Superconducting Quantum Interference Device

SQUID

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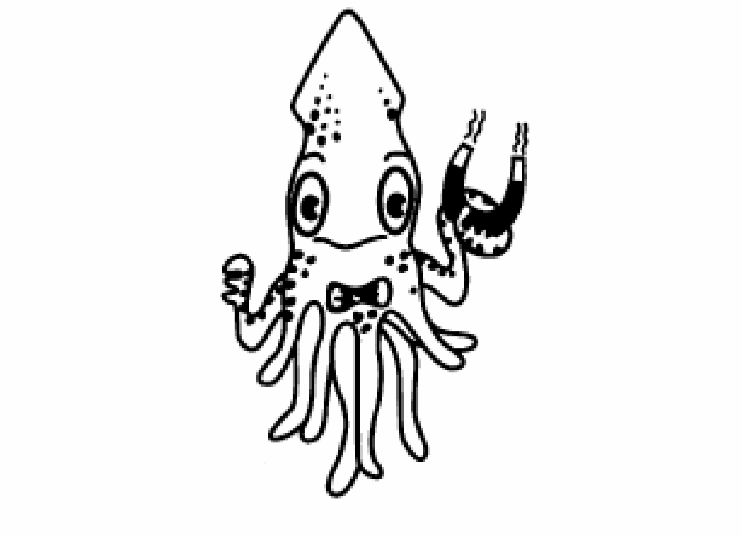


Outline

The method of magnetic measurement:

:DC susceptibility → To measure the static magnetic moment include M-T and M-H.

:AC susceptibility → To measure the dynamic magnetic moment will separate the moment response into amplitude and phase.

The kinds of probe: Standard and RSO

The condition for operation:

Temperature range: 1.8K→400K

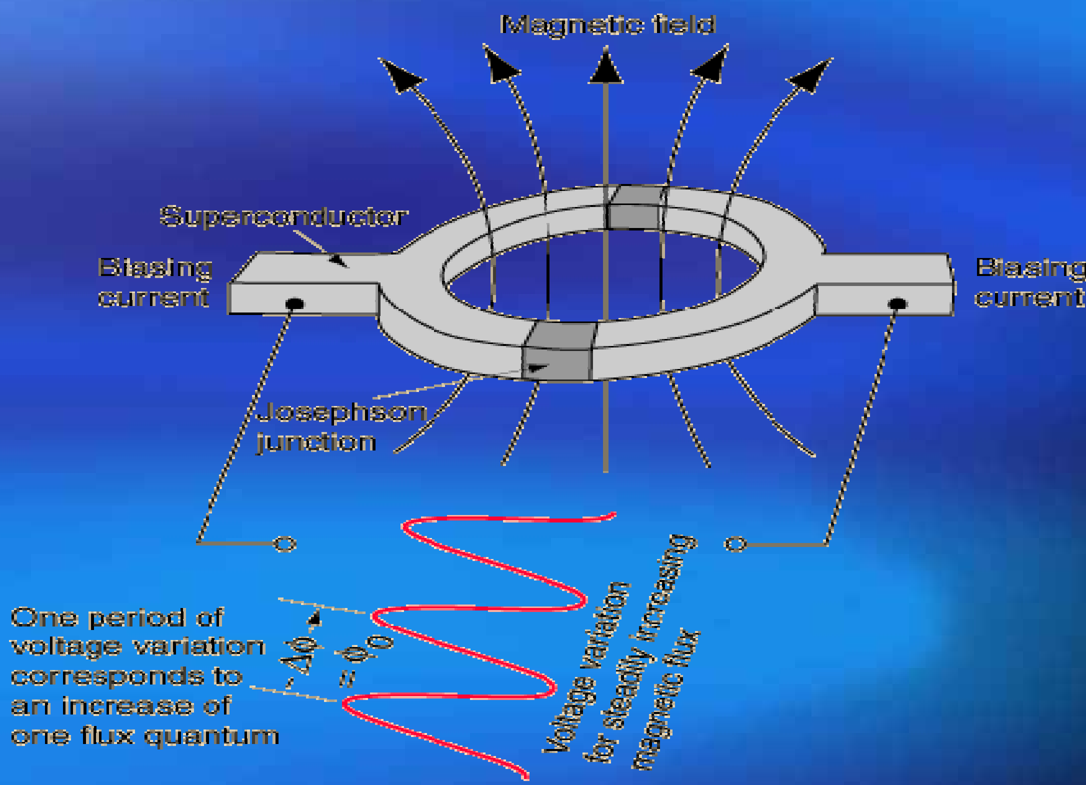
Maximum magnetic field: 7T

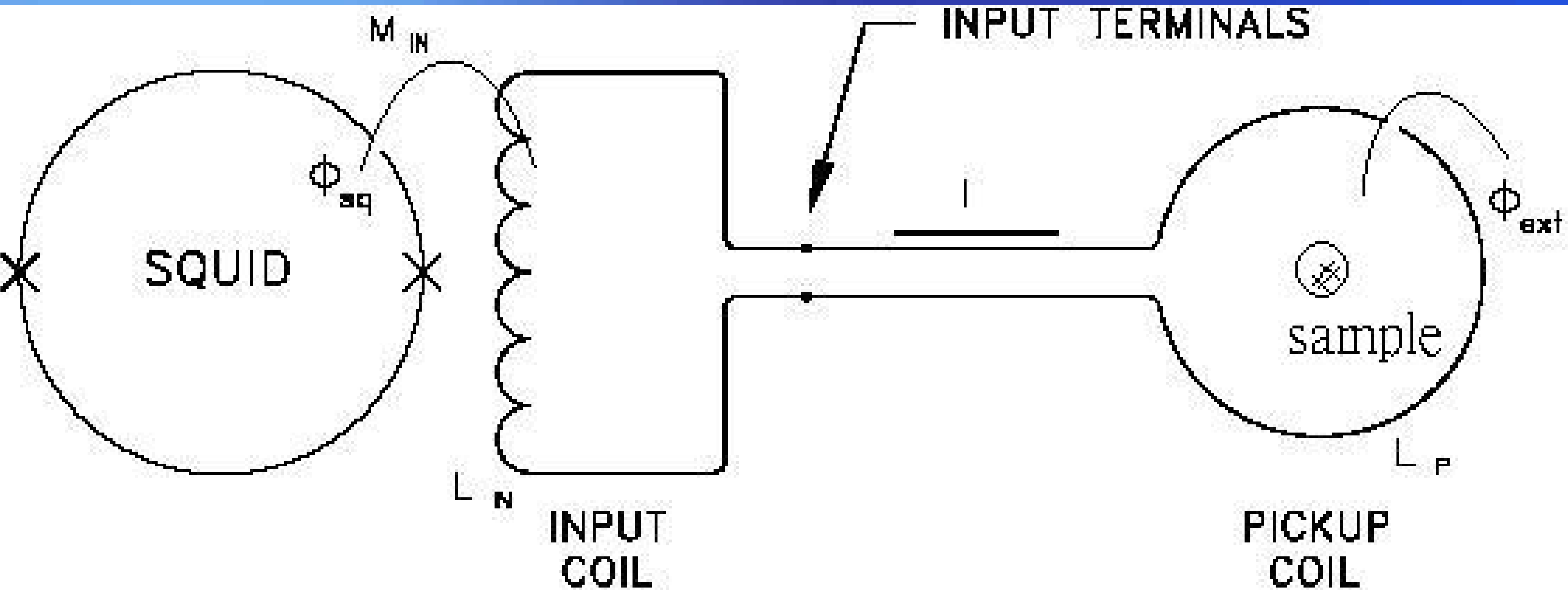
Resolution: 10^{-7} emu (Reliable)   Upper limit: ~1 emu

Introduction

- Essential Mechanism → **Josephson junction**

A **Josephson junction** is an superconductor-insulator-superconductor (SIS) layer structure placed between two electrodes





INPUT TERMINALS
M IN
Φ sq
SQUID
I
Φ ext
sample
L IN
INPUT
COIL
L P
PICKUP
COIL

Advantage of MPMS AC System

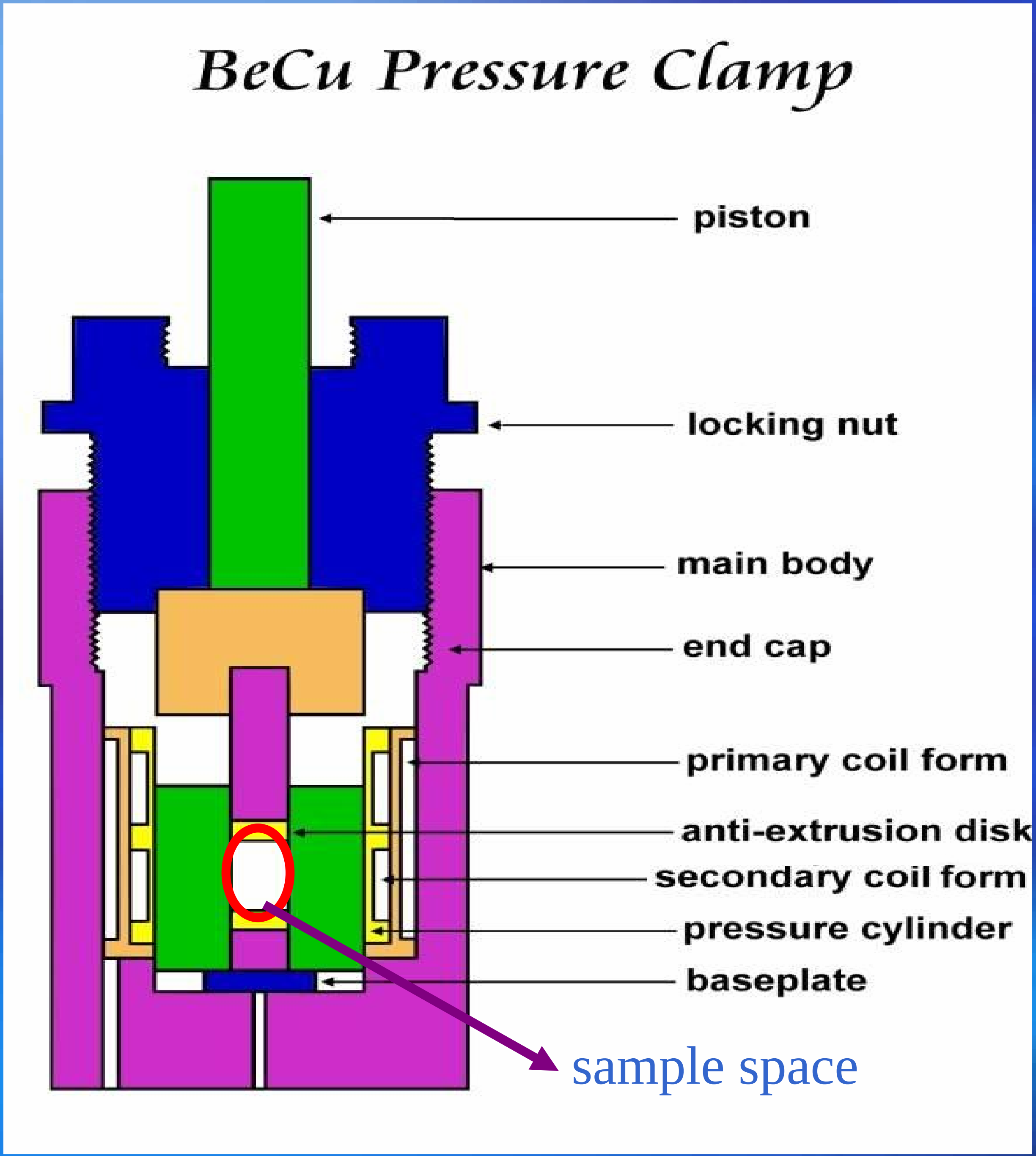
Conventional AC suceptometers measure the voltage induced in an inductive detection coil by an oscillating AC magnetic moment. The most common systems use mutual inductance bridge to measure the voltage induced. → High pressure effect

These systems measure only signals with frequencies at or very near the applied excitation. → The natural constraint

⇩

Voltage induced is proportional to the frequencies of the oscillating drive field

High pressure effect



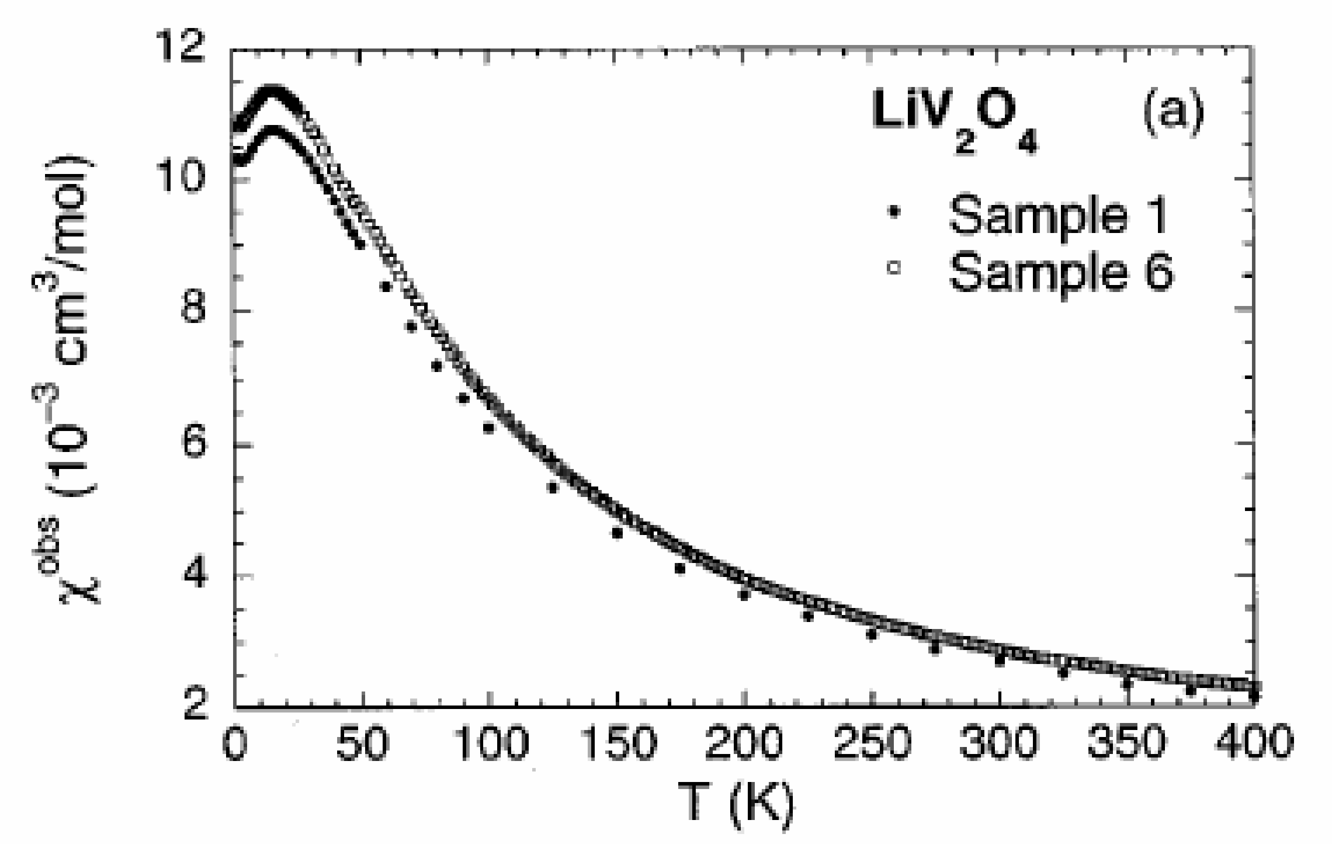
How does MPMS solve it?

★ MPMS AC option combining an AC drive field with a SQUID-based detection system.

★The SQUID is an extremely sensitive flux-to-voltage converter that directly measures the change in flux as the sample moves through a superconducting detection coil coupled to the SQUID circuit.

DC Measurement

When the external dc field is applied to the sample, the magnetization changed with temperature will be obtained due to the spin-spin, spin-orbital and orbital-orbital effect interacting with magnetic field.



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AC Measurement:

An oscillating AC magnetic field is applied to the sample. The change in flux seen by the detection circuitry is caused only by the magnetic moment of the sample as it responses the applied AC field.

X_{ac}= dM/dH obtained from these measurement is described as having both **real** and **imaginary** components **X'** and **X''** , where the imaginary component is proportional to the energy losses in the sample.

What can be derived from AC Measurement?

→**Structure details of materials**, **resonance phenomena**, **electrical conductivity** by induced currents, relaxation processes such as **flux creep** in SC and **energy exchange** between magnetic **spins** and the lattice in the **paramagnetic** materials.

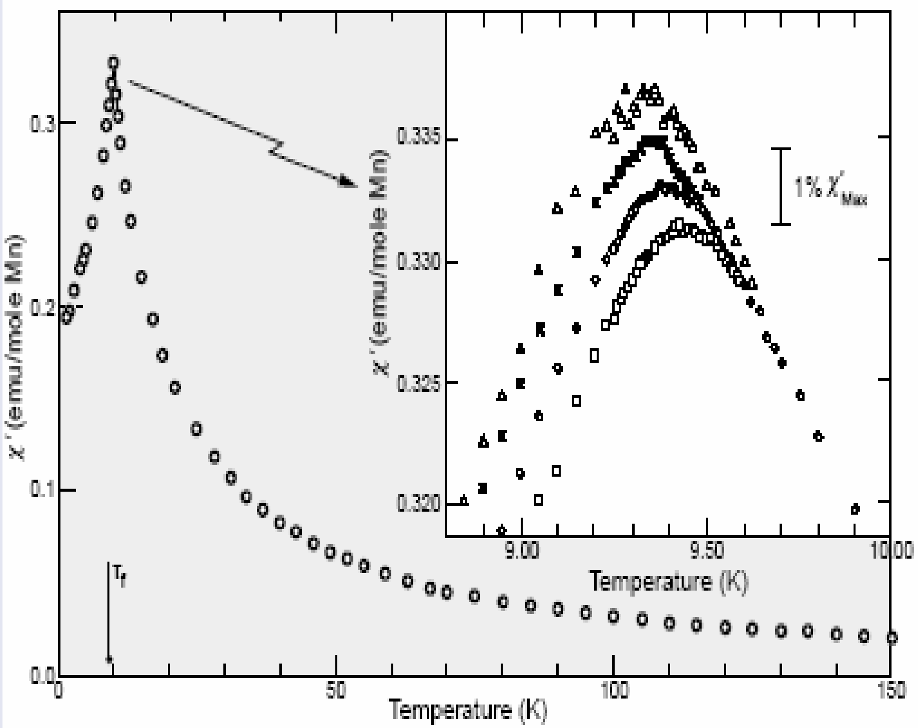
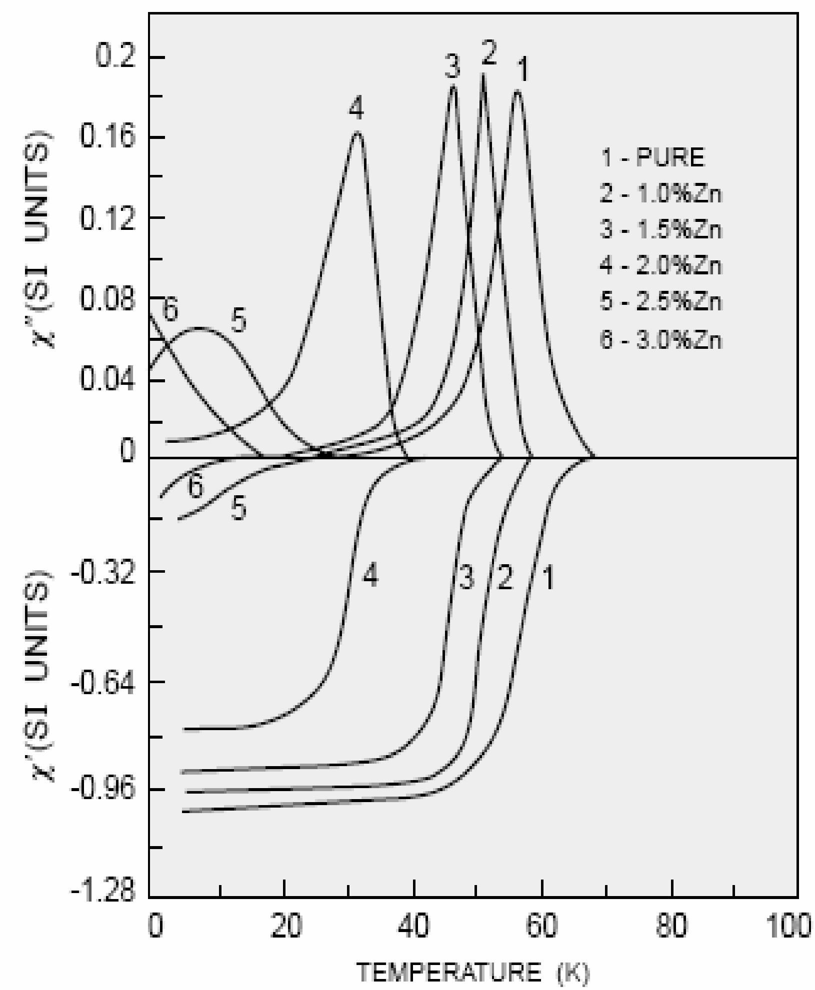


Figure 1. AC susceptibility of CuMn (1 at% Mn) showing the cusp at the freezing temperature. The inset shows the frequency dependence of the cusp from 2.6 Hz (triangles) to 1.33 kHz (squares). Figure reprinted with permission.[2]

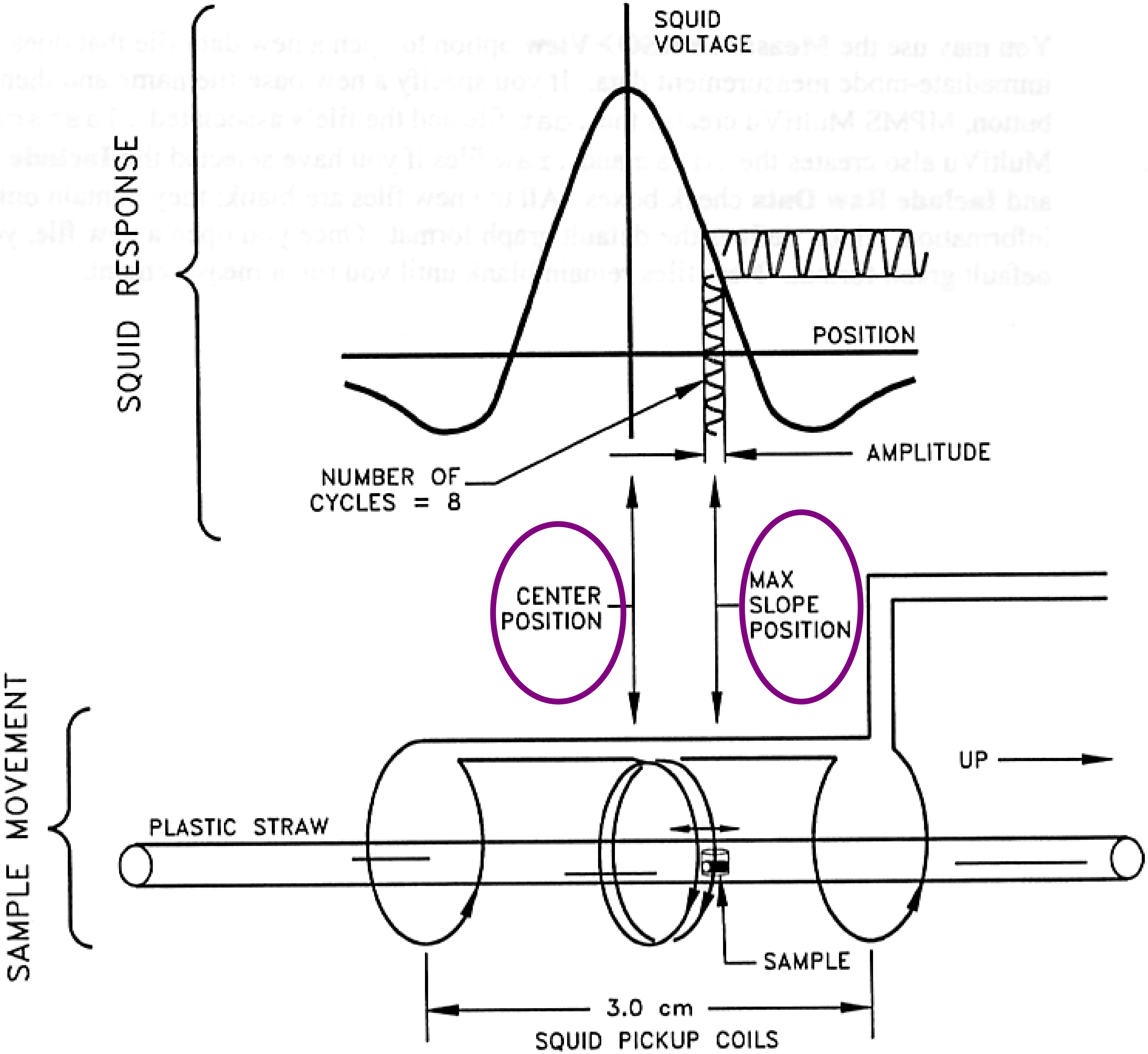


Introduction to AC susceptibility for MPMS

RSO Measurement (Reciprocating Sample Option)

RSO measure a sample by moving it rapidly and sinusoidally through the SQUID pickup coil.

The option's use of a high-quality servo motor and a digital signal processor (DSP) allow rapid measurement. The servo motor, unlike the stepper motor performing DC measurements, doesn't stop sample movement for each data reading. Lock-in techniques that use the DSP reduce the contribution of low-frequency noise to the measurement.


SQUID
VOLTAGE
SQUID RESPONSE
POSITION
AMPLITUDE
NUMBER OF
CYCLES = 8
CENTER
POSITION
MAX
SLOPE
POSITION
SAMPLE MOVEMENT
UP
PLASTIC STRAW
SAMPLE
3.0 cm
SQUID PICKUP COILS

Temperature Control system

- Heater
- Impedance
- Thermal meter

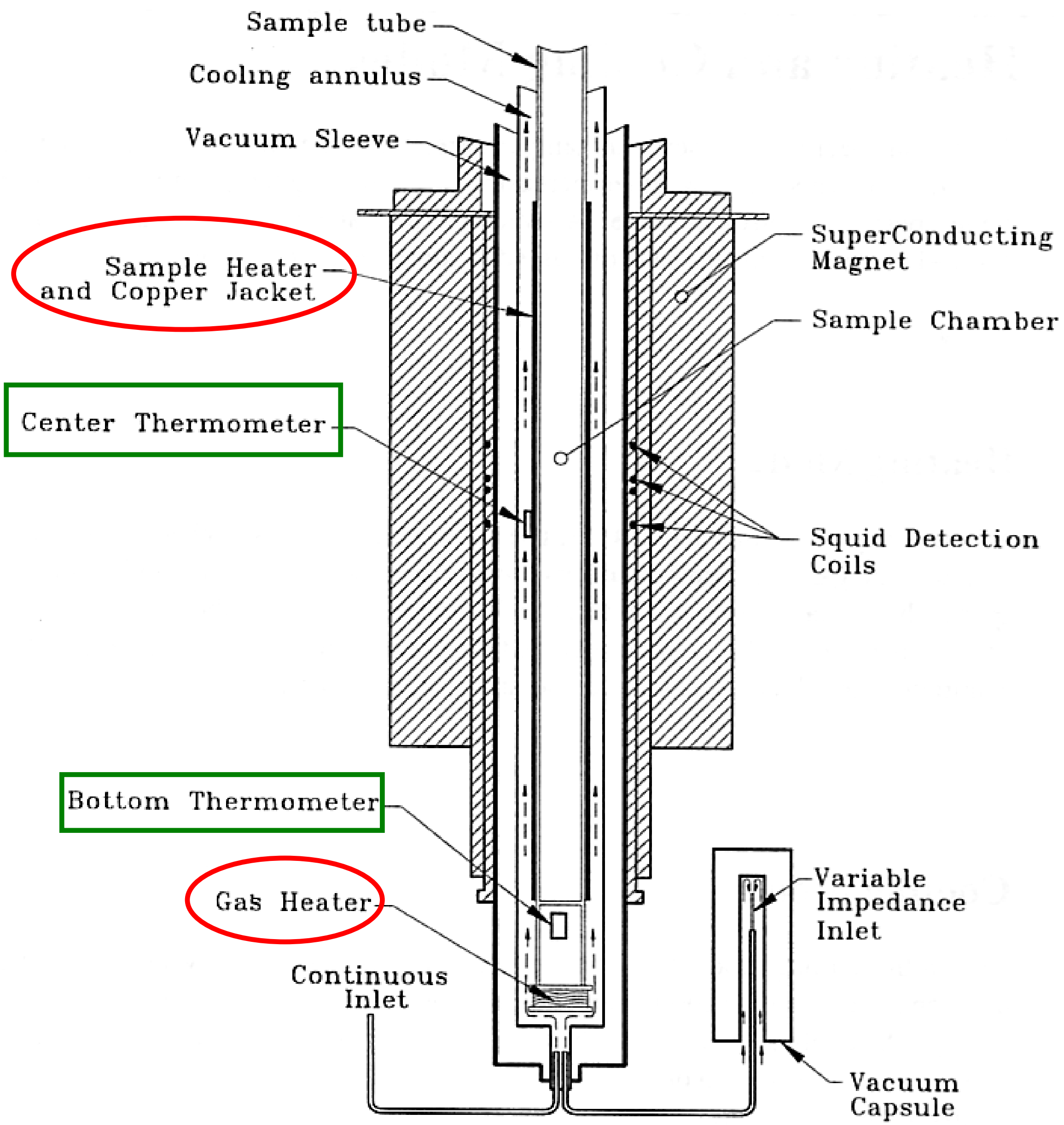
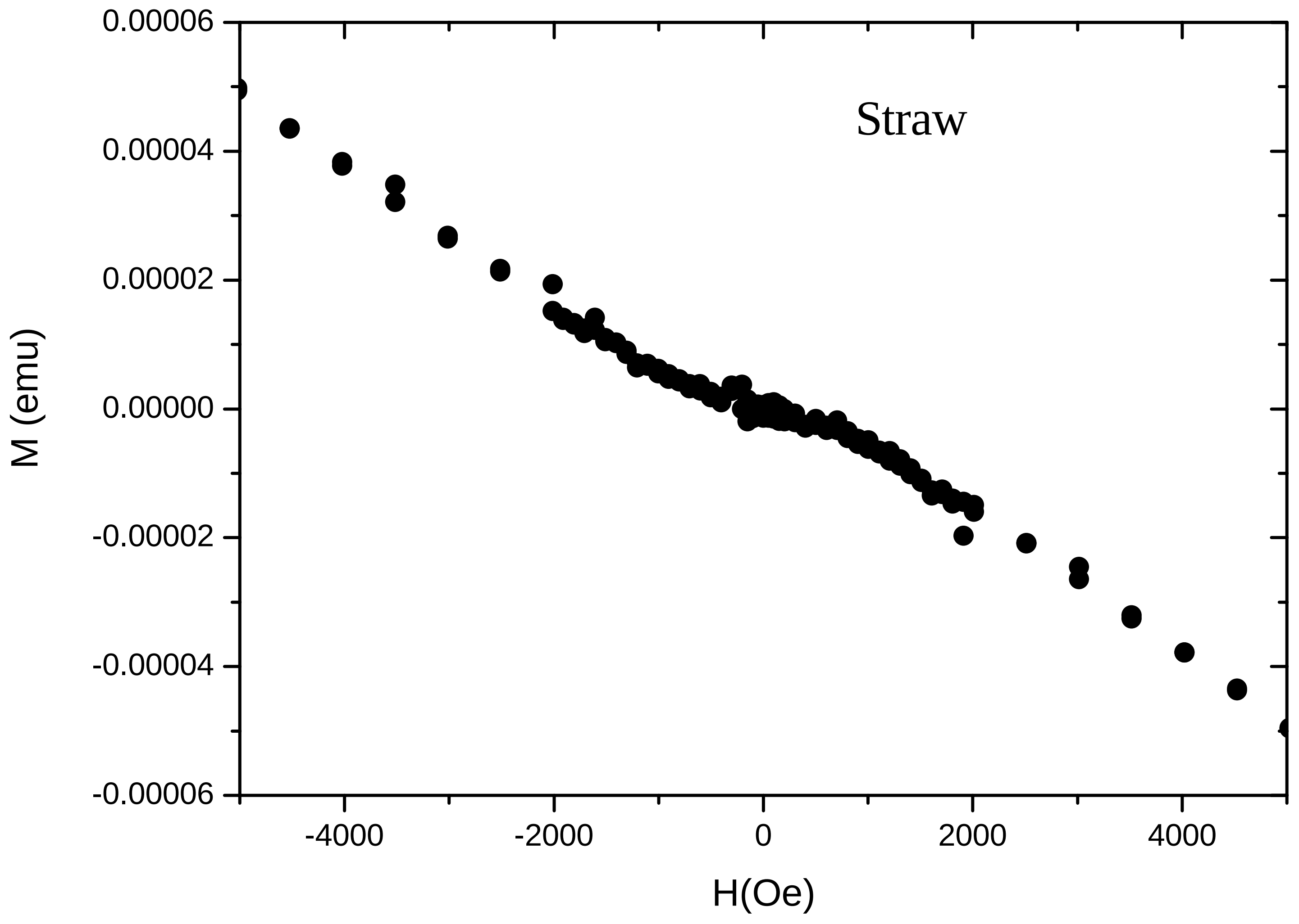
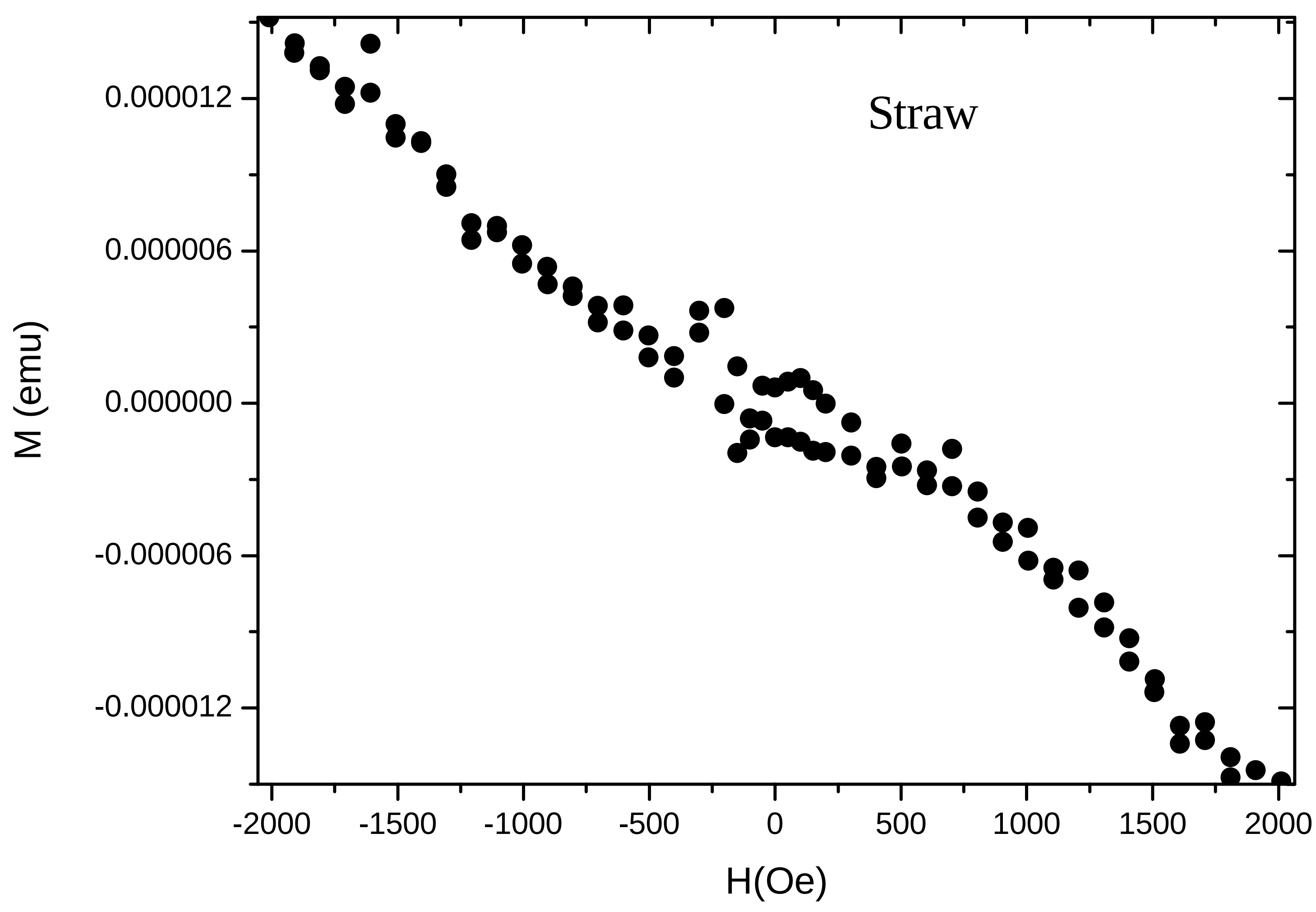


Figure 1-2. Cross Section of Probe



Straw
0.00006
0.00004
0.00002
0.00000
-0.00002
-0.00004
-0.00006
M (emu)
-4000
-2000
0
2000
4000
H(Oe)


Straw
0.000012
0.000006
0.000000
-0.000006
-0.000012
M (emu)
-2000
-1500
-1000
-500
0
500
1000
1500
2000
H(Oe)

Thank you for attention

Sun 2005.05.18