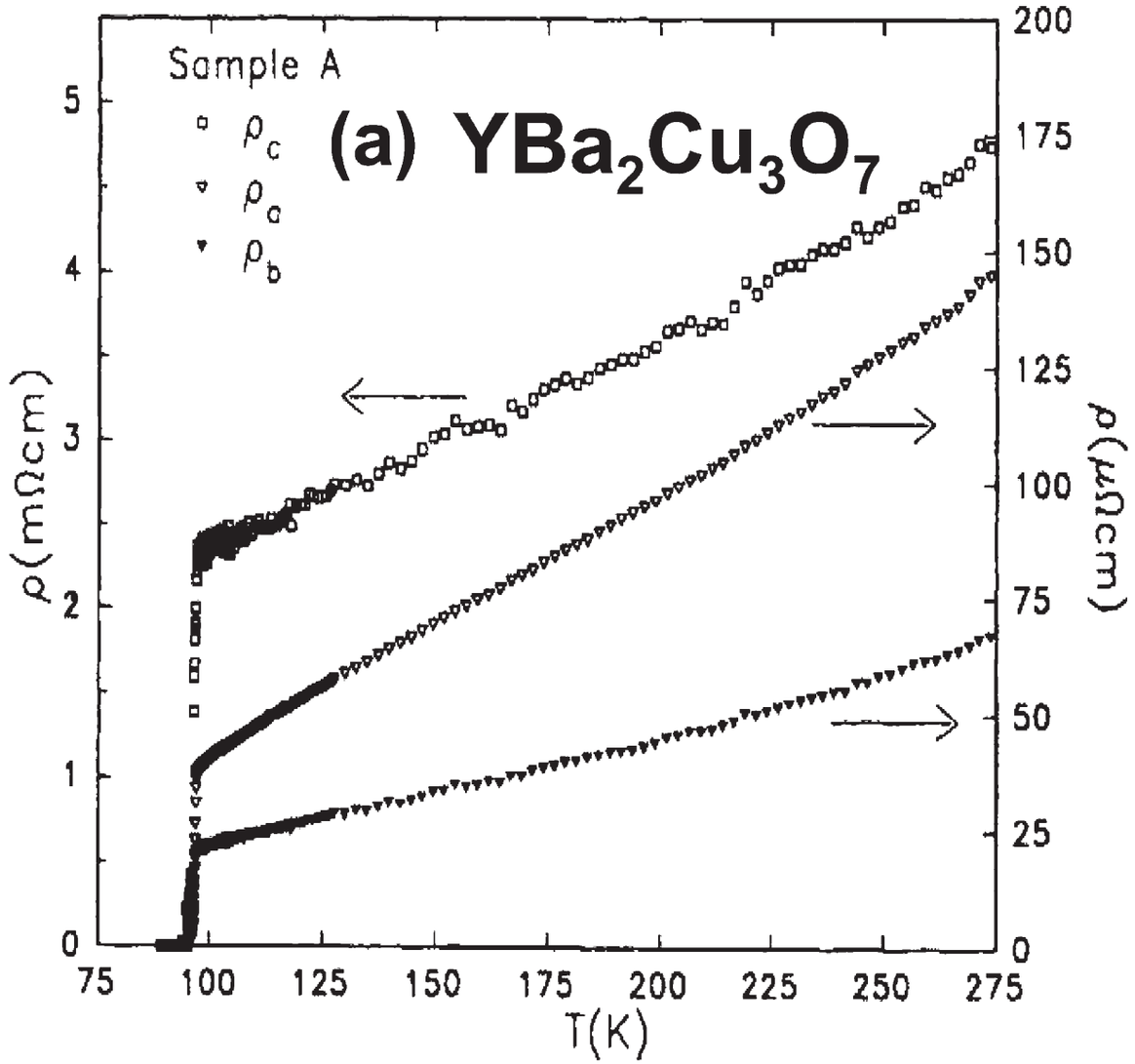
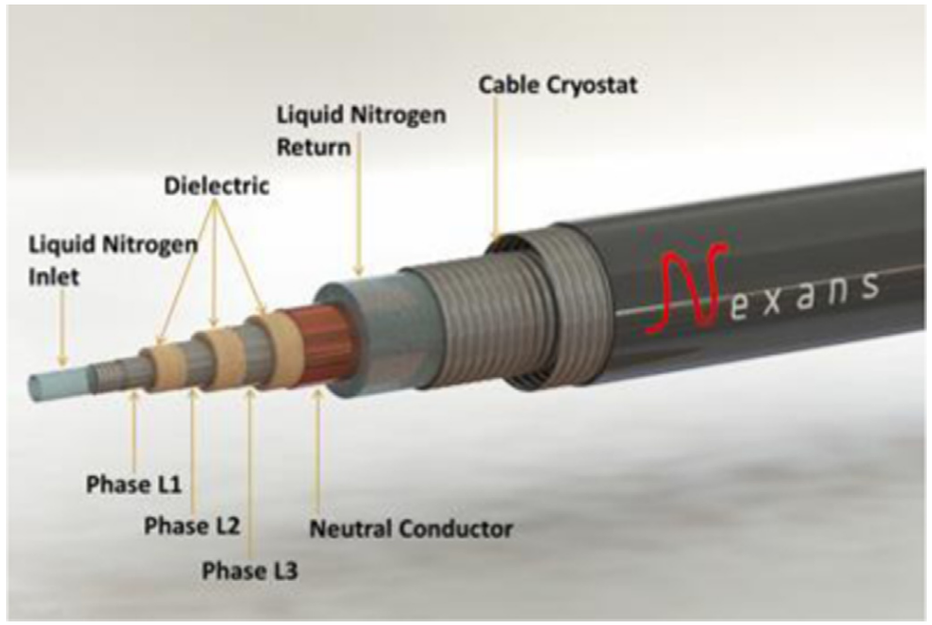
Superconductivity





- AmpaCity (Essen)
- TEPCO (Yokohama)
- …

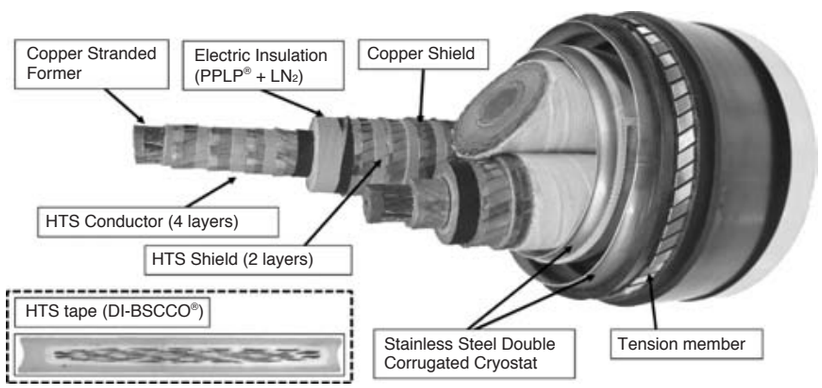
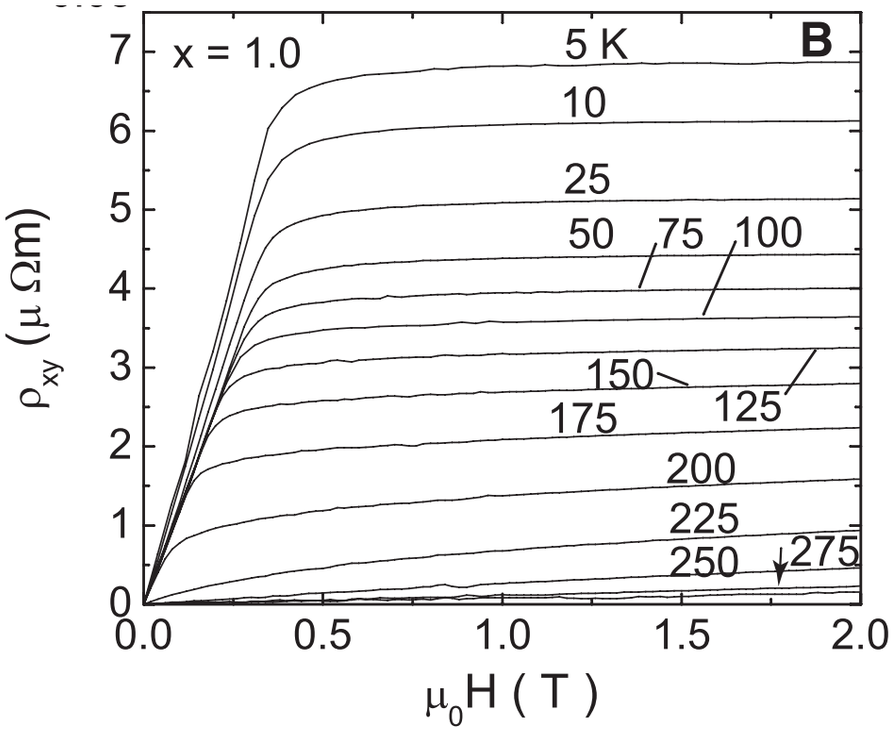


Photo 1. Structure of 3-in-One HTS Cable

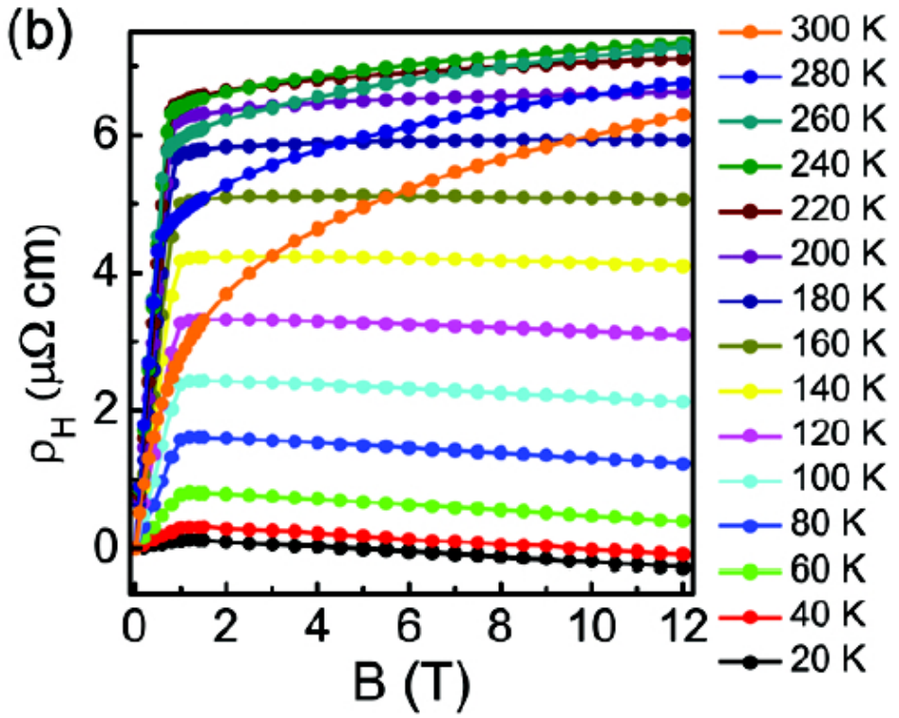
AHE (anomalous Hall effect)

$$R_H = B \cdot (1/ne) + M \cdot \text{const}$$

$CuCr_2Se_3Br$



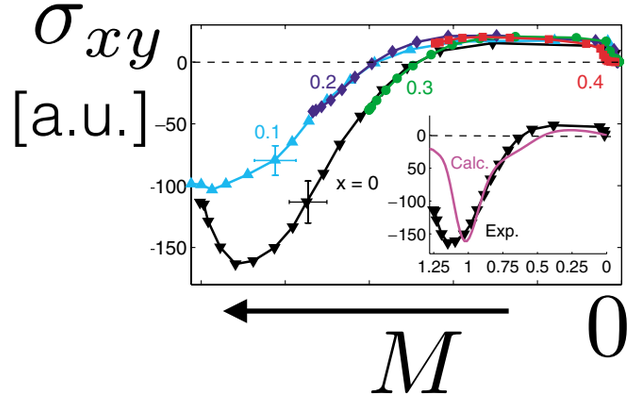
Mn_5Ge_3



atomic spin-orbit interaction

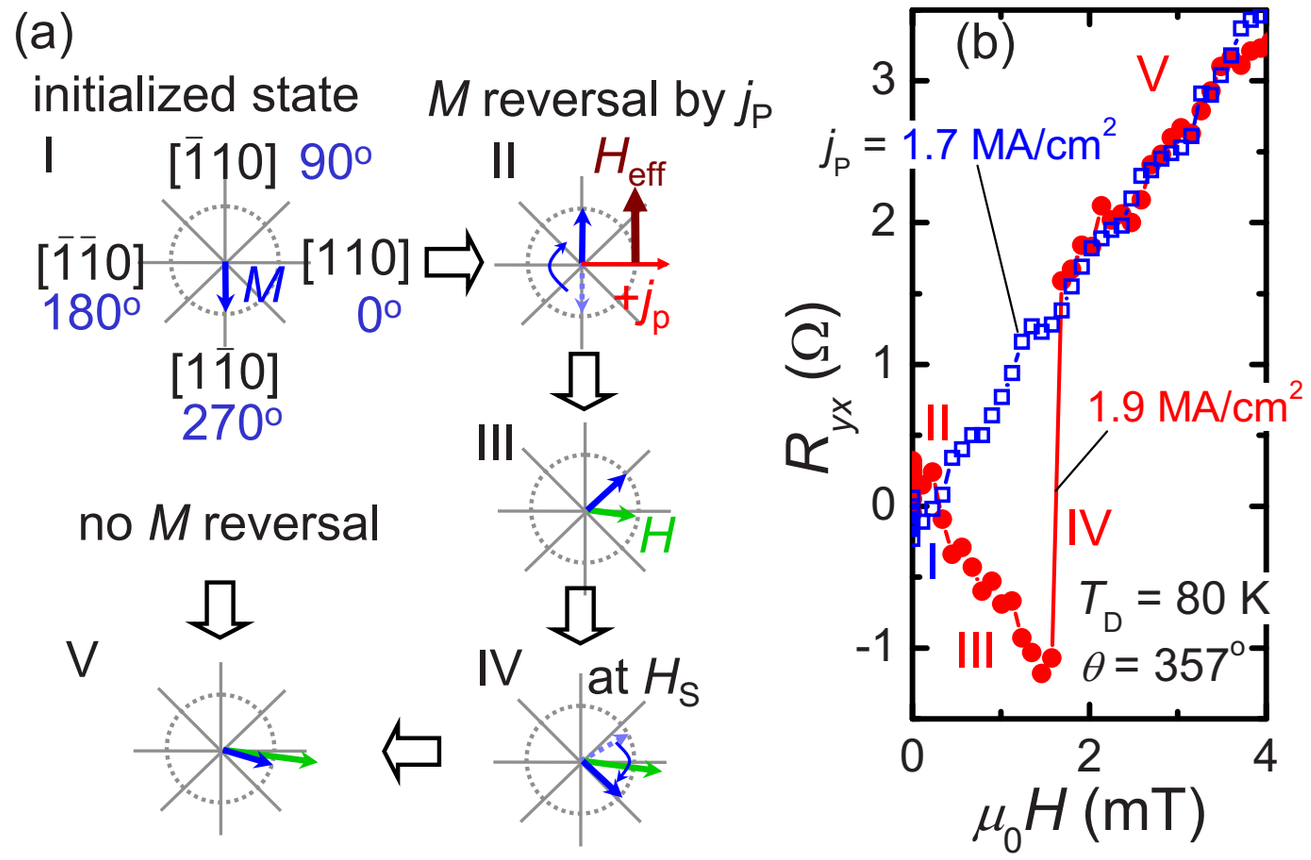
$$\hat{H}_{SO} = \frac{\hbar}{4m^2c^2}\vec{\sigma} \cdot \nabla V \times \vec{p}$$

beware: (SCRO)



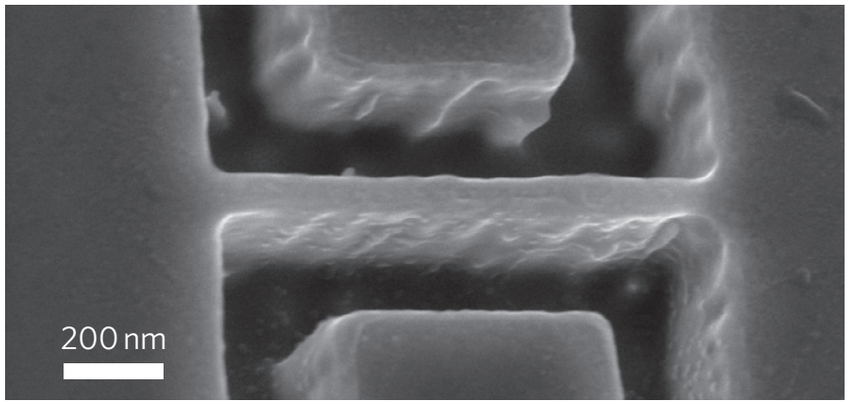
Magnetisation switch by spin-orbit torque

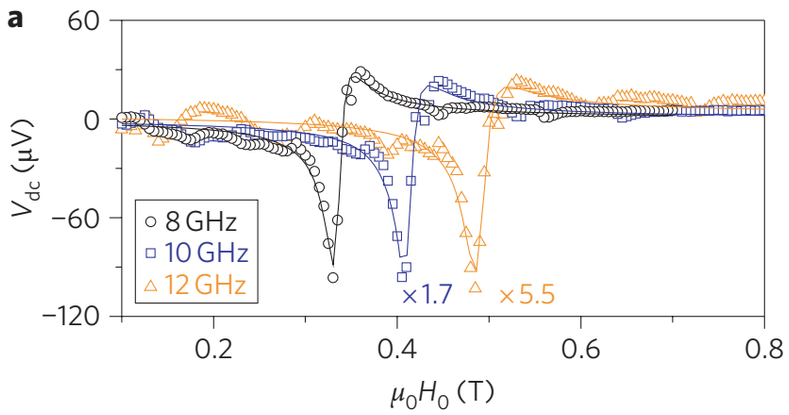
FM layer after application of a current pulse that generates SOT

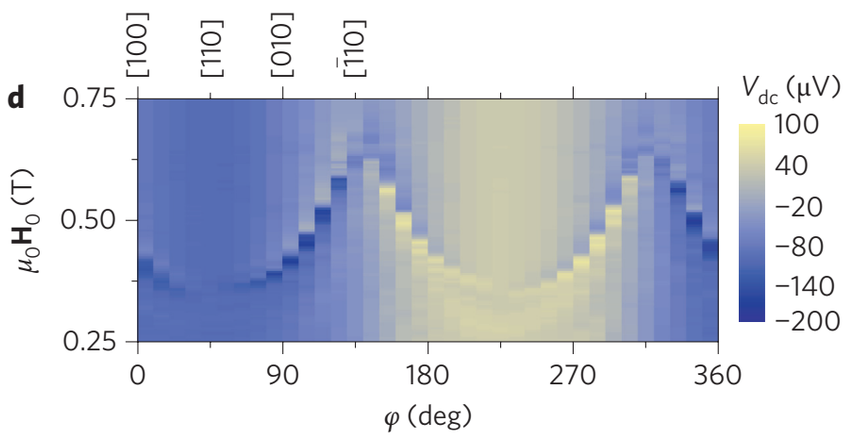


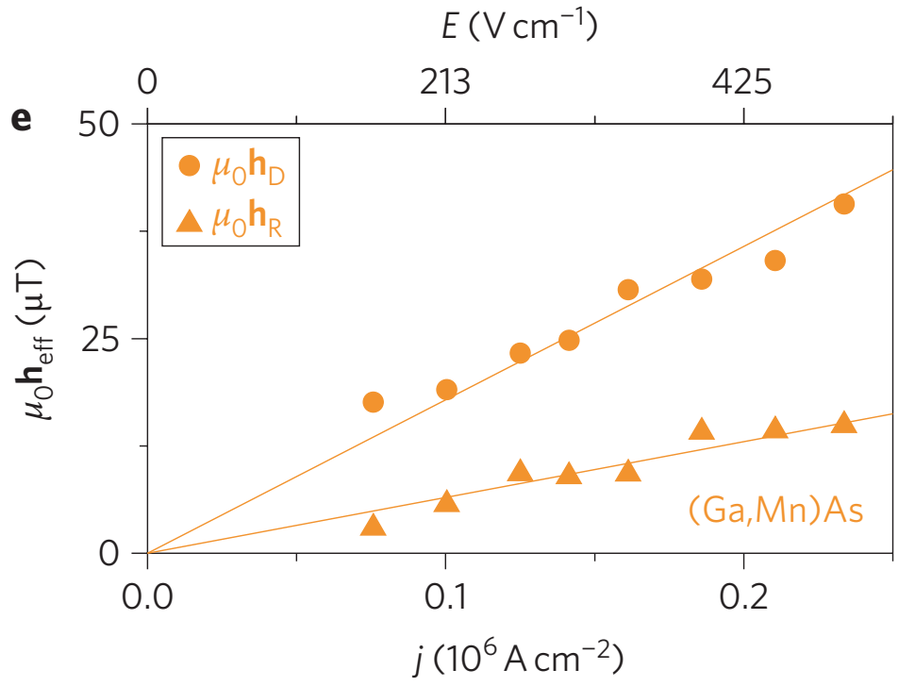
(Ga,Mn)As

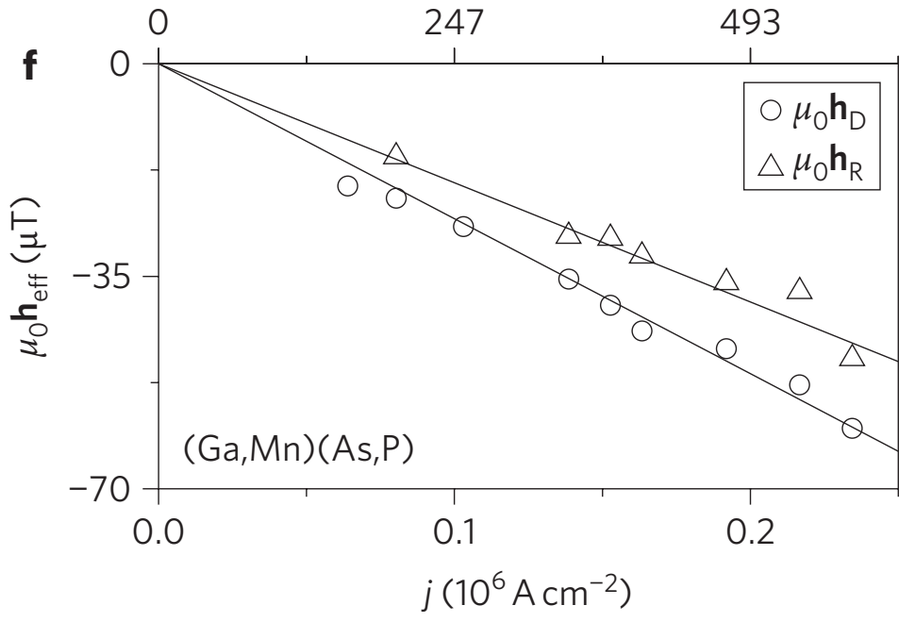
Spin orbit torque - AC



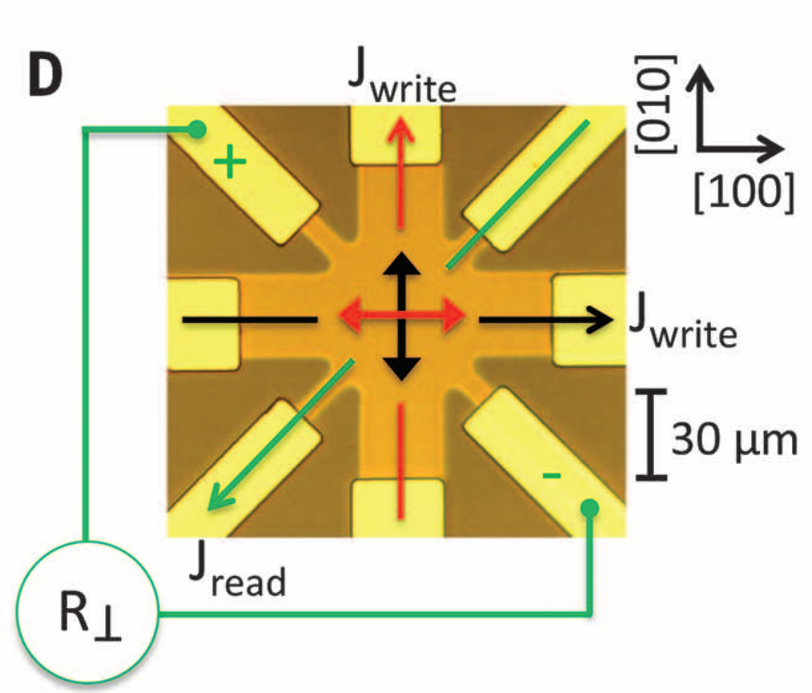


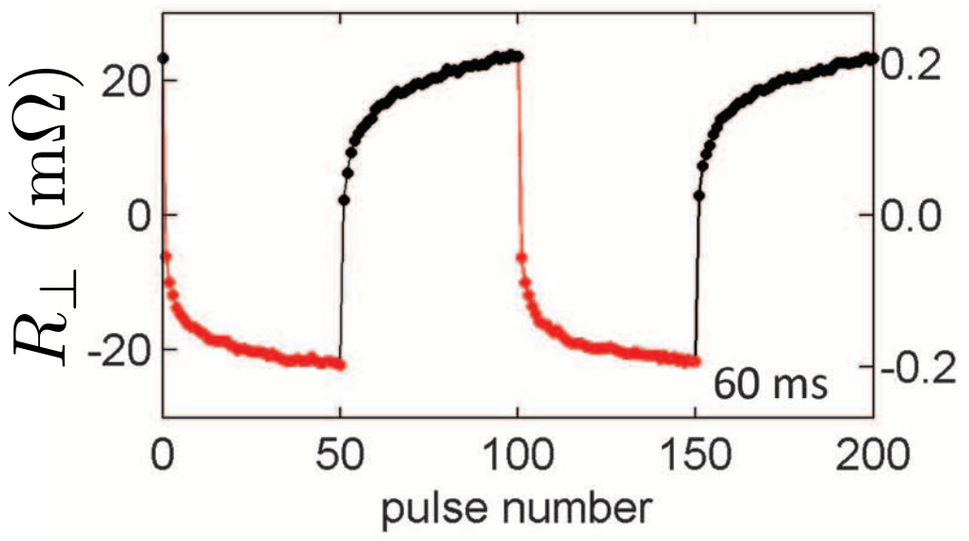


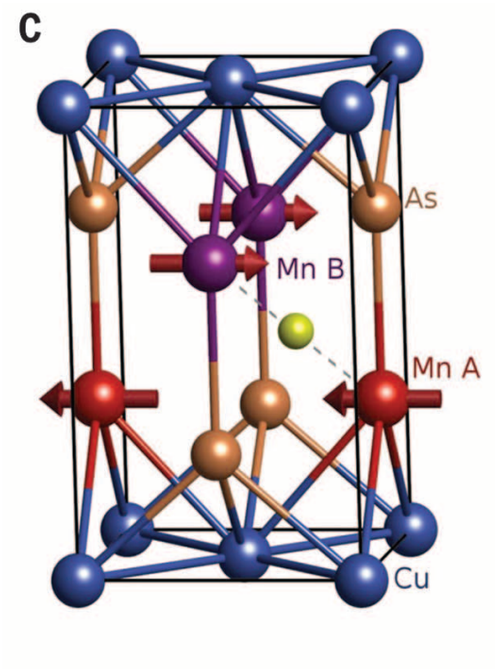


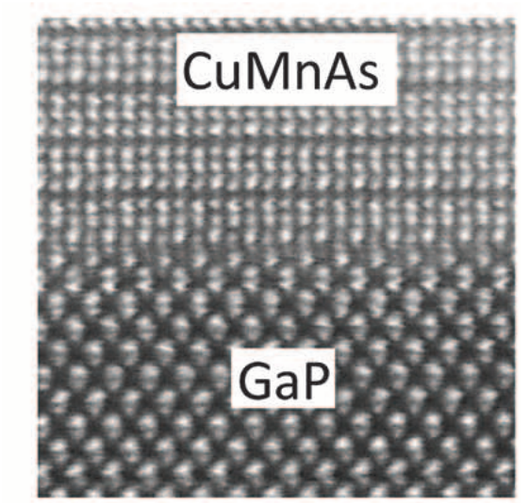


Spin orbit torque - again DC







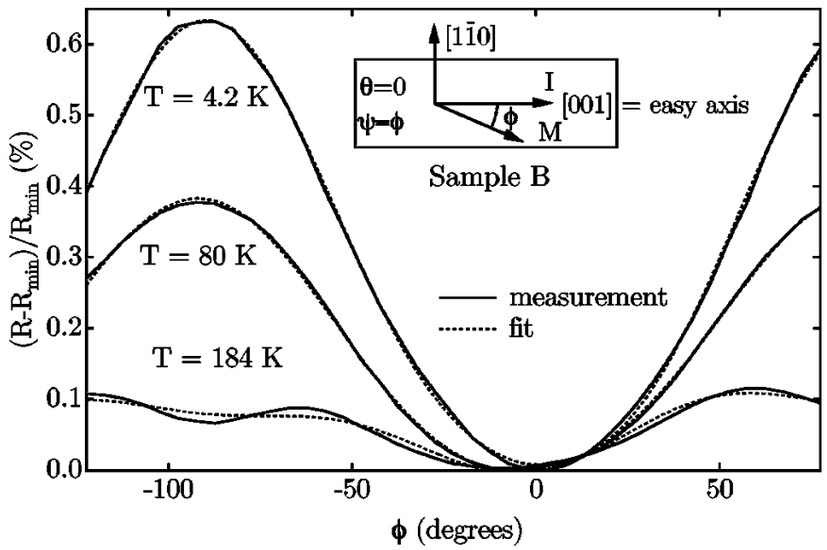


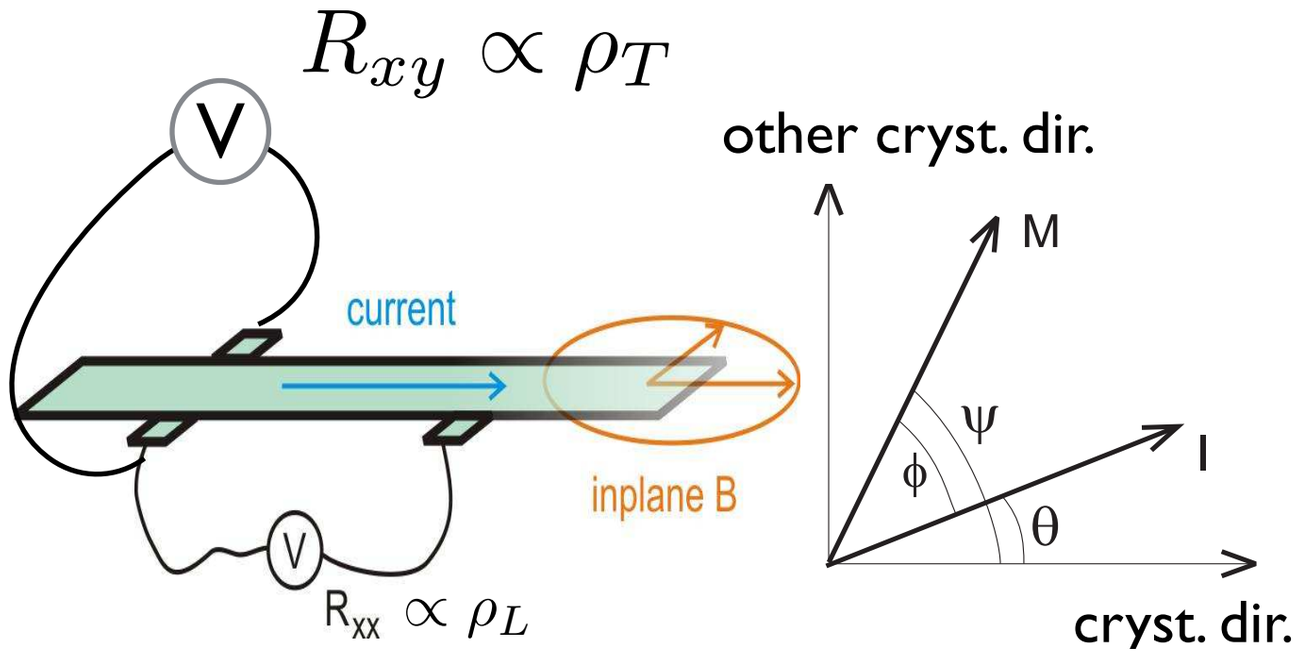
- spin-orbit torque corresponds to a staggered field
- (transverse) AMR used for read-out

switching an antiferromagnet!

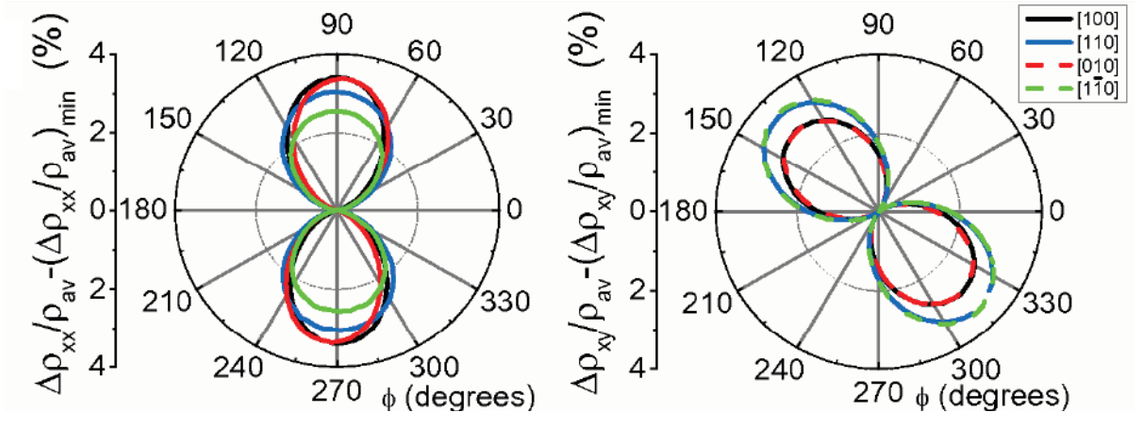
AMR (anisotropic magnetoresistance)

(expitaxial) Fe layer





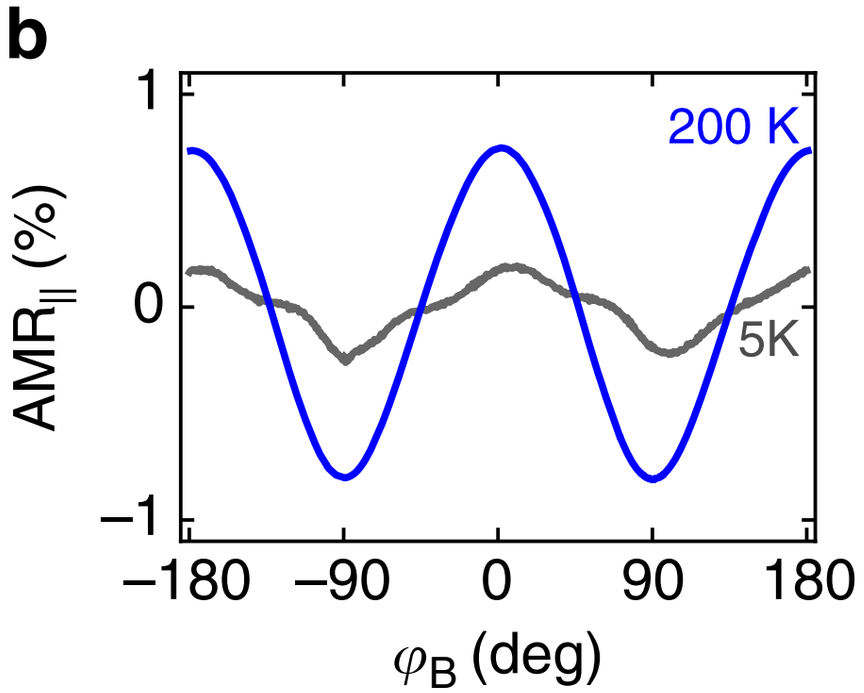
(expitaxial) layer of (Ga,Mn)As

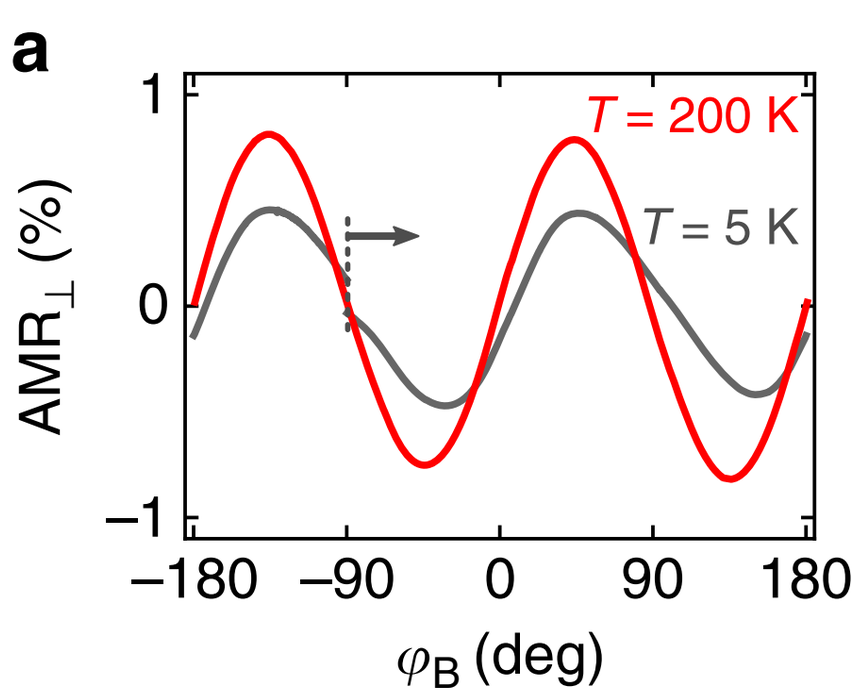


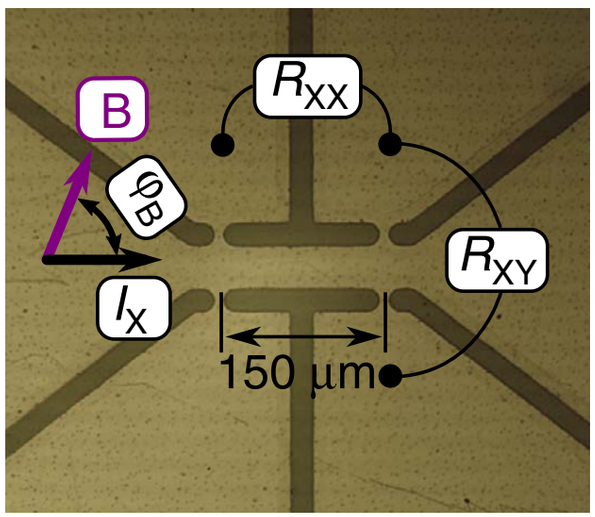
$$\Delta\rho_L/\rho_{av} = C_I \cos 2\phi + C_{I,C} \cos(2\phi + 4\theta) + C_C \cos(4\phi + 4\theta) + C_U \cos(2\phi + 2\theta)$$

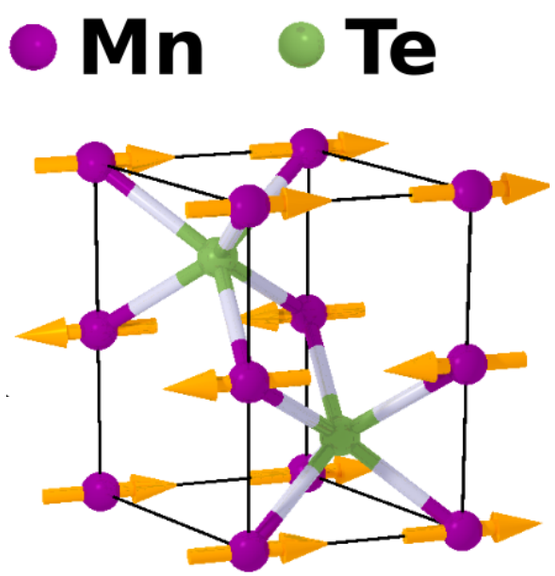
$$\Delta\rho_T/\rho_{av} = C_I \sin 2\phi - C_{I,C} \sin(2\phi + 4\theta)$$

Anisotropic magnetoresistance in an antiferromagnet

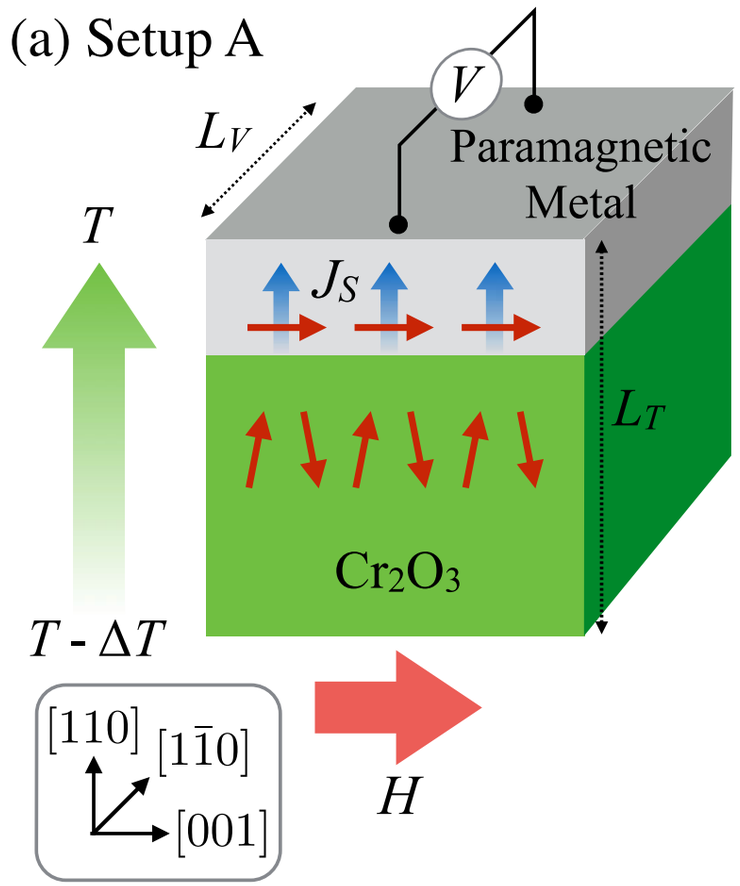


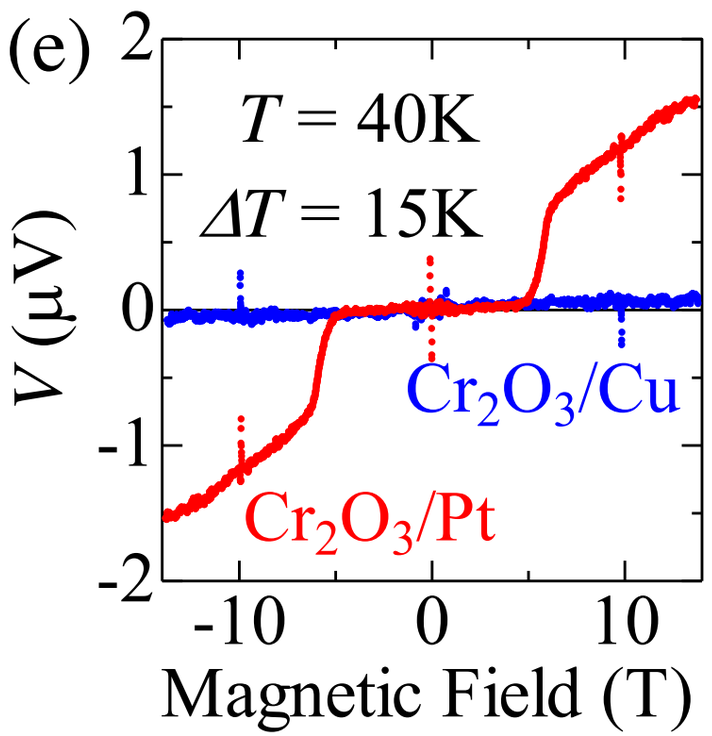


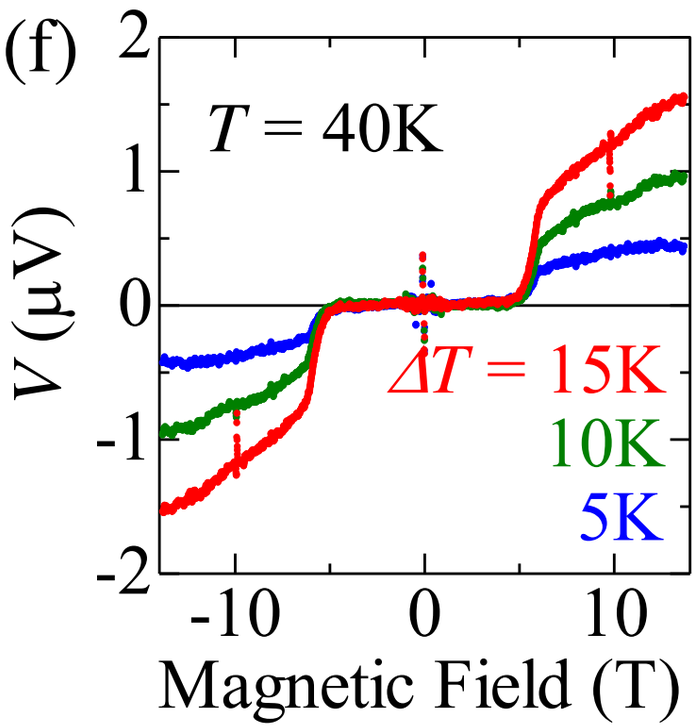




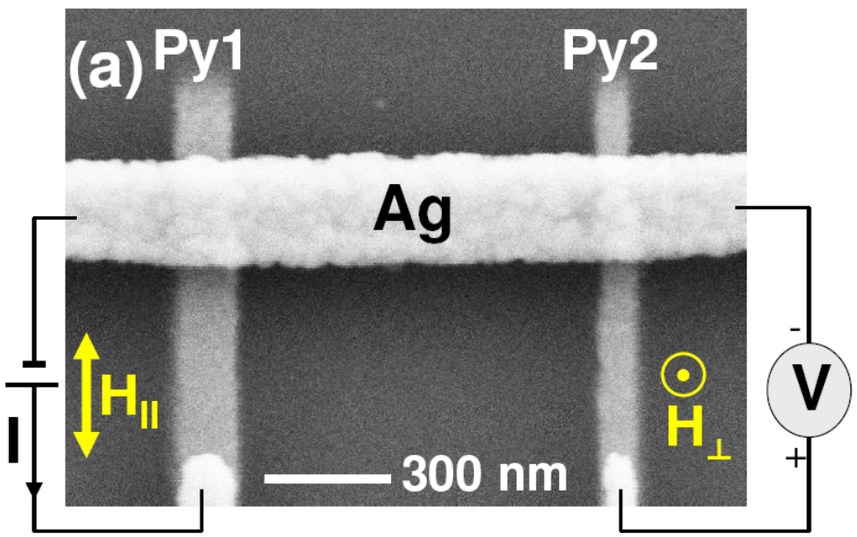
Spin caloritronics

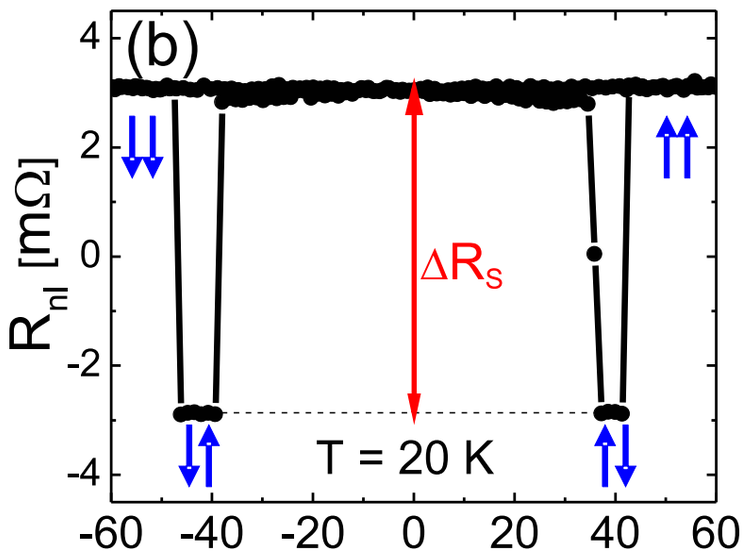






Spin precession in solid state devices: Hanle effect



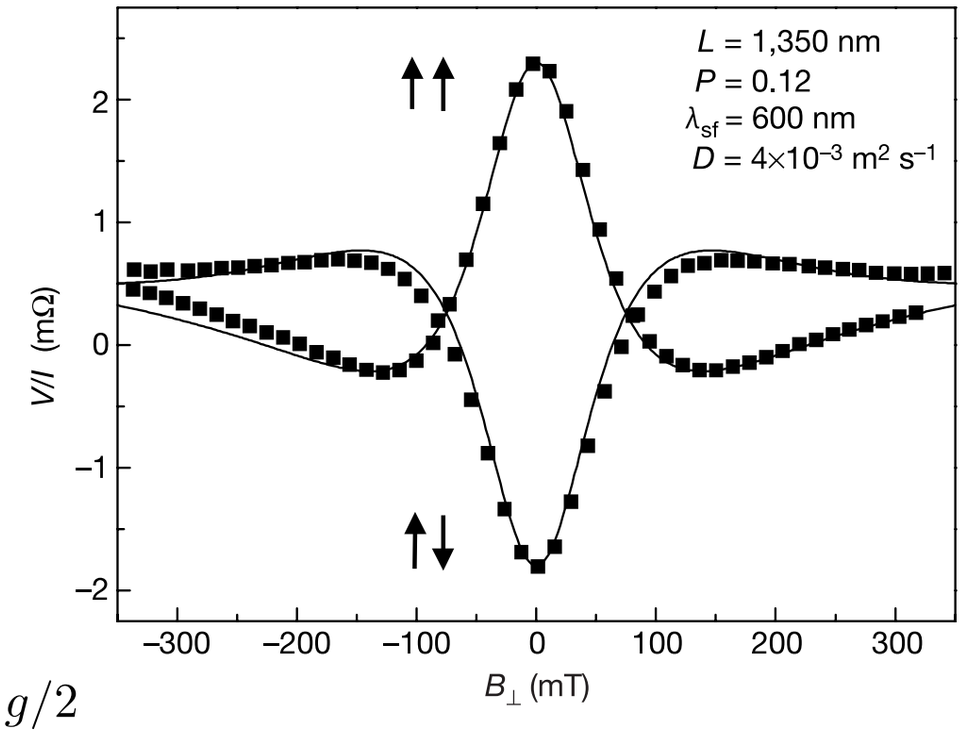


spin valves: Johnson-Silsbee concept

non-local transport

$$V(B_\perp) = \pm I \frac{P^2}{e^2 N_{\mathrm{Al}} A} \int_0^\infty P(t) \cos(\omega_{\mathrm{L}} t) \exp(-t/\tau_{\mathrm{sf}}) \mathrm{d}t$$

$$P(t) = \frac{1}{\sqrt{4\pi D t}} \exp[-L^2/4Dt] \qquad \Omega_L = g\mu_B B/\hbar = eB/m \cdot g/2$$



Spin transfer torque

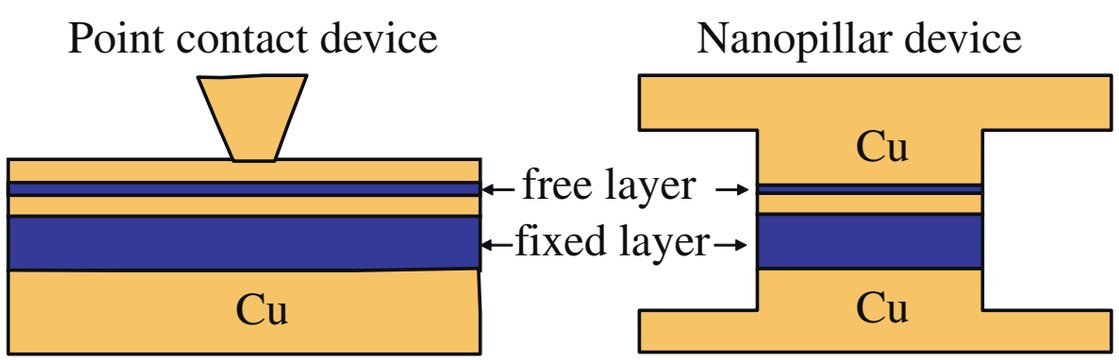


Fig. 6. Schematic experimental geometries.

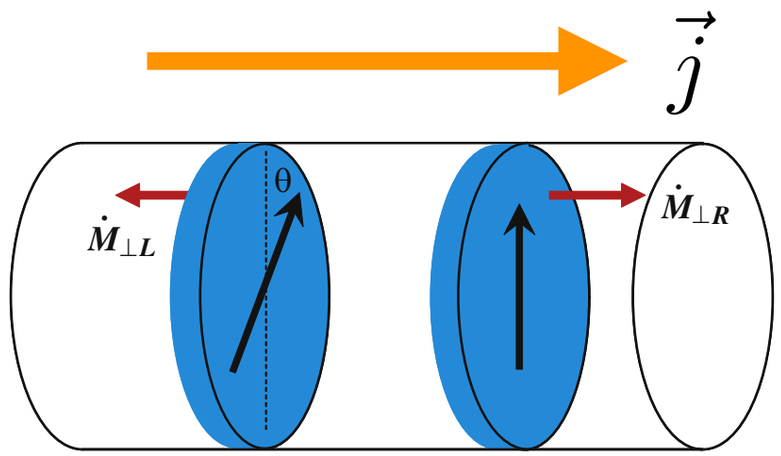


Fig. 11. Sample geometry for the perfectly symmetric N/F/N/F/N device assumed in our analysis of the perpendicular component of the spin-torque vector. The perpendicular spin torques on the two magnetic layers are equal and opposite.