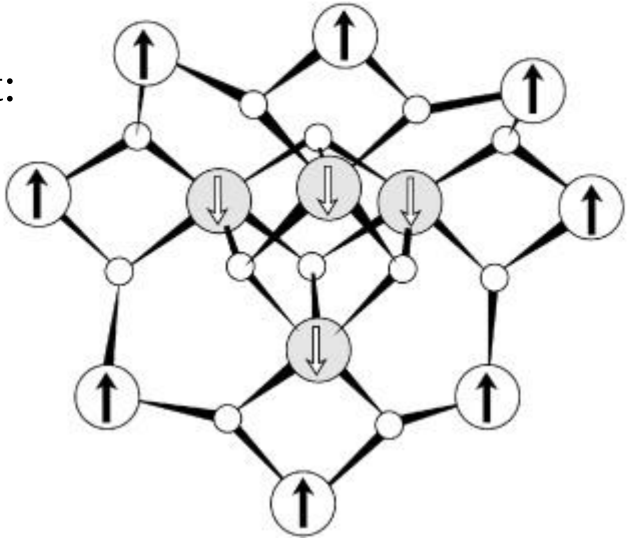
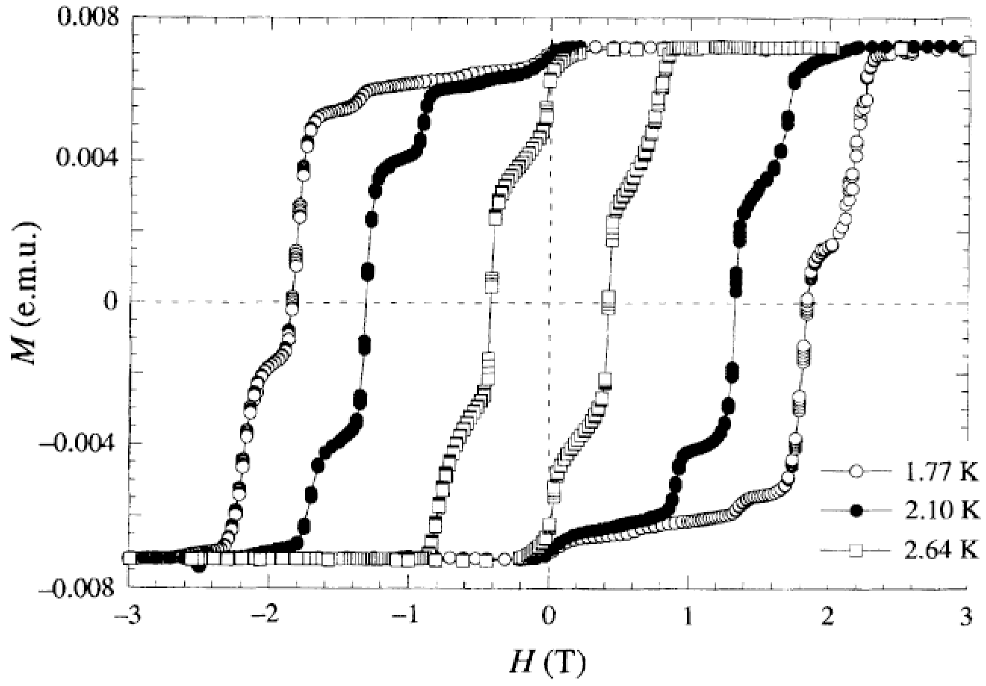
# Quantum tunneling of magnetization in $Mn_{12}$-acetate

Single molecule magnet:
$Mn_{12}$-acetate



We measure the magnetization curve of a $Mn_{12}$-acetate.
The molecule consists of 12 Mn atoms, 8 Mn atoms having spin up and 4 Mn atoms having spin down. Each Mn atom has a spin S = 5/2 and orbital moment L = 0.
For simplicity we assume a uni-axial crystal field and then an energy level scheme described by $E = -D J_z^2$ at H = 0 T.
Calculate the expected difference in magnetic field between two subsequent drops of the magnetization.

$D = 0.052$ meV; $\mu_B = 0.06$ meV/T




Adapted from: L. Thomas *et al.* Nature **383**, 145 (1996); J. R. Friedman *et al.* Phys. Rev. Lett. **76**, 3830 (1996)

# Solution: quantum tunneling of magnetization in $Mn_{12}$-acetate

The magnetization drop is due to QTM induced by spin-phonon scattering between states with opposite $J_z$ values.
In field the energy scheme is described by $E = -D J_z^2 - g\mu_B J_z H$.
At low T, after saturation at high field only the ground state is occupied. Then, reversing the field, a drop in M(H) is observed when the ground state $J_z = S$ is degenerate with a state with opposite $J_z = -S+n$ i.e.

$$-DS^2 - g\mu_B S H = -D(-S+n)^2 - g\mu_B (-S+n) H$$

$$-DS^2 - g\mu_B S H = -DS^2 - Dn^2 + 2nDS - g\mu_B (-S+n) H$$

$$Dn(2S + n) = g\mu_B (2S+n) H$$

$$H = -Dn/g\mu_B$$

$$\Delta H = -D(n-1)/g\mu_B - (-Dn/g\mu_B) = D/g\mu_B$$

Because L = 0, g = 2 and then $\Delta H = 0.43$ T