Noise measurements in superparamagnetic tunnel junctions

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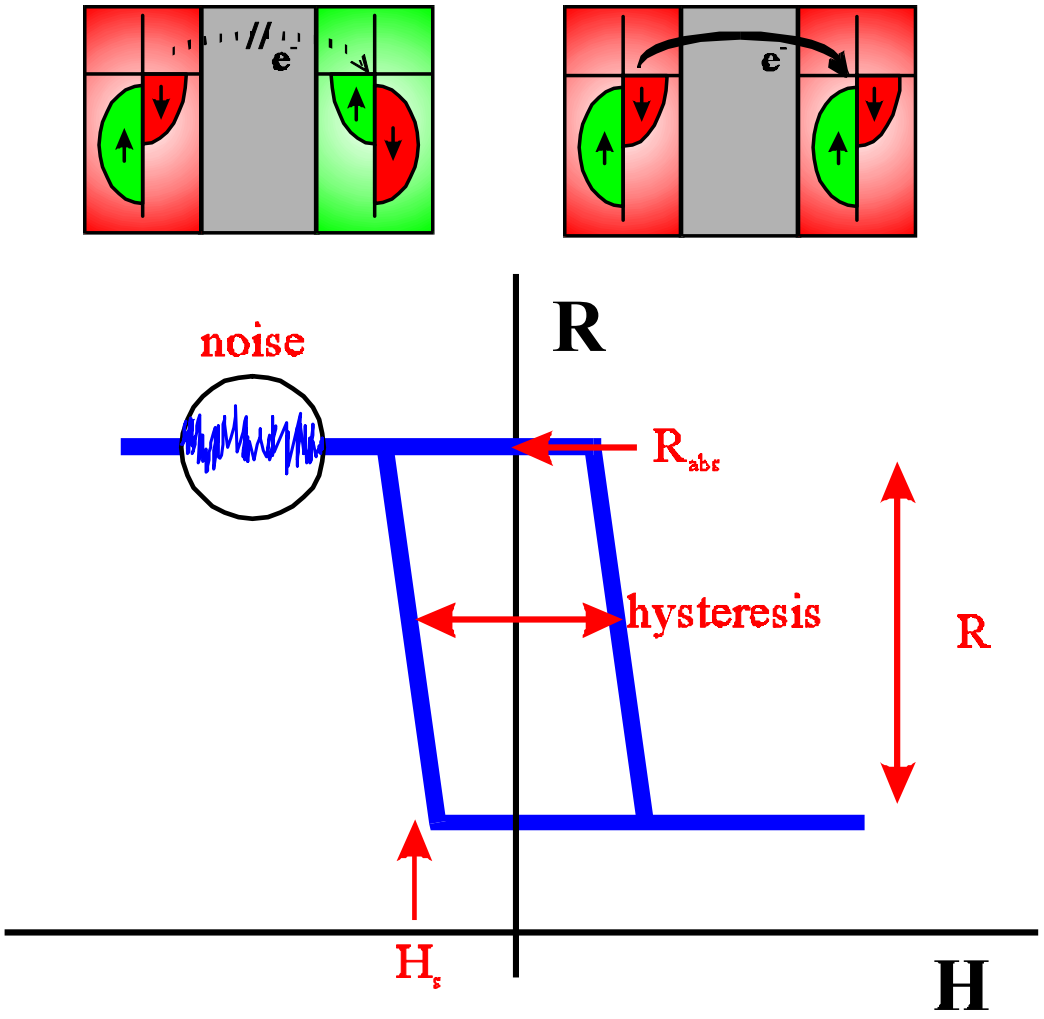
Superparamagnetic tunnel junctions

Tunnel-magnetoresistance specifications



sensitivity

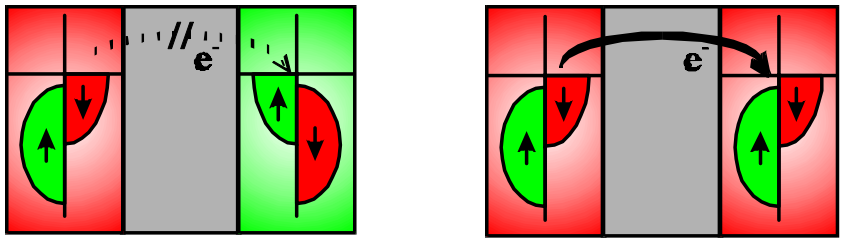
absolute resistance

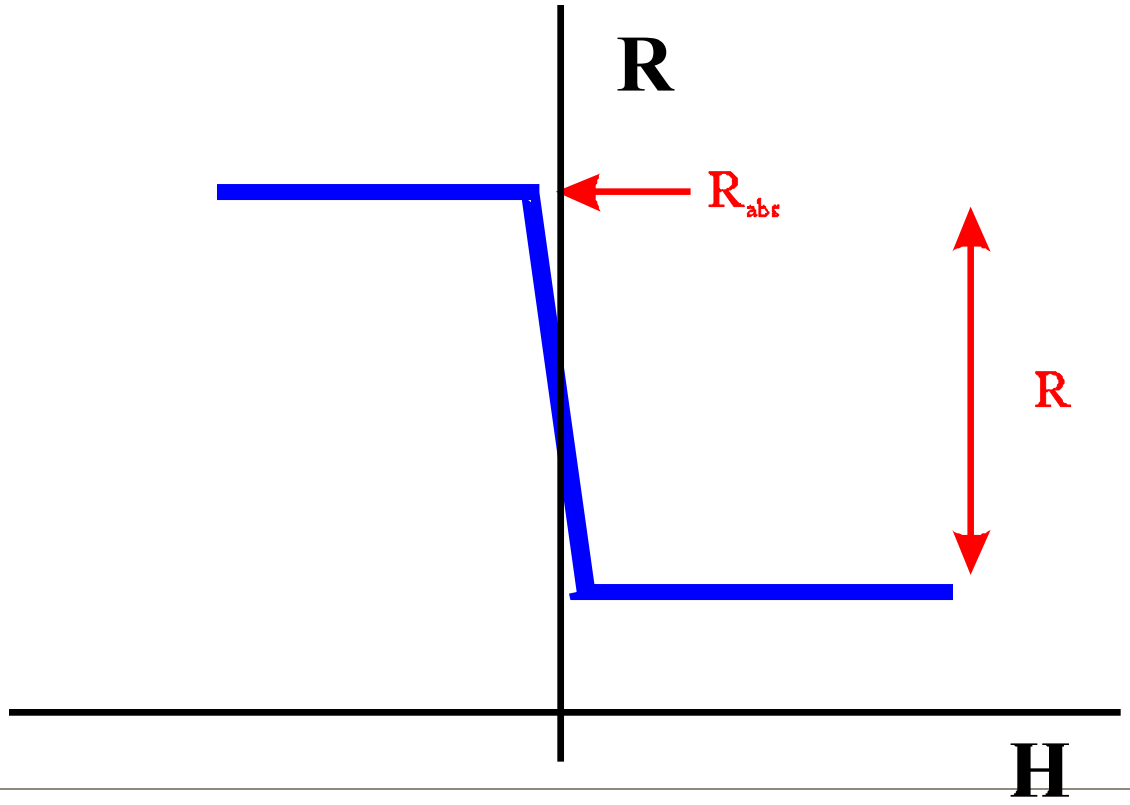
hysteresis H_c

signal noise

Superparamagnetic tunnel junctions

Tunnel-magnetoresistance specifications





sensitivity

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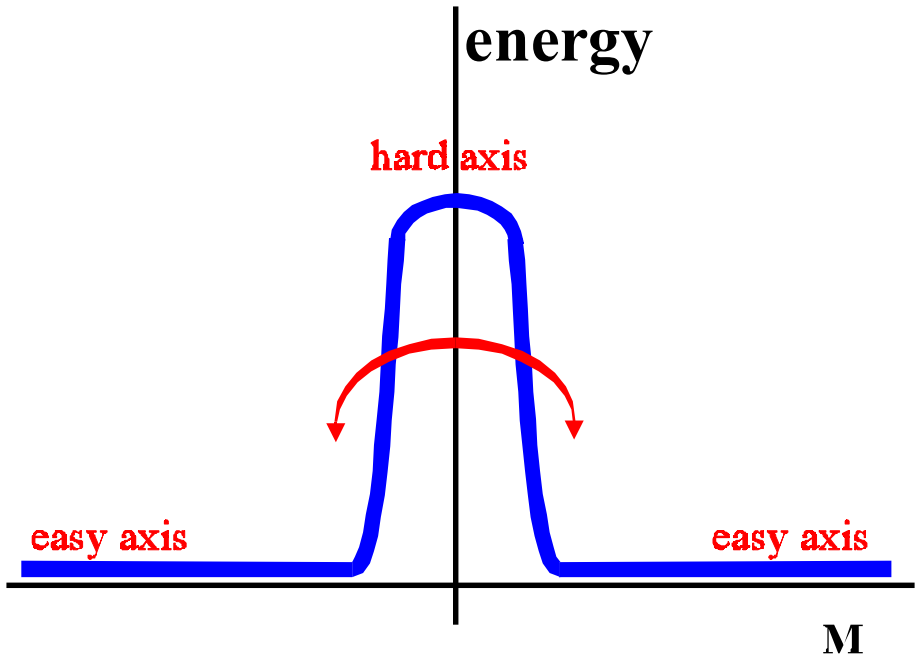
Superparamagnetic tunnel junctions
Thermally unstable magnetization

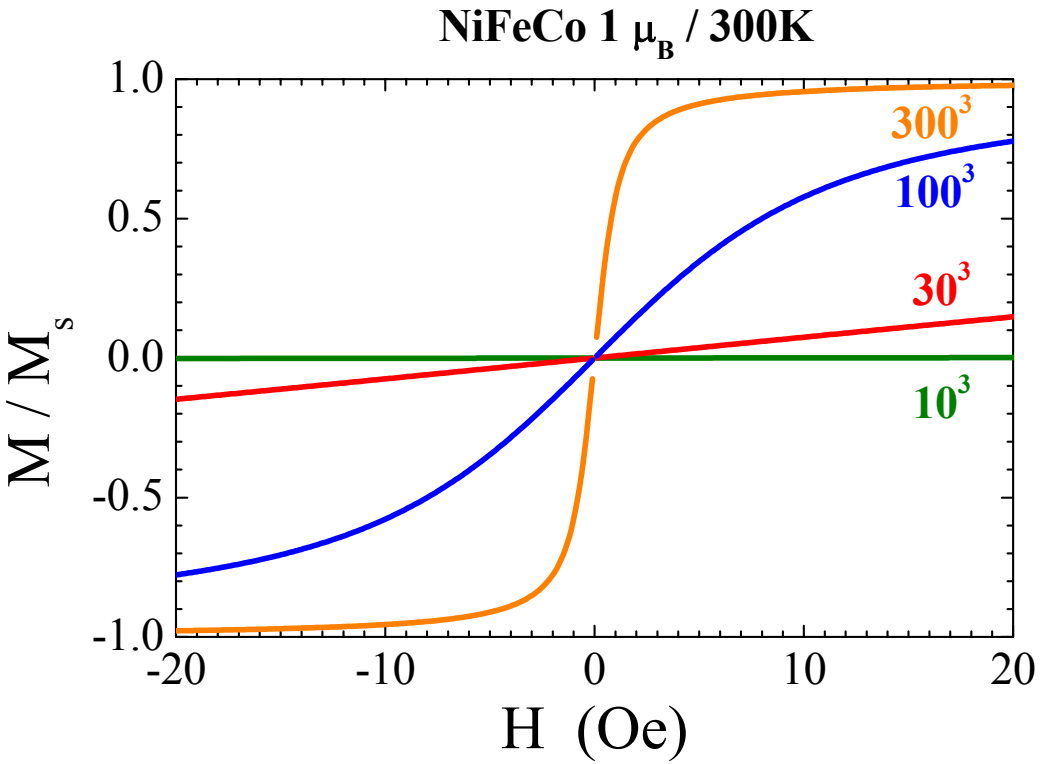


Arrhenius equation:

$$1/\tau = f_0 e^{-\Delta E/kT}$$

$$\Delta E = K_{anisotropy} * \text{Volume}$$

Superparamagnetic tunnel junctions
Magnetization of superparamagnetic particles



$L(a) = \coth(a) - 1/a$

$a = M_s * Vol * H/kT$

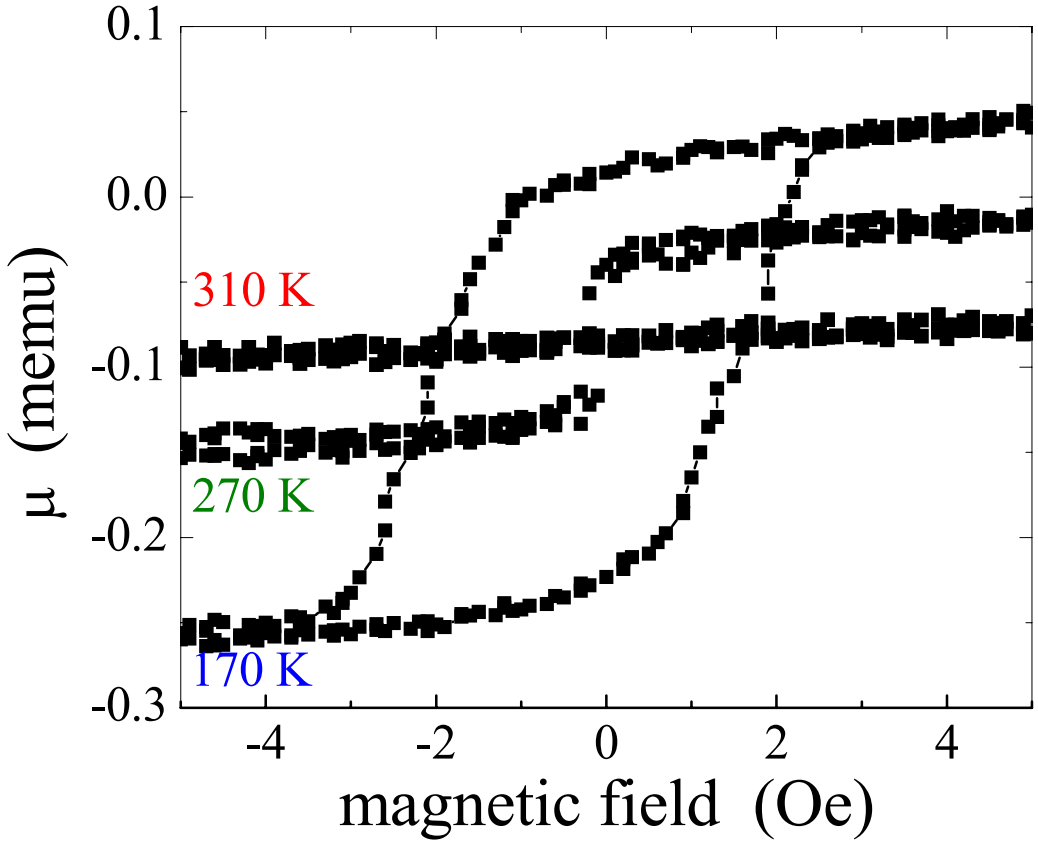
volume

magnetic field

temperature

Superparamagnetic tunnel junctions

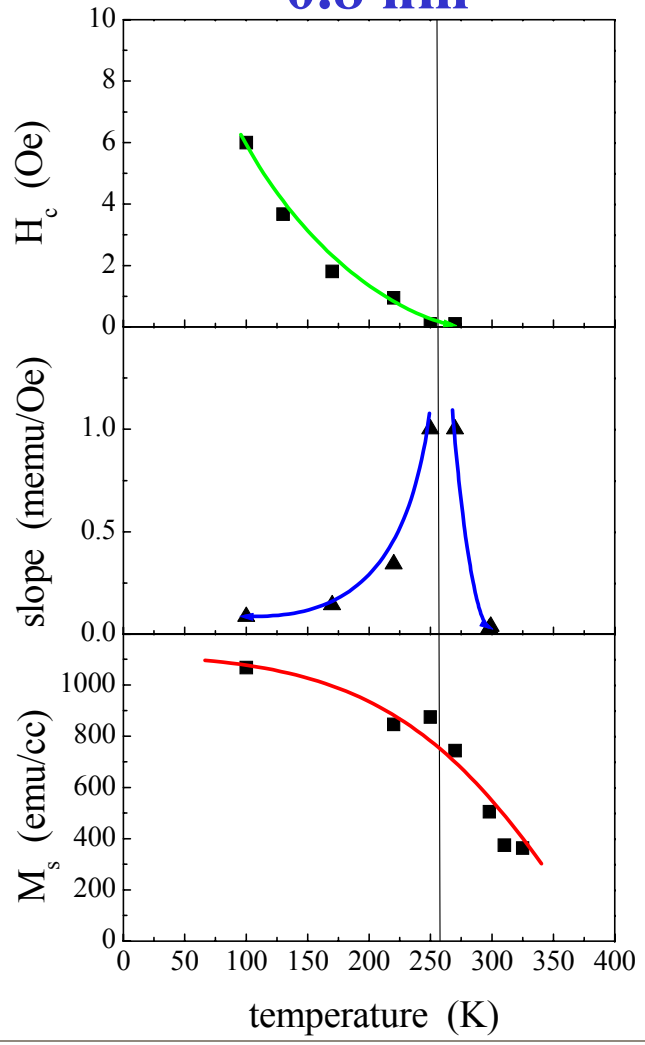
Cu / 0.8 nm NiFeCo / Cu



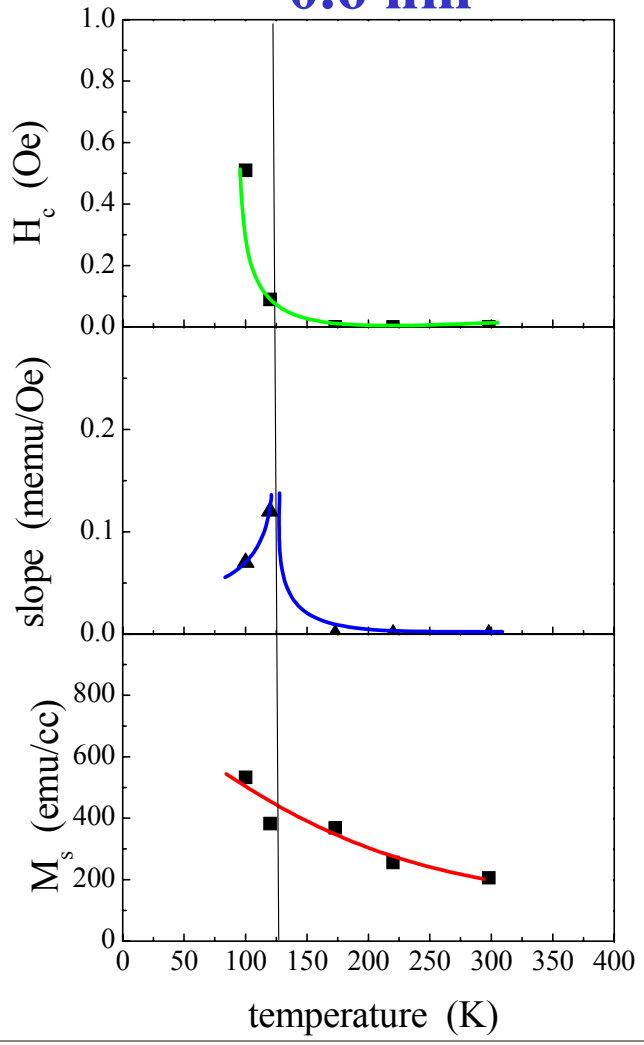
Superparamagnetic tunnel junctions

Cu / NiFeCo / Cu

0.8 nm

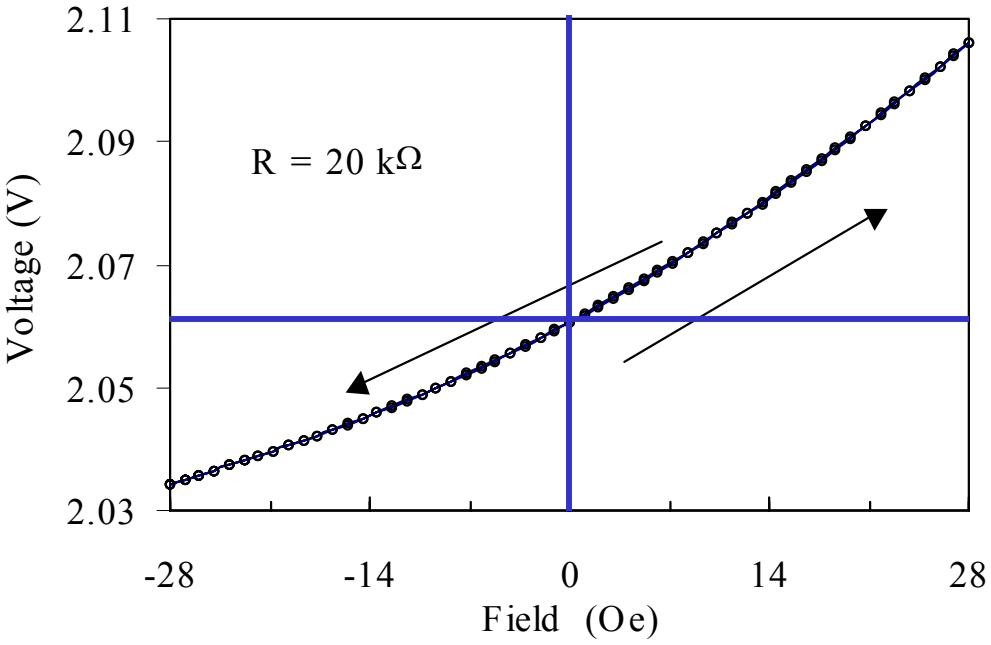


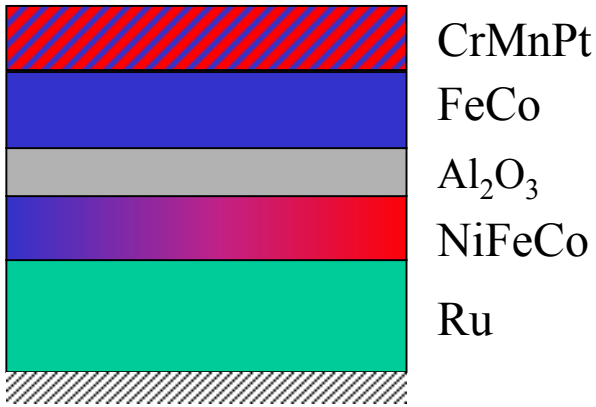
0.6 nm



Superparamagnetic tunnel junctions

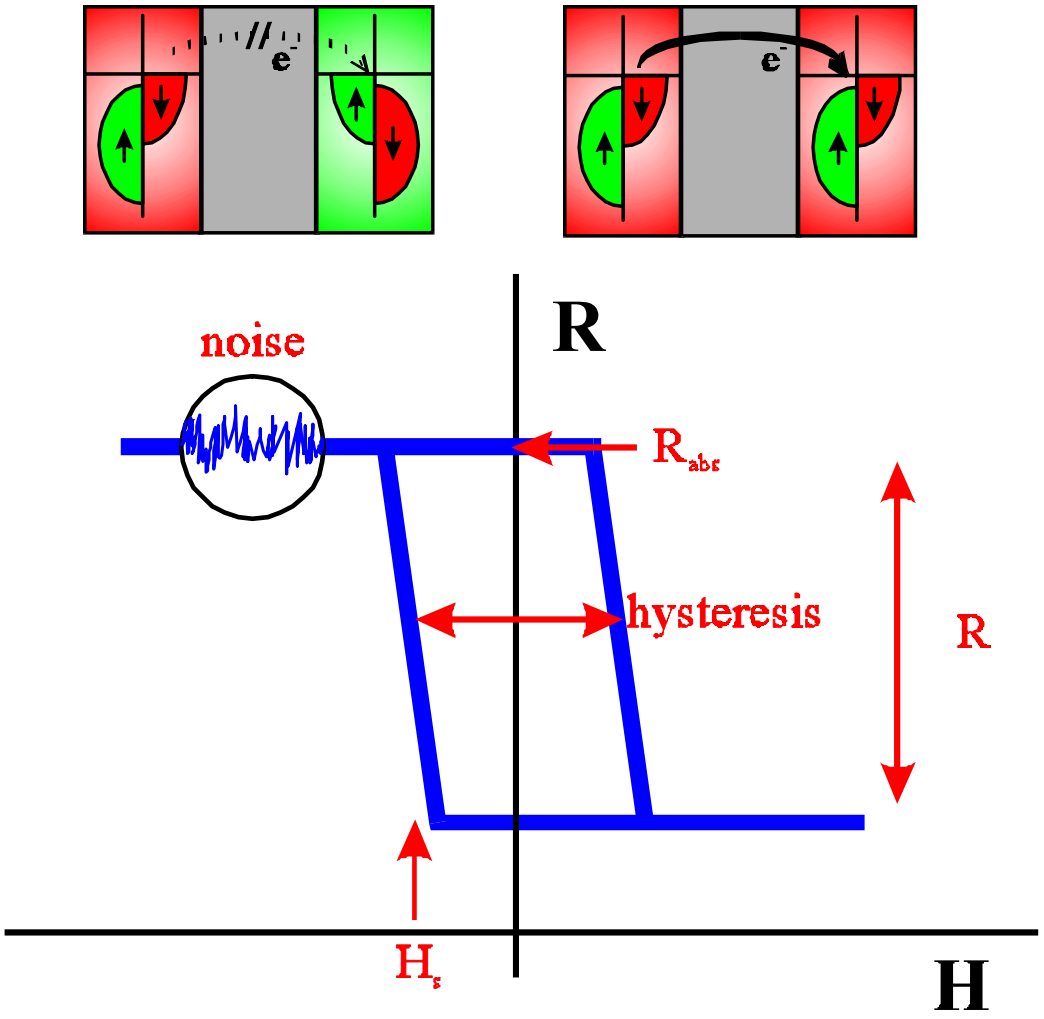
hysteresis-free magnetic field sensor





Superparamagnetic tunnel junctions

Tunnel-magnetoresistance specifications



sensitivity

absolute resistance

hysteresis H_c

signal noise

Electronic Noise

- **Thermal noise**

Johnson, Nyquist 1928

Is caused by the random, thermally induced, motion of conduction electrons.

$$S_t(f) = 4kTR \quad V^2/Hz$$

$k = (1.38 \times 10^{-23}\ J/K)$

$T = 300K$

$R = 50\ k\Omega$

$S(f) \propto 10^{-16}\ V^2/Hz$

Electronic Noise

- **Shot noise**

Schottky 1918

Results from the random passage of individual charge carriers across a potential barrier.

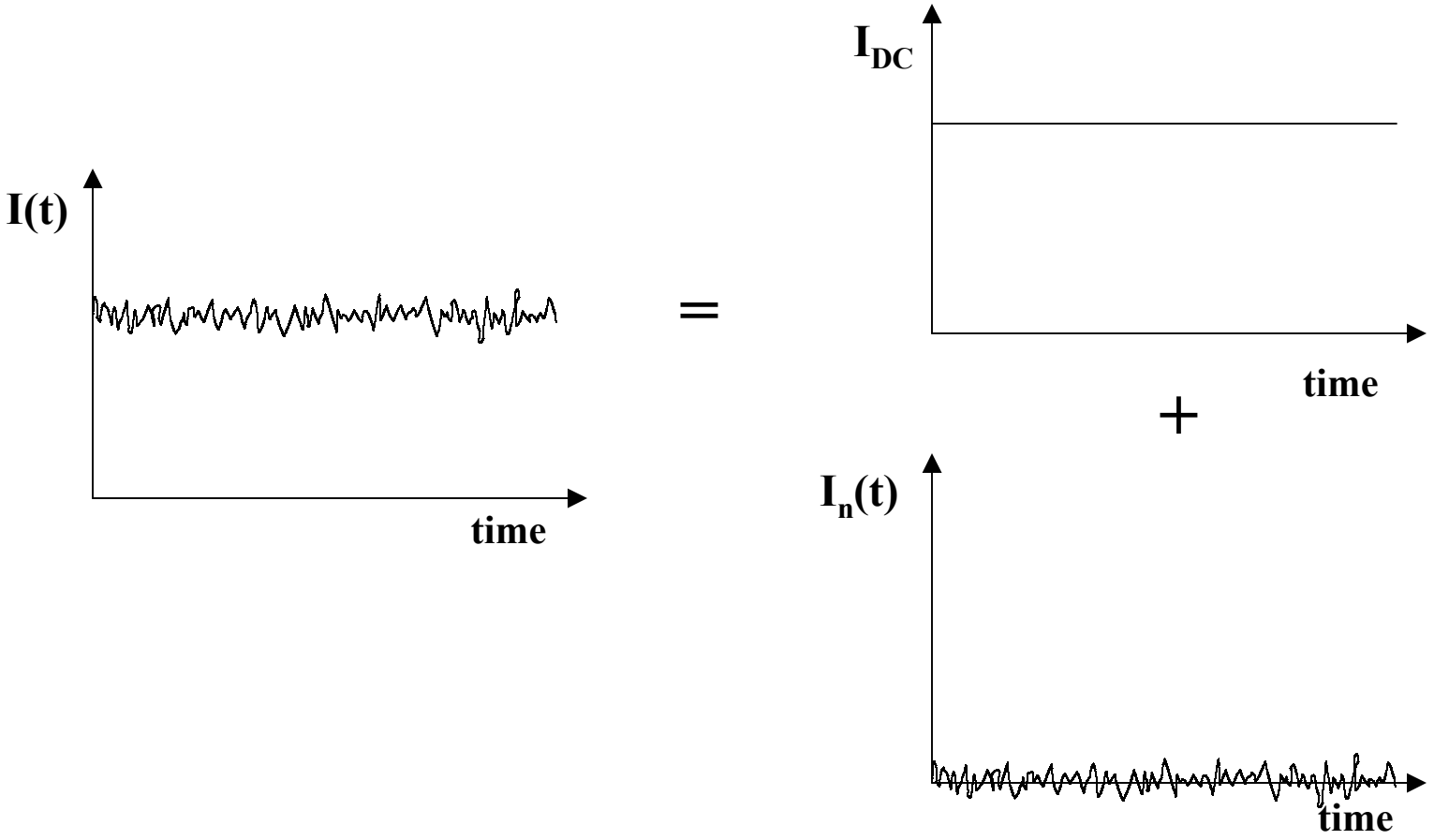
$$S_i(f) = 2eI_{DC} \quad A^2/Hz$$

If I(t) is the total current then :

$$I(t) = I_{DC} + I_n(t)$$

Electronic Noise

- **Shot noise**



Electronic Noise

- **Low frequency noise**

1/f or 'excess' noise

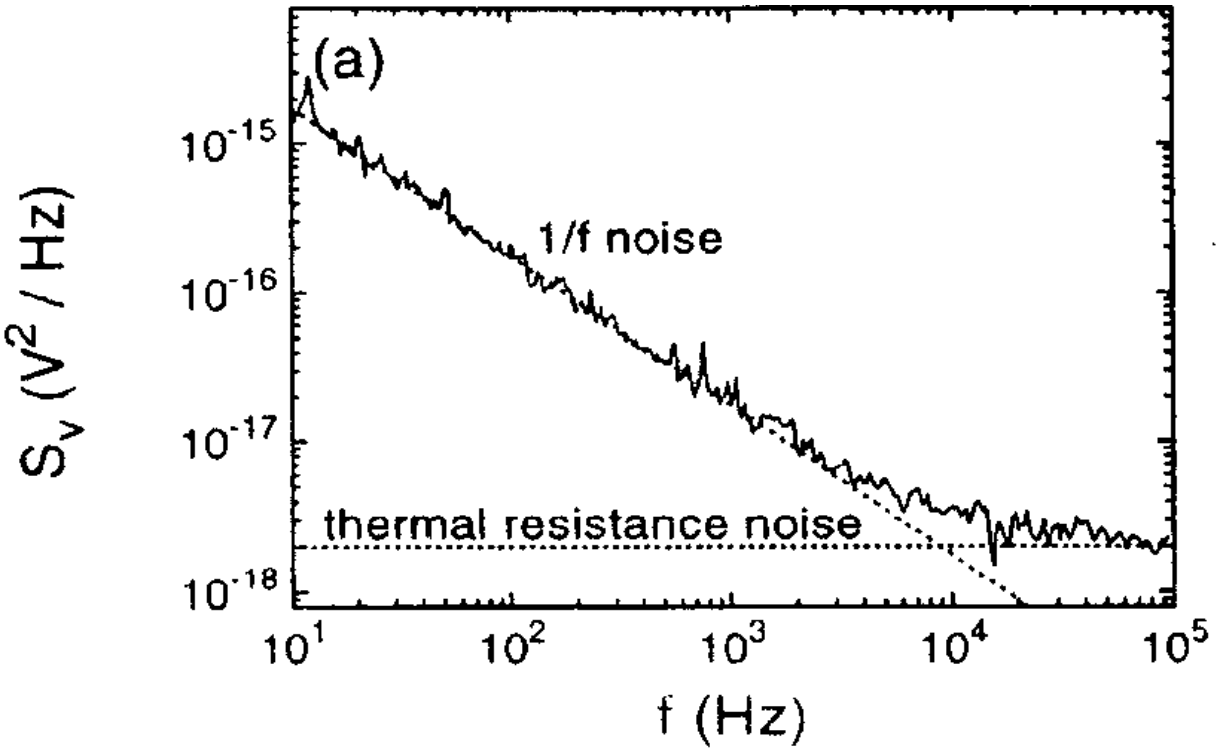
Appears as a fluctuation of the steady current flowing through a device.

$$S_f(f) = K_f / f^{\alpha} \quad V^2/Hz$$

The index α is usually in the range 0.8 – 1.4

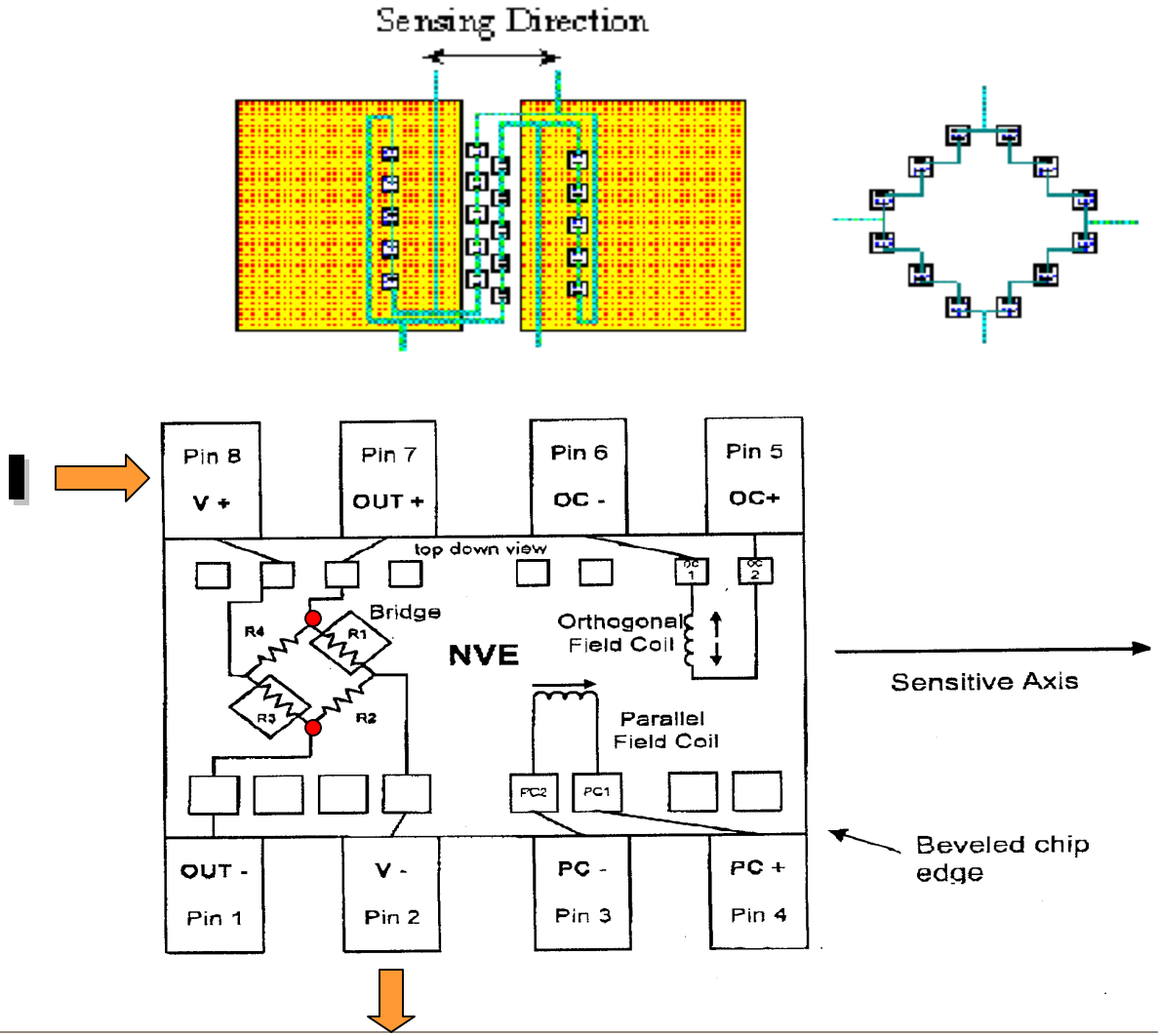
Electronic Noise

- **Low frequency noise**



Superparamagnetic tunnel junctions

The SDT sensor



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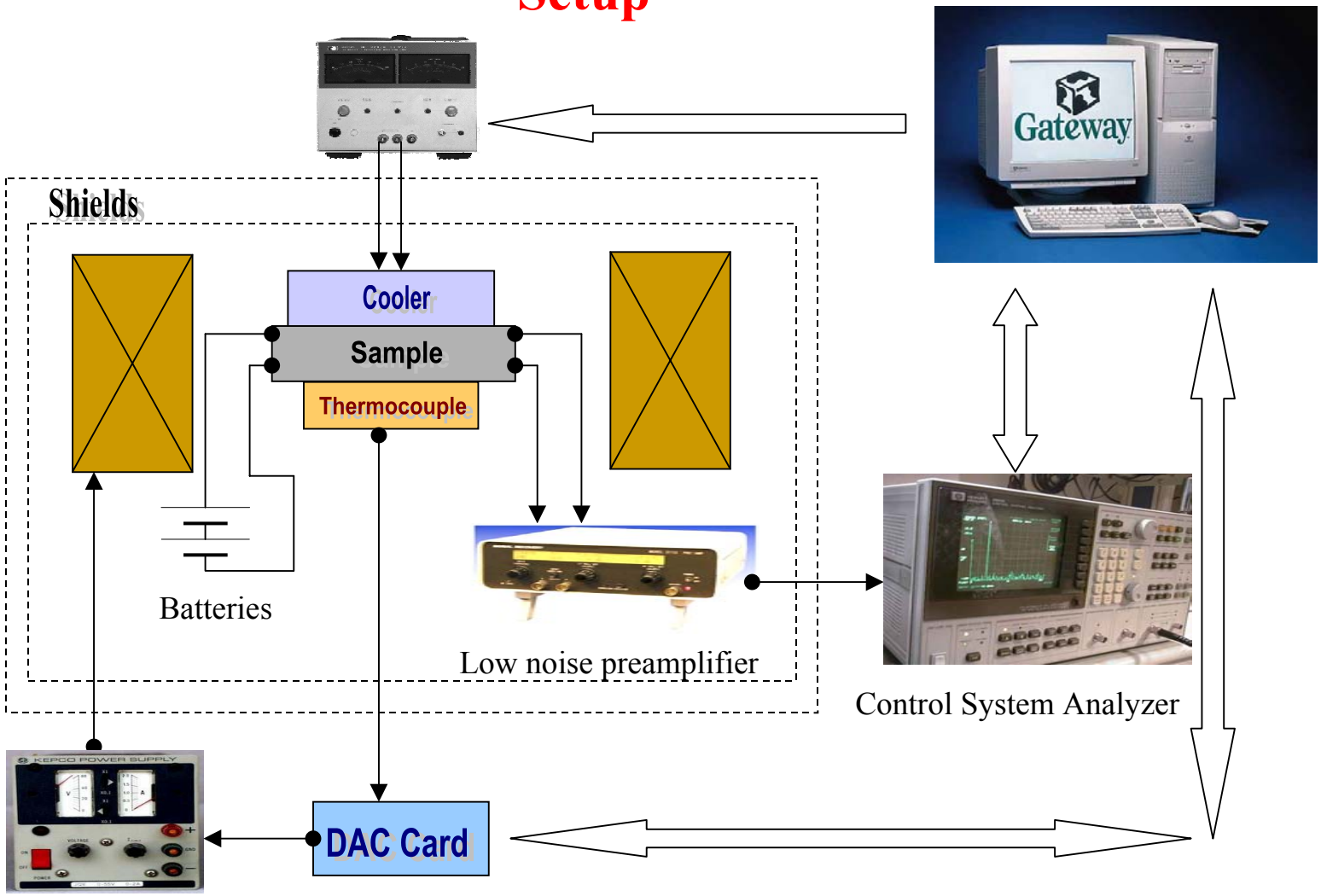
Setup



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