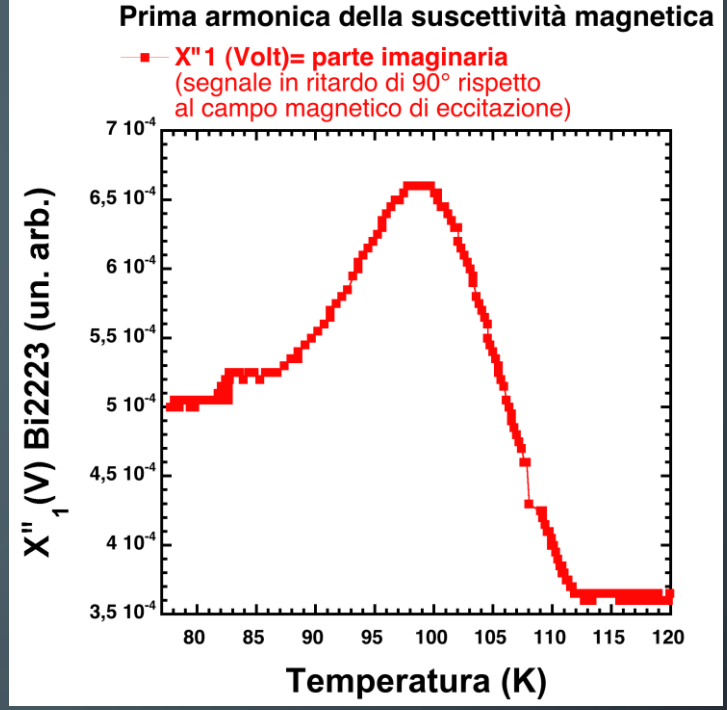


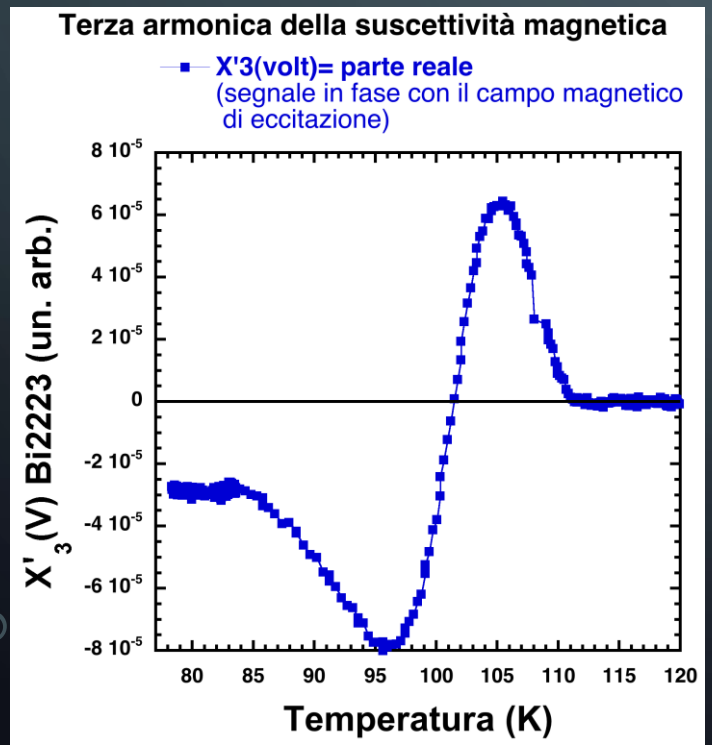
1° Legge di Ohm

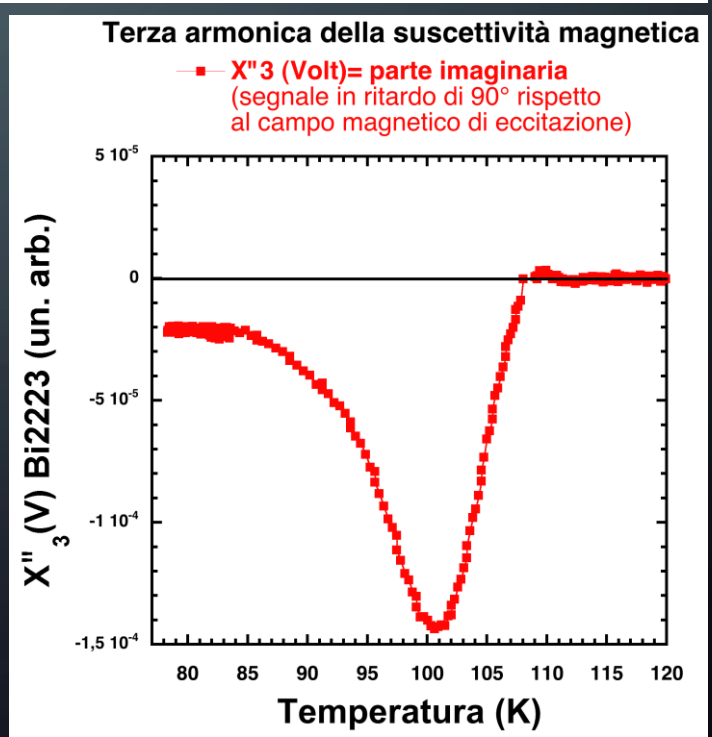
$$\Delta V = R \cdot I$$




Prima armonica della suscettività magnetica
X'1(volt)= parte reale
(segnale in fase con il campo magnetico di eccitazione)
X'1 (V) Bi2223 (un. arb.)
Temperatura (K)


Prima armonica della suscettività magnetica
X"1 (Volt)= parte imaginaria
(segnale in ritardo di 90° rispetto al campo magnetico di eccitazione)
X"1 (V) Bi2223 (un. arb.)
Temperatura (K)


Terza armonica della suscettività magnetica
X'3(volt)= parte reale
(segnale in fase con il campo magnetico di eccitazione)
X'3 (V) Bi2223 (un. arb.)
Temperatura (K)


Terza armonica della suscettività magnetica
X"3 (Volt)= parte imaginaria
(segnale in ritardo di 90° rispetto al campo magnetico di eccitazione)
X"3 (V) Bi2223 (un. arb.)
Temperatura (K)

APPLICAZIONI PRATICHE

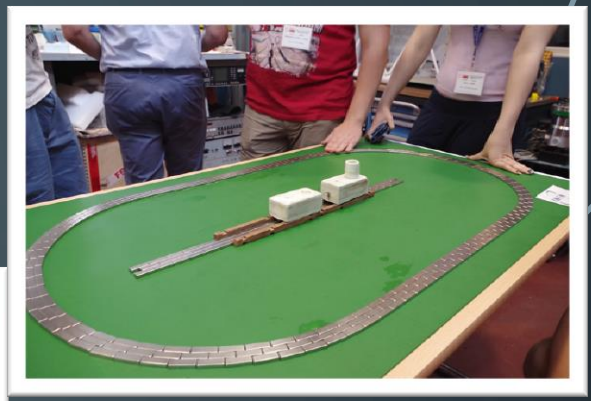
Circuiti elettrici superconduttori

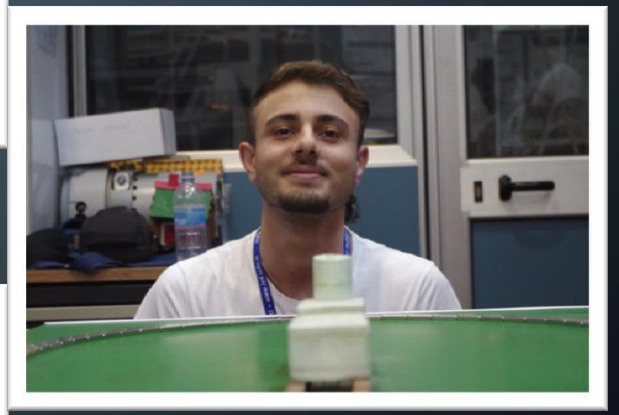
RMN

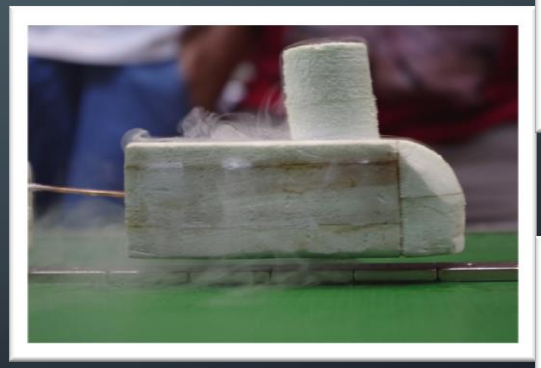
Treni MagLev

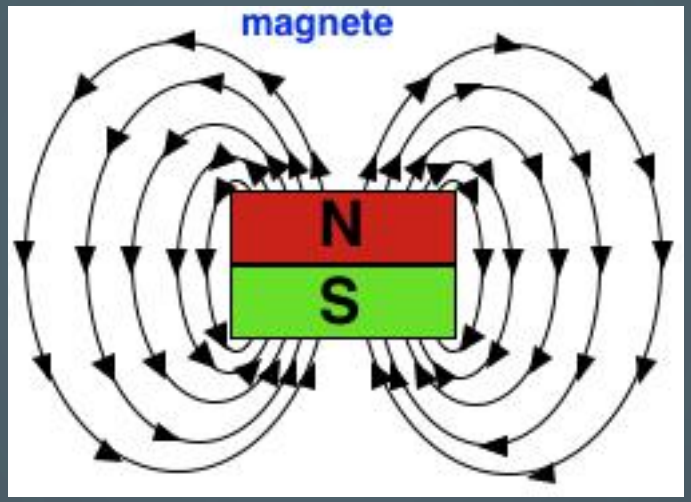
ESPERIMENTO 4°

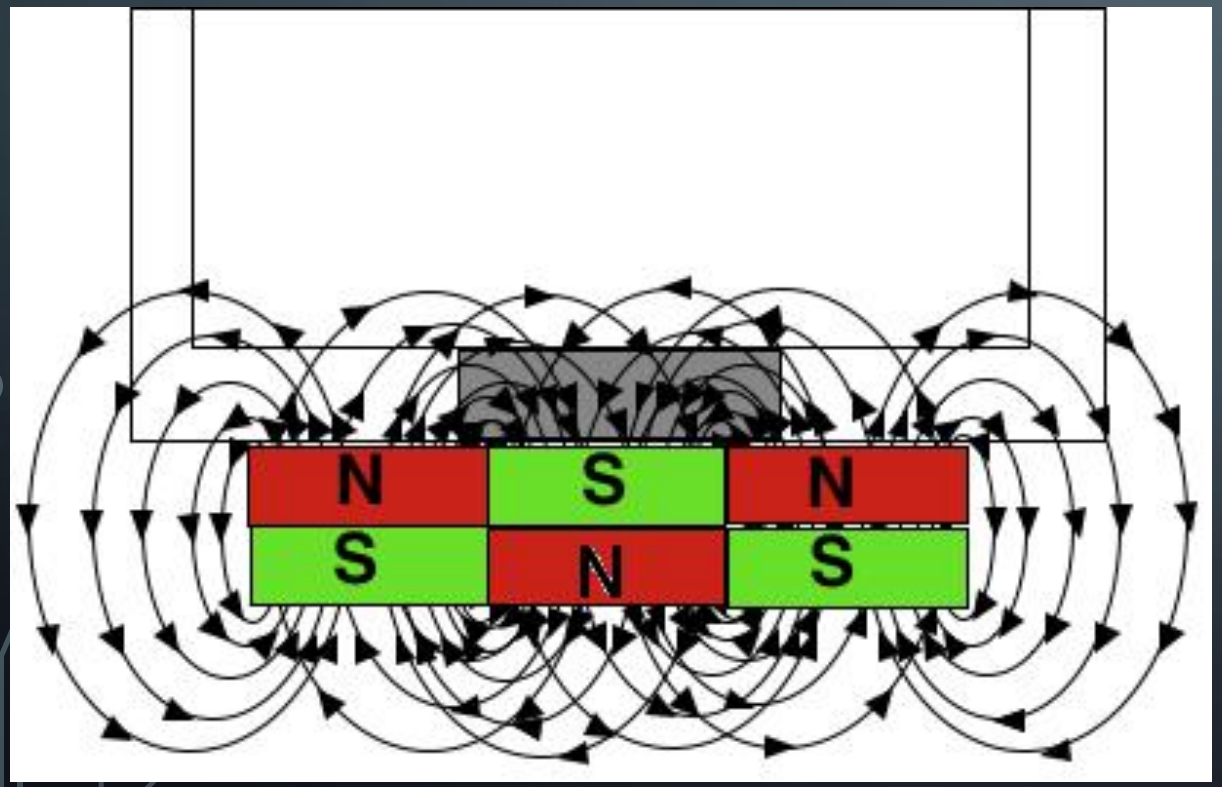
Scopo: applicazione pratica con il treno Maglev

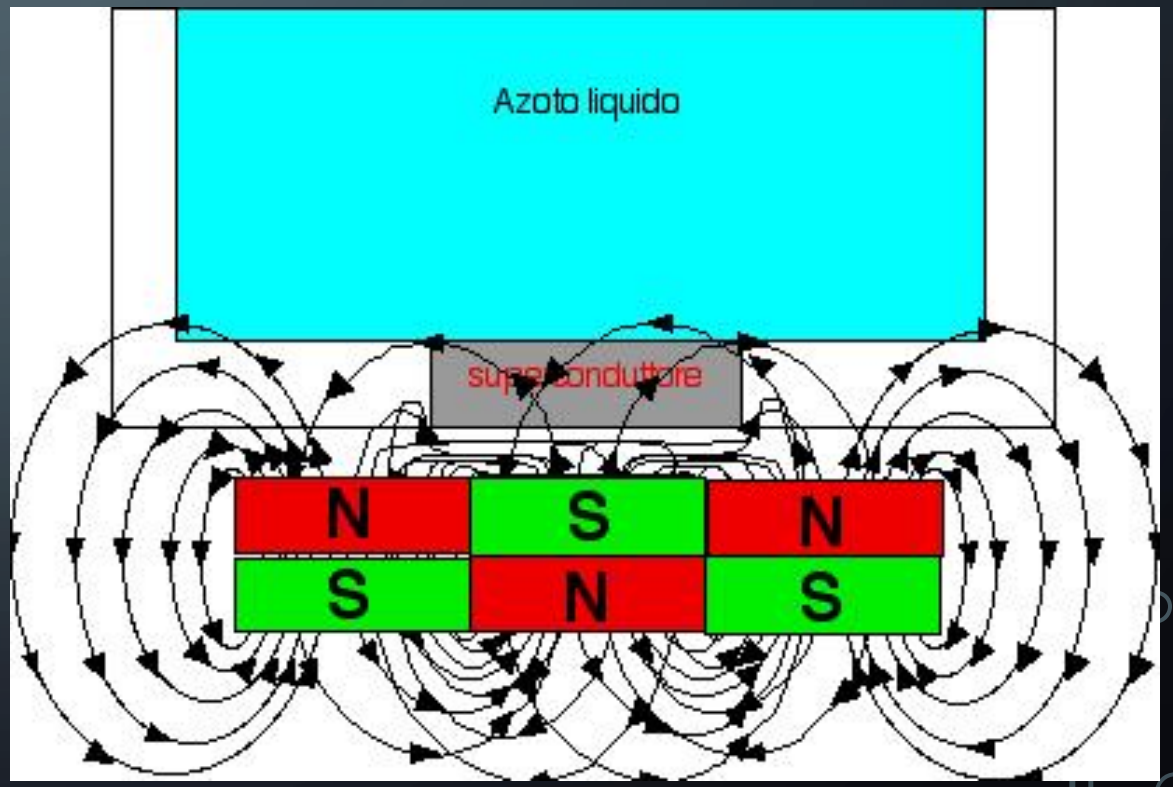




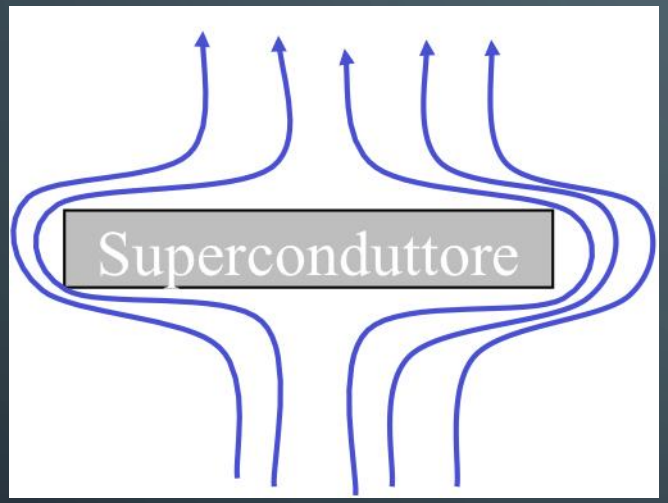



magnete
N
S

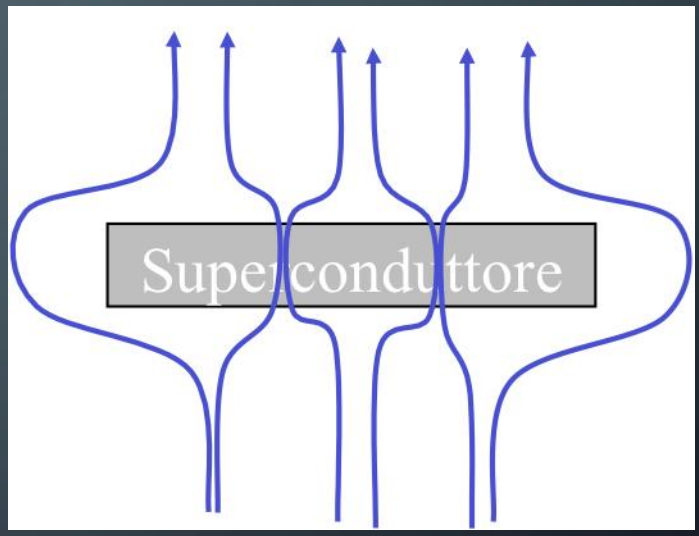

N
S
N
S
N
S


Azoto liquido
superconduttore
N
S
N
S
N
S

TIPI DI SUPERCONDUTTORI

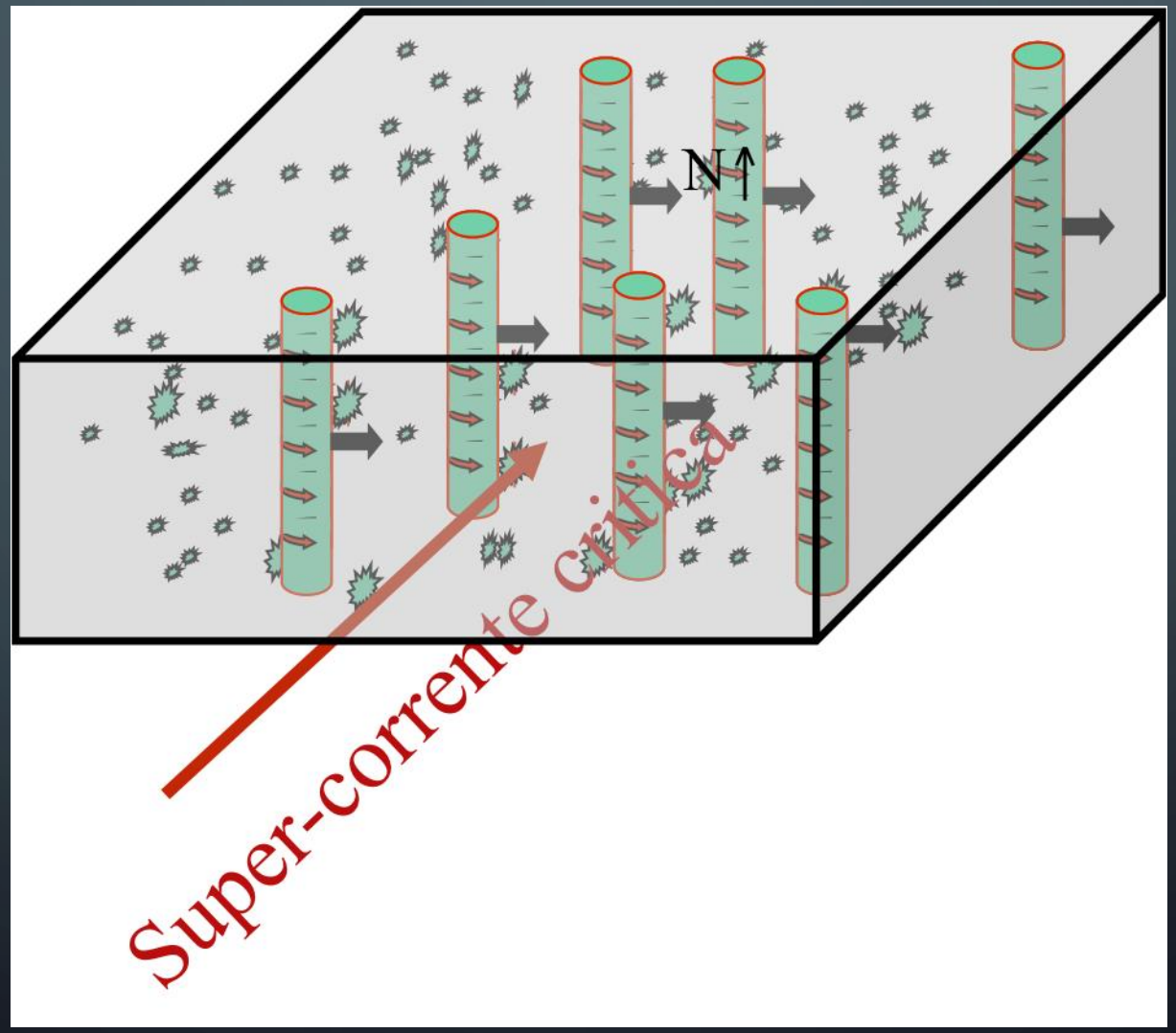


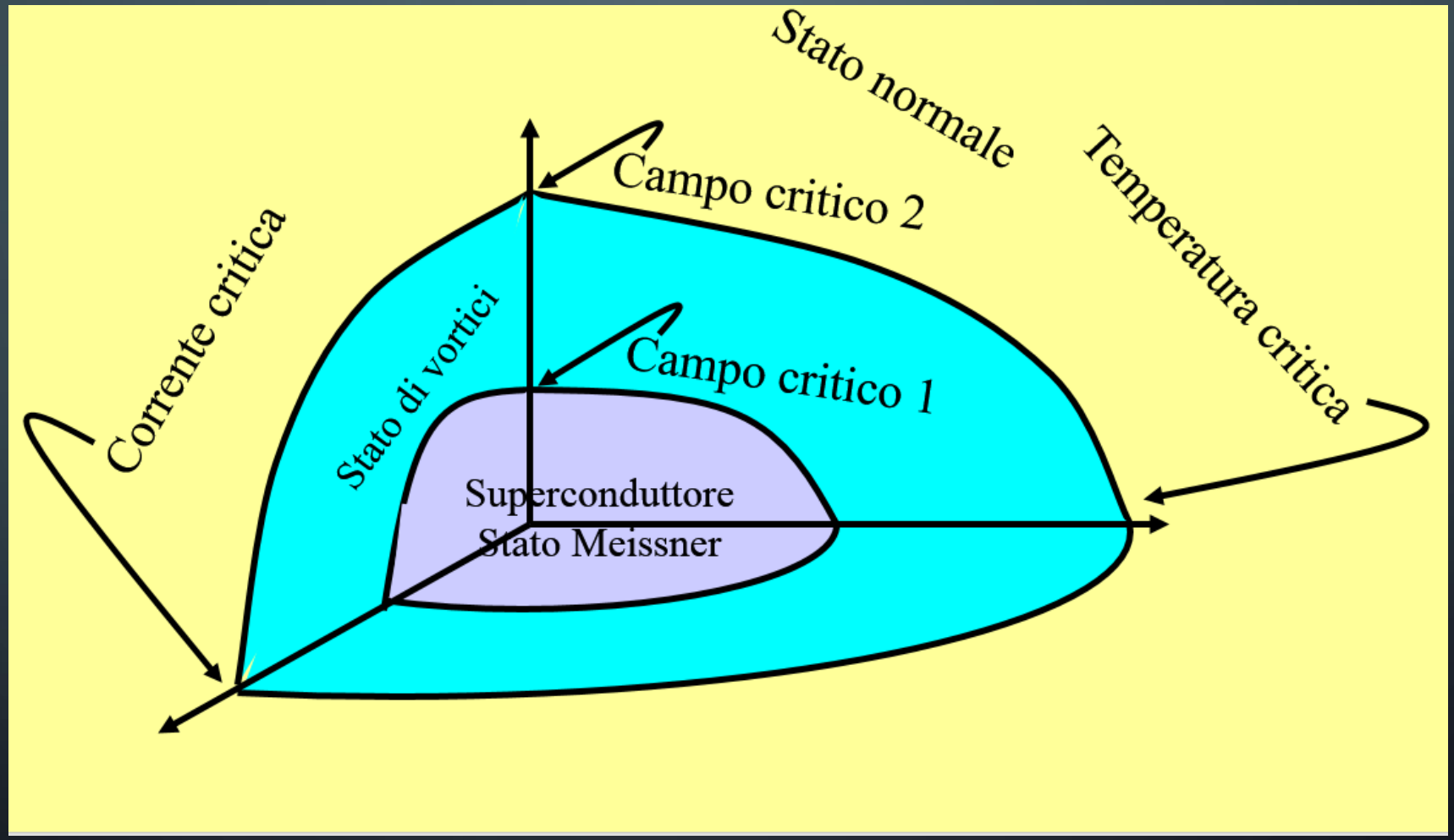
Tipo I
TOTALE espulsione del campo magnetico



Tipo II
PARZIALE espulsione del campo magnetico

FLUSSONI




Stato normale
Campo critico 2
Temperatura critica
Corrente critica
Stato di vortici
Campo critico 1
Superconduttore
Stato Meissner

THANKS A LOT!