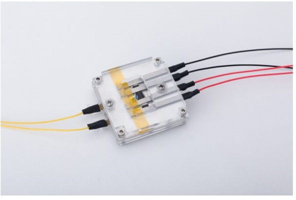

Quantum Levitation 4-Point Tc Experiment User Manual

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HANDLING INSTRUCTIONS

The superconductor is a ceramic, brittle material that is sensitive to moisture. Its oxygen content strongly affects the superconducting properties. Oxygen atoms in water (from air moisture) react with the material and quickly degrade it, causing it to lose its superconducting properties.
Keep the superconductor in a sealed box with moisture absorbing material such as silica gel.

Superconductor refill

You can easily replace the superconductor if needed. Use the two screws in the center to remove the top cap. Take out the superconducting bar from its slot and replace it with a new one.

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THERMOMETER CALIBRATION

Objective: Calibrate the resistance thermometer

Methods:

1. Connect the pt-100 thermometer to a multimeter (resistance measurement). The room temperature resistance should be ~110Ω.
2. Measure the resistance at 3 different temperatures (at least):
   – room temperature (~296K)
   – iced water* (~273K)
   – liquid nitrogen (~77K)

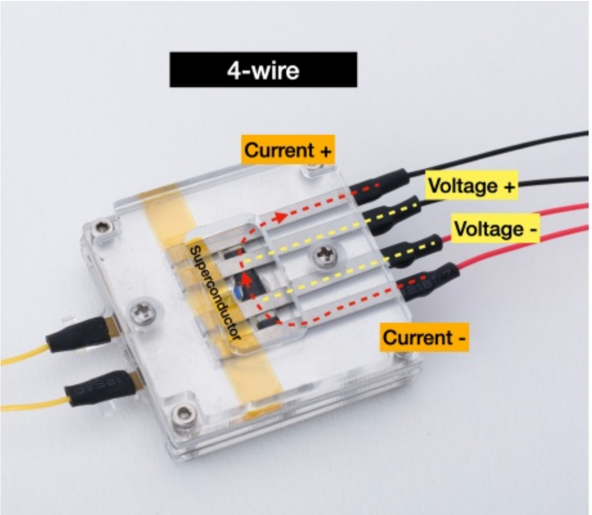
Data analysis:

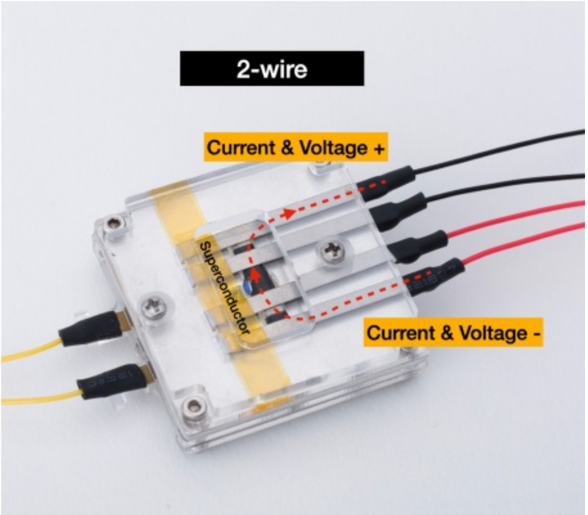
1. Plot the temperature [K] vs. resistance[Ω].
2. Find the curve equation :
   $Temp [K] = a R [\Omega] + b$
   * place the entire setup in a plastic bag before dipping it in iced water.

EXPERIMENTS

SUPERCONDUCTOR TC, 2-WIRE VS. 4-WIRE

Objective: understand the difference between 2-wire & 4-wire measurements. Measure the Tc of a superconductor.



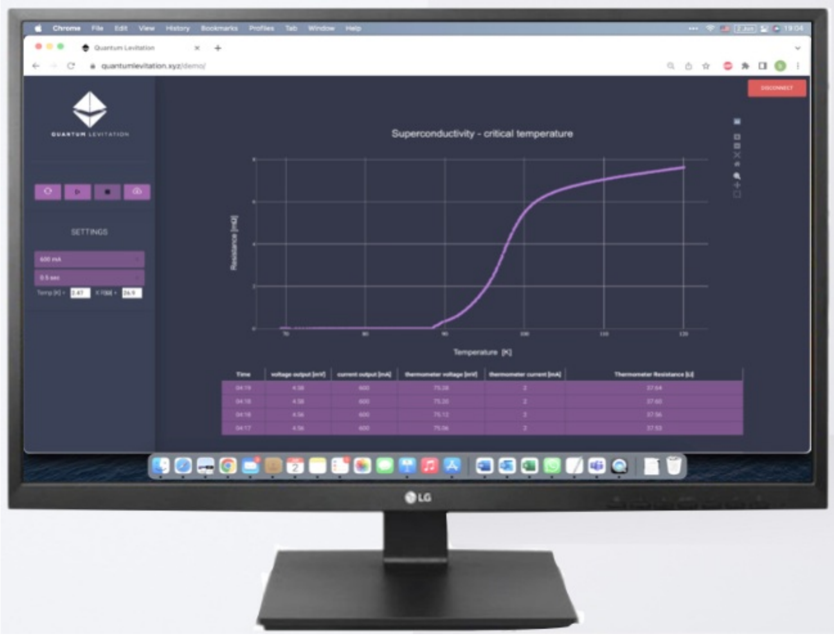


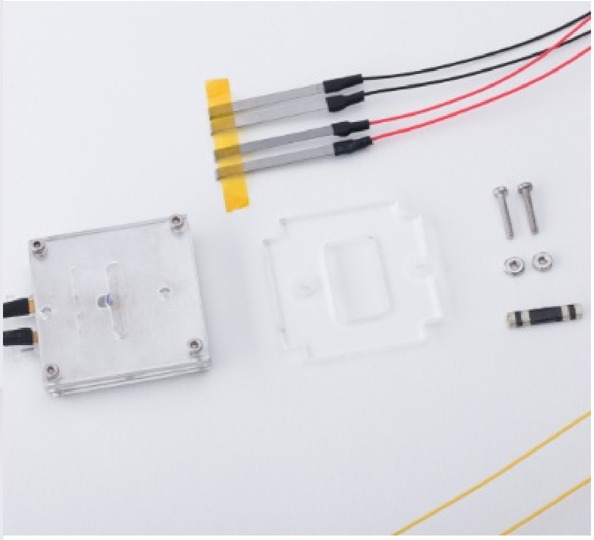
Methods:

1. Make a 2-wire connection according to the drawing above.
2. Configure the current supply to a desired current. Do not exceed 1 Ampere to avoid heating.
3. Carefully dip the entire setup in liquid nitrogen. Let it cool until the bubbling subsides.
4. Take the setup out of the liquid nitrogen. Record the voltage and temperature while heating.
   Tip If the heating is too fast, place the setup above the liquid in the cold vapor.
5. Repeat the measurement in a 4-wire connection.

Analyze:

1. Plot the superconductor resistance (R=V/I) vs. the temperature. Use the thermometer formula you calculated in the previous experiment.
2. Compare the 2-wire data to the 4-wire data. Explain the differences.
3. Which measurement is suitable for measuring the critical temperature? Why?
4. Characterize the transition from normal to superconducting state:
   What is the width (in K) of the transition?
   Determine the critical temperature.
   Can you suggest several ways to define the Tc?
5. What are the Superconductor properties that effect the transition temperature & width?





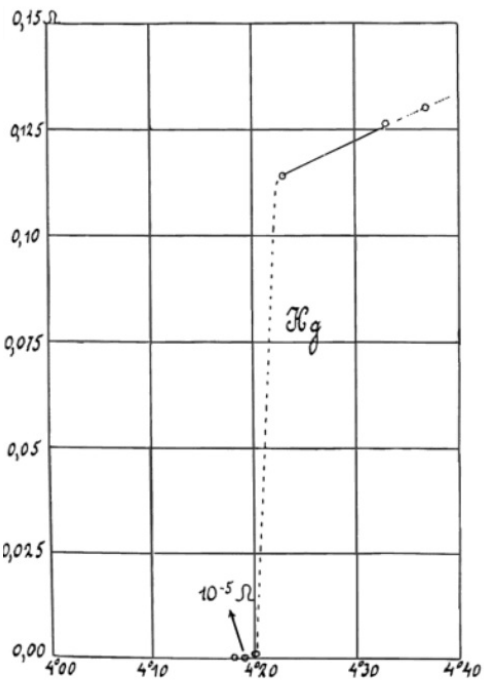
In a 4-wire measurement the voltage probes are connected inside the current path. Current does not flow through the voltage probe contacts and hence the measured voltage
is sensitive only to the voltage drop inside the material.

When is it OK to use 2-wire resistance measurement?

When the resistance of the object in question is much higher than that of the contacts (as for example in the thermometer case), we can disregard the voltage drop at the contacts and assume that the major contribution comes from the material itself.

Superconductivity introduces one of the most difficult challenges for physicists – how to sensitively measure the high resistance (measured in volts) of the normal state and the infinitesimally low & zero resistance of the superconducting state at the same time.

The original graph from Onnes's publication from 1911 showing the resistance of mercury as a function of its temperature. (H. K. Onnes, Comm. Leiden, 124c, 1911).



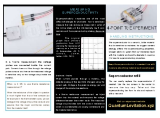
2-wire vs. 4-wire

When current passes through a material, the potential energy of the electrons changes along the current path. Voltage is the potential energy (per unit charge) of the conductive electrons.

In a 2-wire resistance measurement we inject current into the material and measure the voltage difference between the current leads. The measured voltage drop includes both the contact resistance (which is unpredictable and usually not relevant) and the material resistance.

Quantum® **Visit our experiment website:**
QuantumLevitation.xyz

Documents / Resources

 **Quantum Levitation 4-Point Tc Experiment** [pdf] User Manual
4-Point Tc Experiment, 4-Point, Tc Experiment, Experiment