H_2:H versus Si:P. Similarities and Differences

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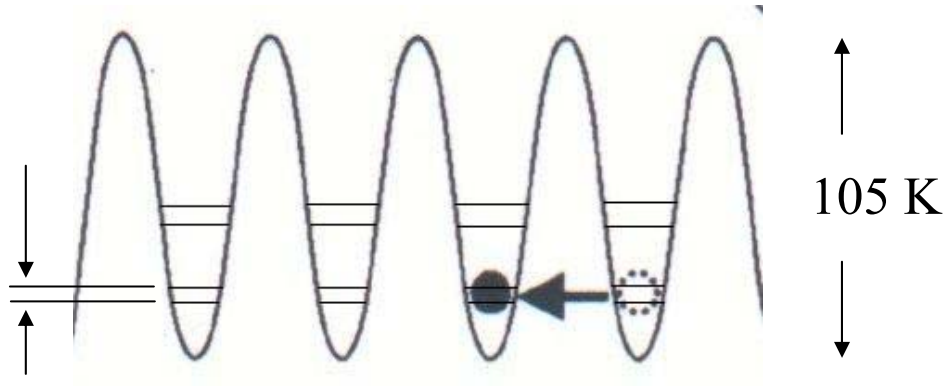
Atomic hydrogen inside solid H_2 films

Andreev and Lifshitz 1969
Sov. Phys. JETP 29, 1107

Delocalized Impuritons

$$\Delta \cdot \tau_{hop} \approx \hbar$$

$$\Delta = 10^{-3} - 10^{-1}\,\mathrm{K}$$



High energy storage

$n_{max} \approx 4\times10^{19}$ cm^{-3} at T<0.1 K

Quantum diffusion,
Bose-Einstein Condensation
Superfluid properties of solid

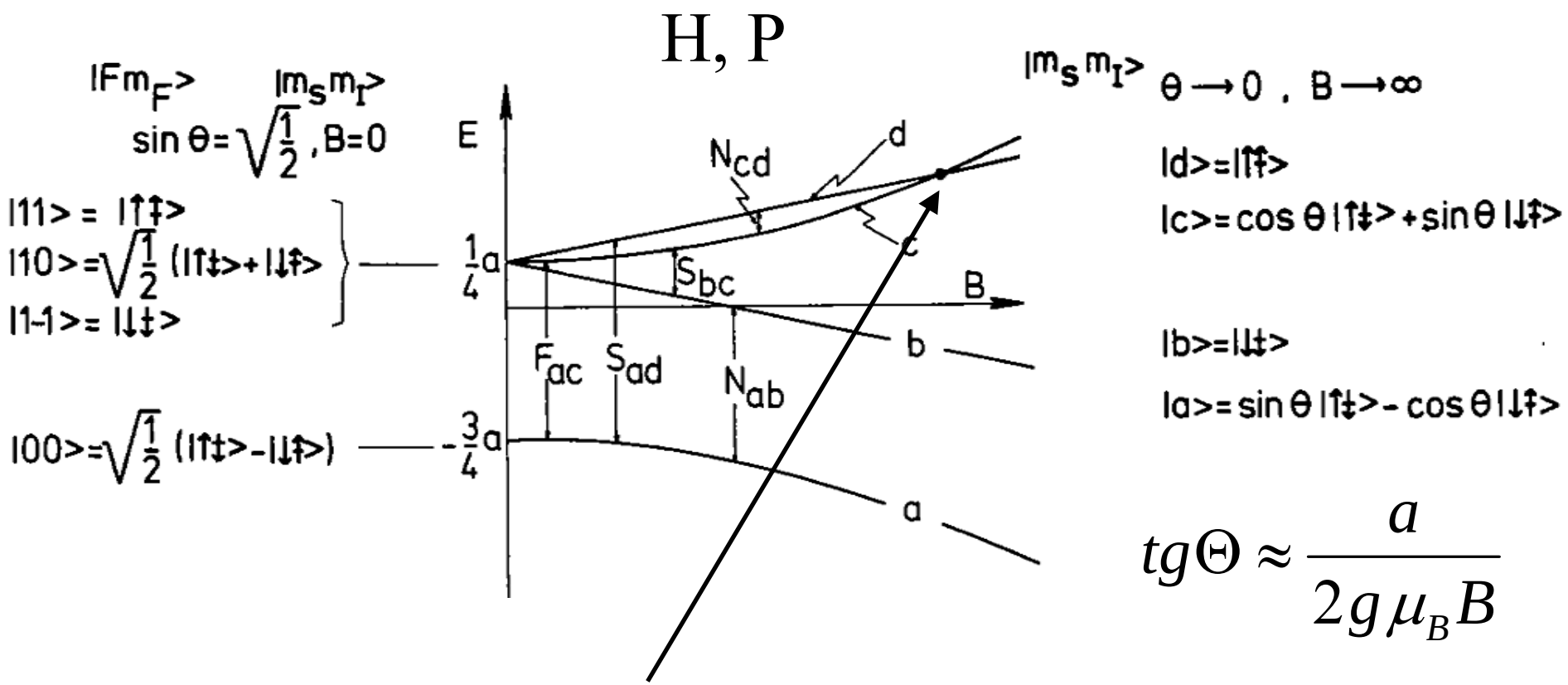
SUPERSOLID

METALLIC HYDROGEN

Quantum computing?

J. Ahokas, J. Järvinen, V.V. Khmelenko, D.M. Lee, and S. Vasiliev:
Exotic Behavior of Hydrogen Atoms in Solid H_2 at Temperatures below 1 K.
Phys. Rev. Lett. **97**, 095301 (2006)

Hyperfine level diagram for H-like atoms with isotropic hyperfine interaction

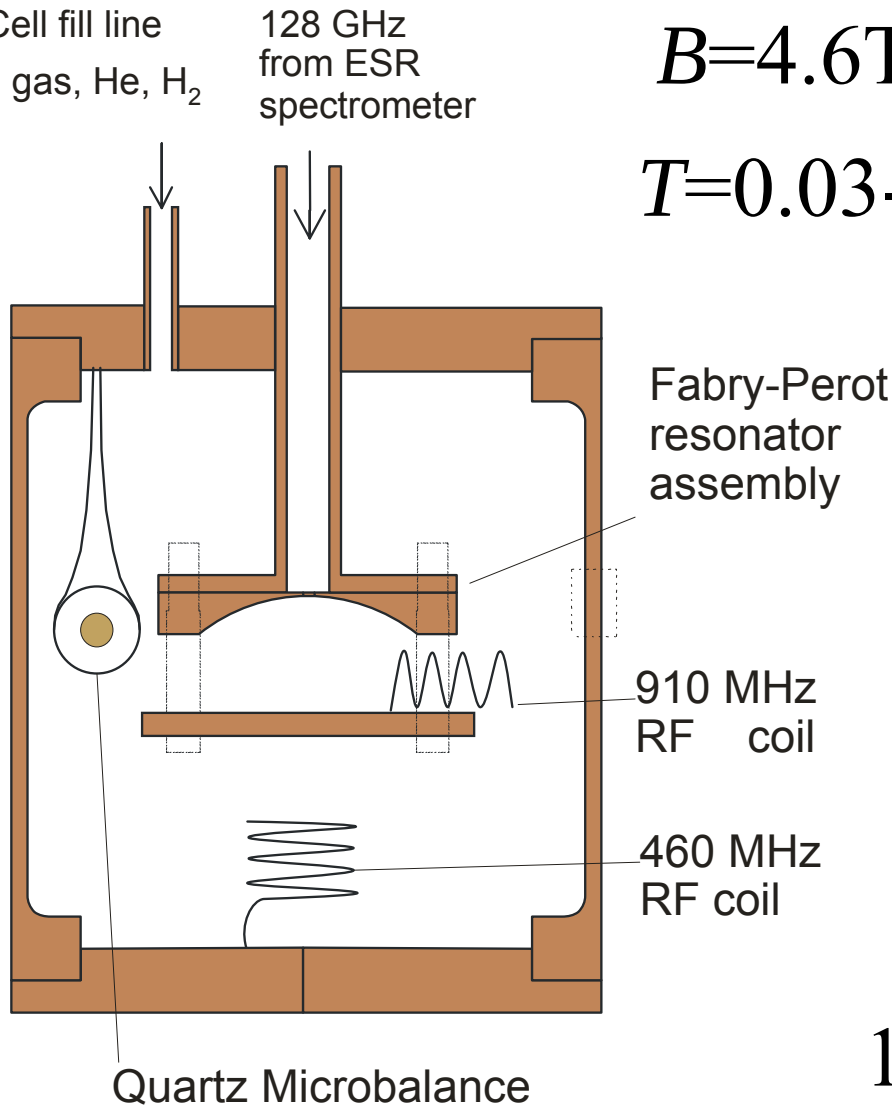


$$tg\Theta \approx \frac{a}{2g\mu_B B}$$

Level crossing for H is at 16.7 T, $\Theta^2 \sim 2.5\times10^{-5}$

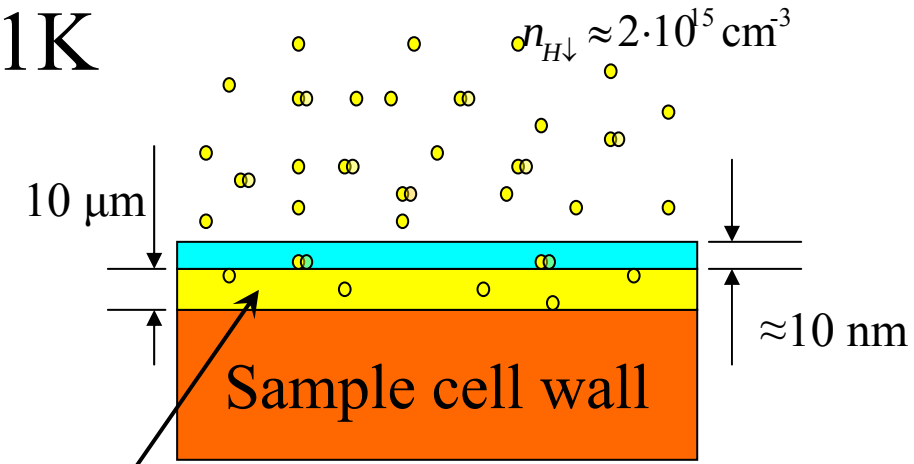
for Si:P-at 3.34 T, $\Theta^2 \sim 1.6\times10^{-7}$

Experimental setup



B=4.6T

T=0.03-1K



Solid H_2 film
doped with H atoms
$n_H = 10^{16} - 4 \cdot 10^{19}$ cm^{-3}

128 GHz ESR, ENDOR

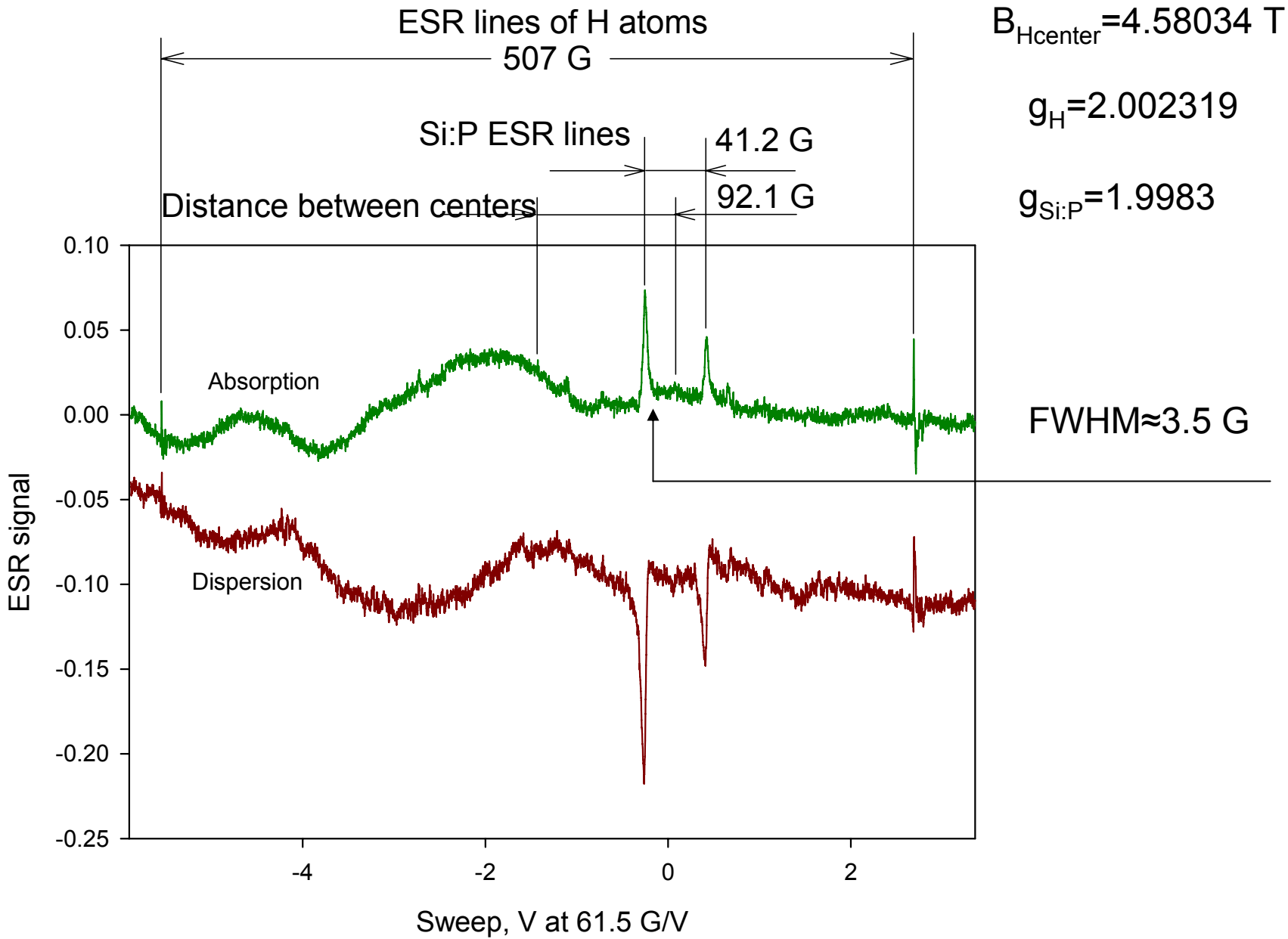
ESR spectrum of H and Si:P at 0.15 K

f_{ESR}=128.50999 GHz

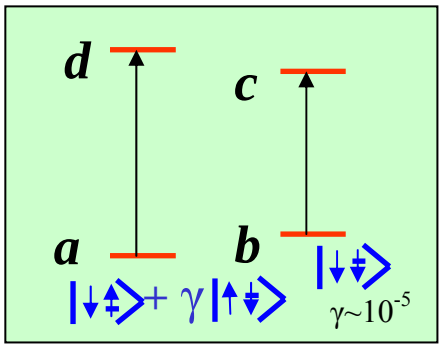
$B_{Hcenter}$=4.58034 T

g_H=2.002319

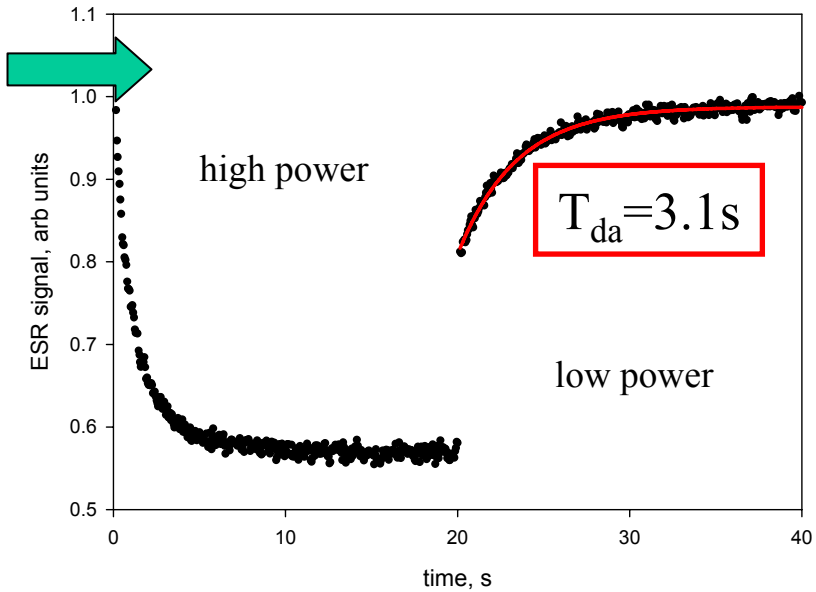
$g_{Si:P}$=1.9983



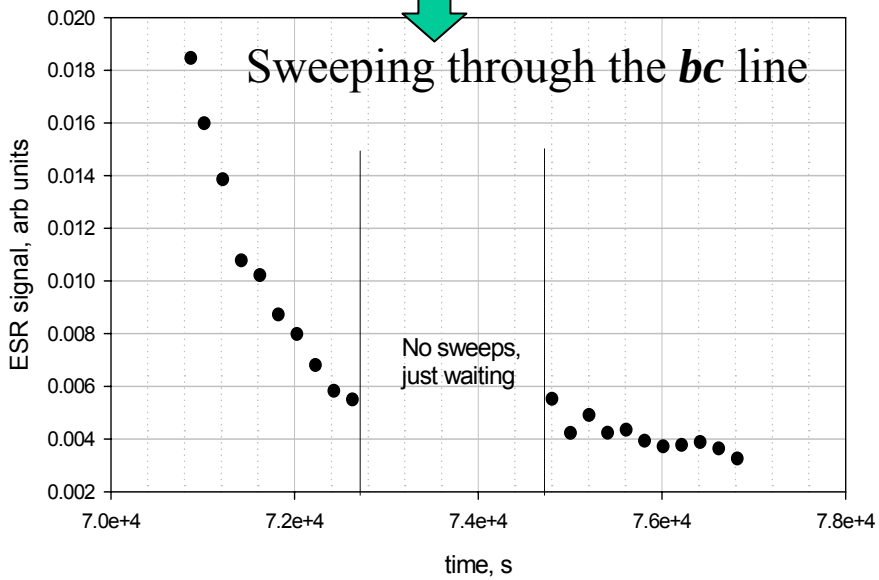
T_1 Relaxation of ESR transitions

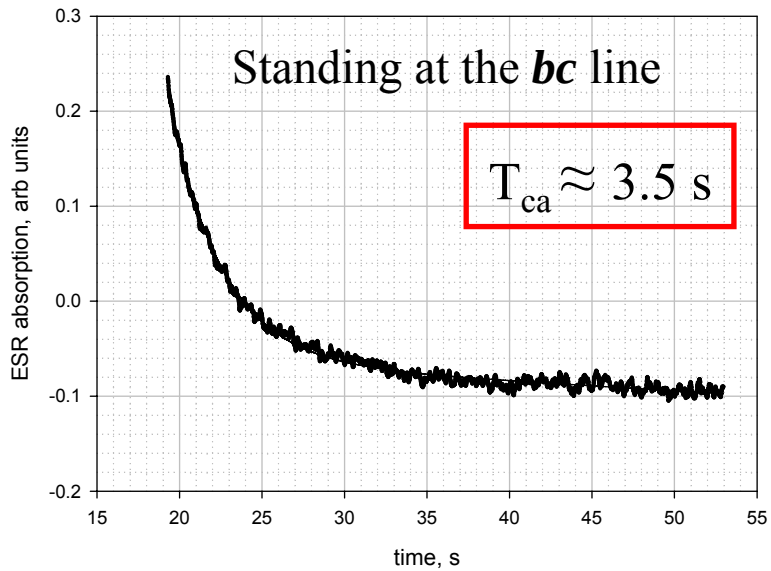


a-d transition,
T=150 mK



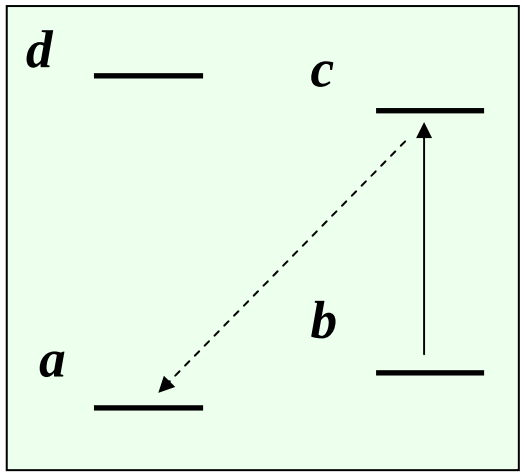
b-c transition, T=150 mK





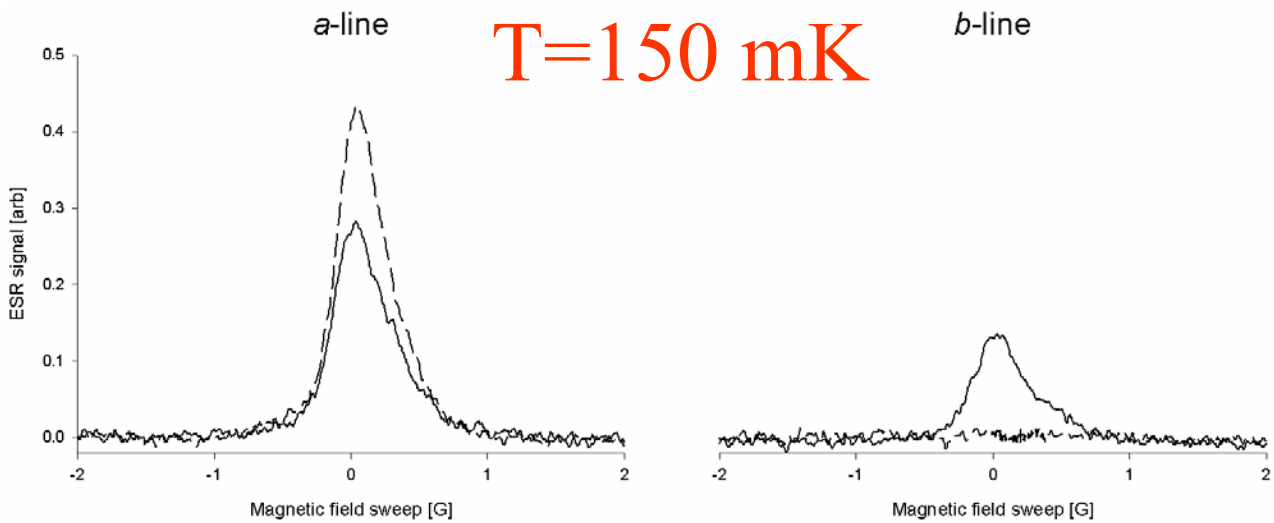
Dynamic nuclear polarization

Overhauser effect



H_2:H

T=150 mK

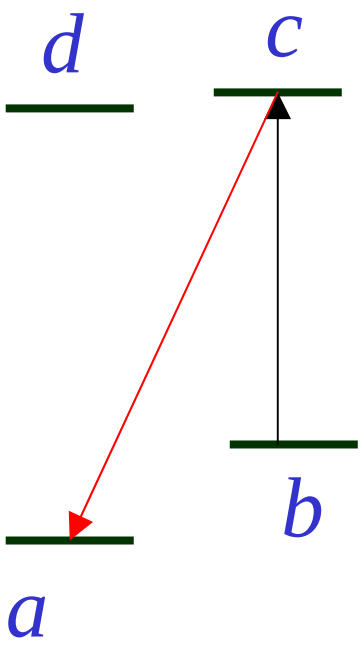


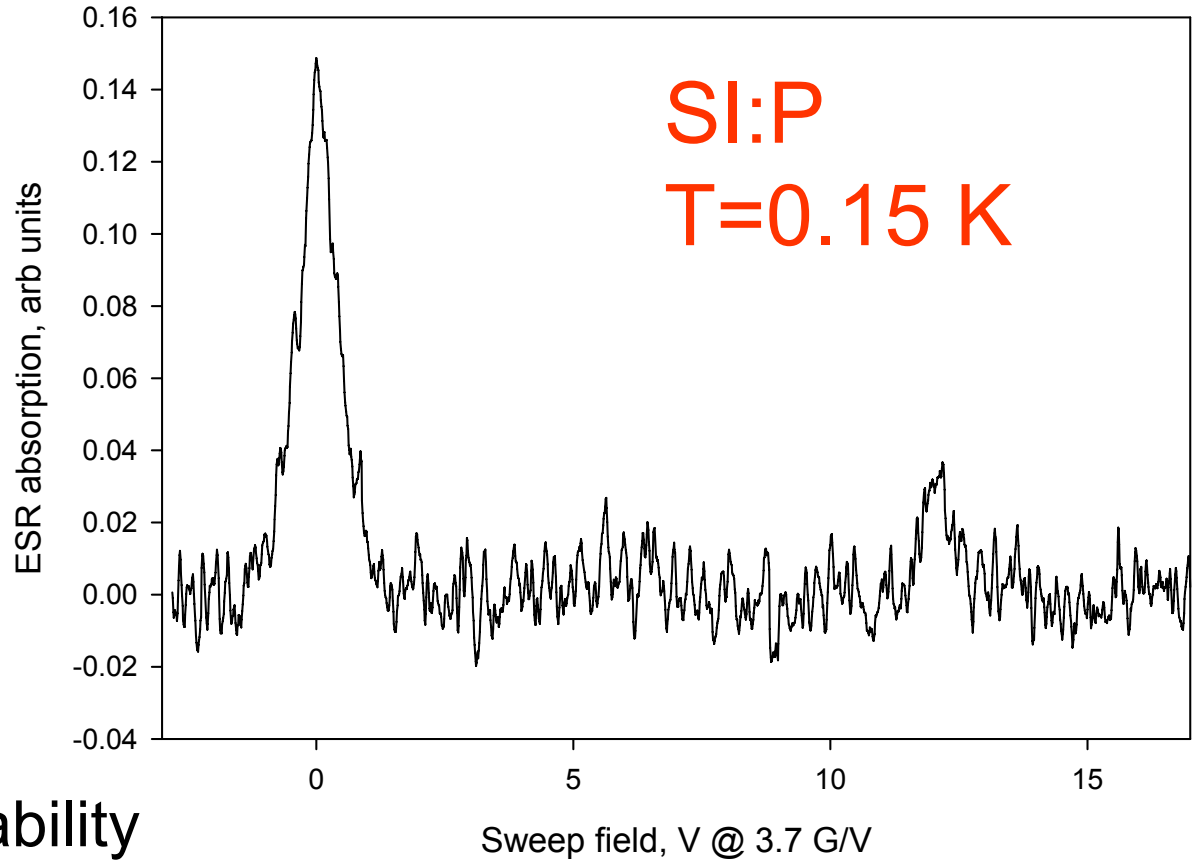
$$W_{a\leftrightarrow c} = \left(\frac{a}{2g\mu_B B}\right)^2 W_{b\leftrightarrow c} \approx 2.5\cdot 10^{-5} W_{b\leftrightarrow c}$$

in 4.6 T field

Anomalously fast cross-relaxation

Dynamic nuclear polarization after 300 s pumping of *b*-*c* transition



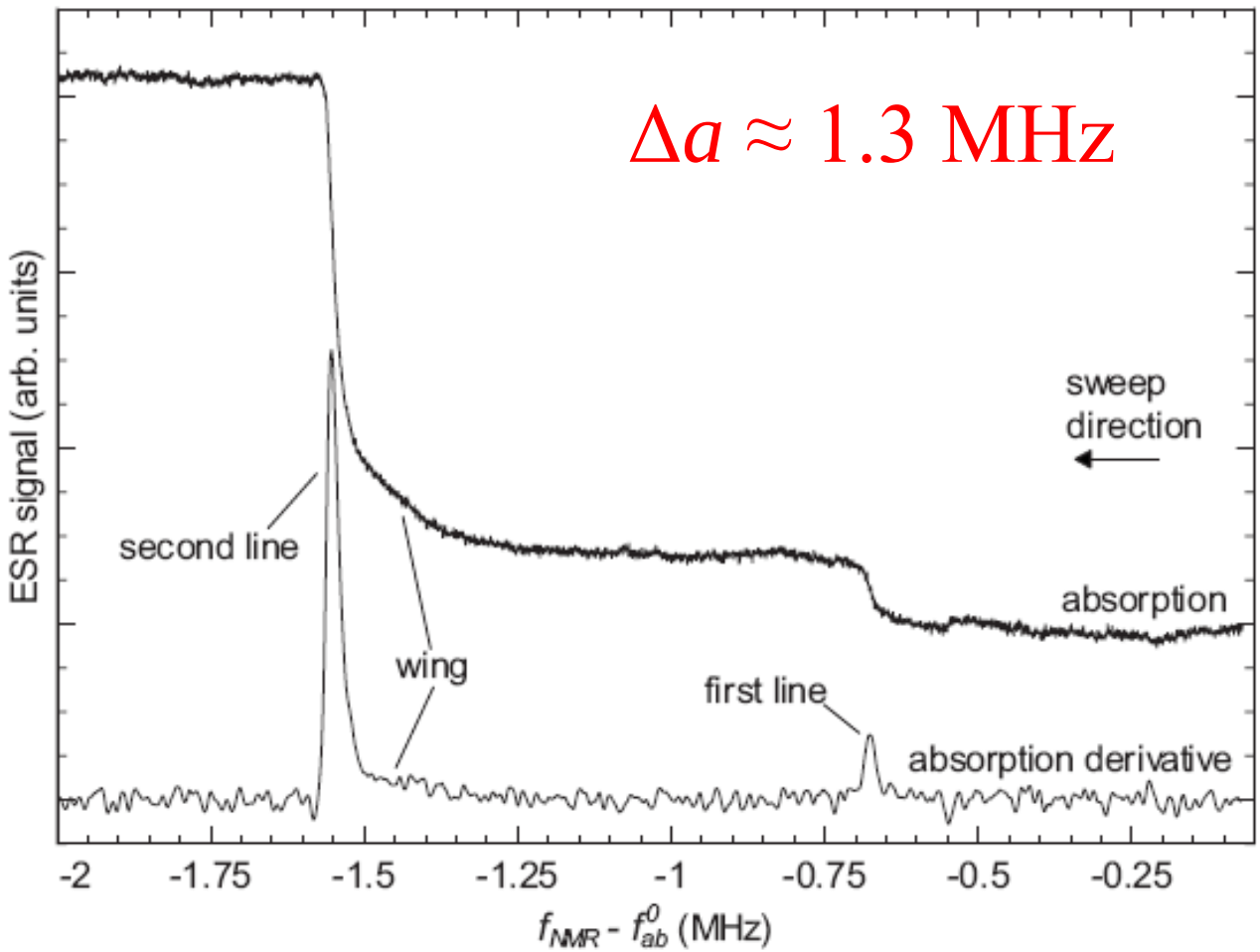


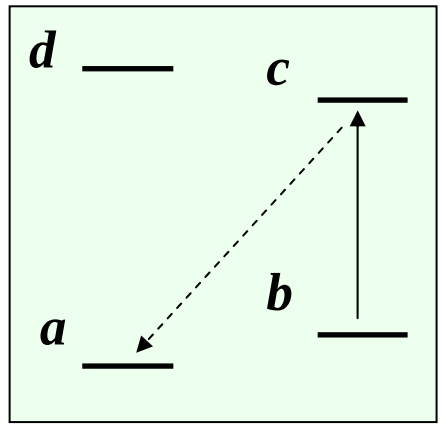
a-*c* transition probability

$$W_{ac} = \left(\frac{a}{2g\mu_B B}\right)^2 W_{bc} \approx \left(\frac{41}{2\cdot 4.58\cdot 10^4}\right)^2 W_{bc} \approx 1.6\cdot 10^{-7} W_{bc}$$

if T_{1e}=1 s, then $T_{\text{a-c pumping}}$~10^7 s

Observed ENDOR spectra

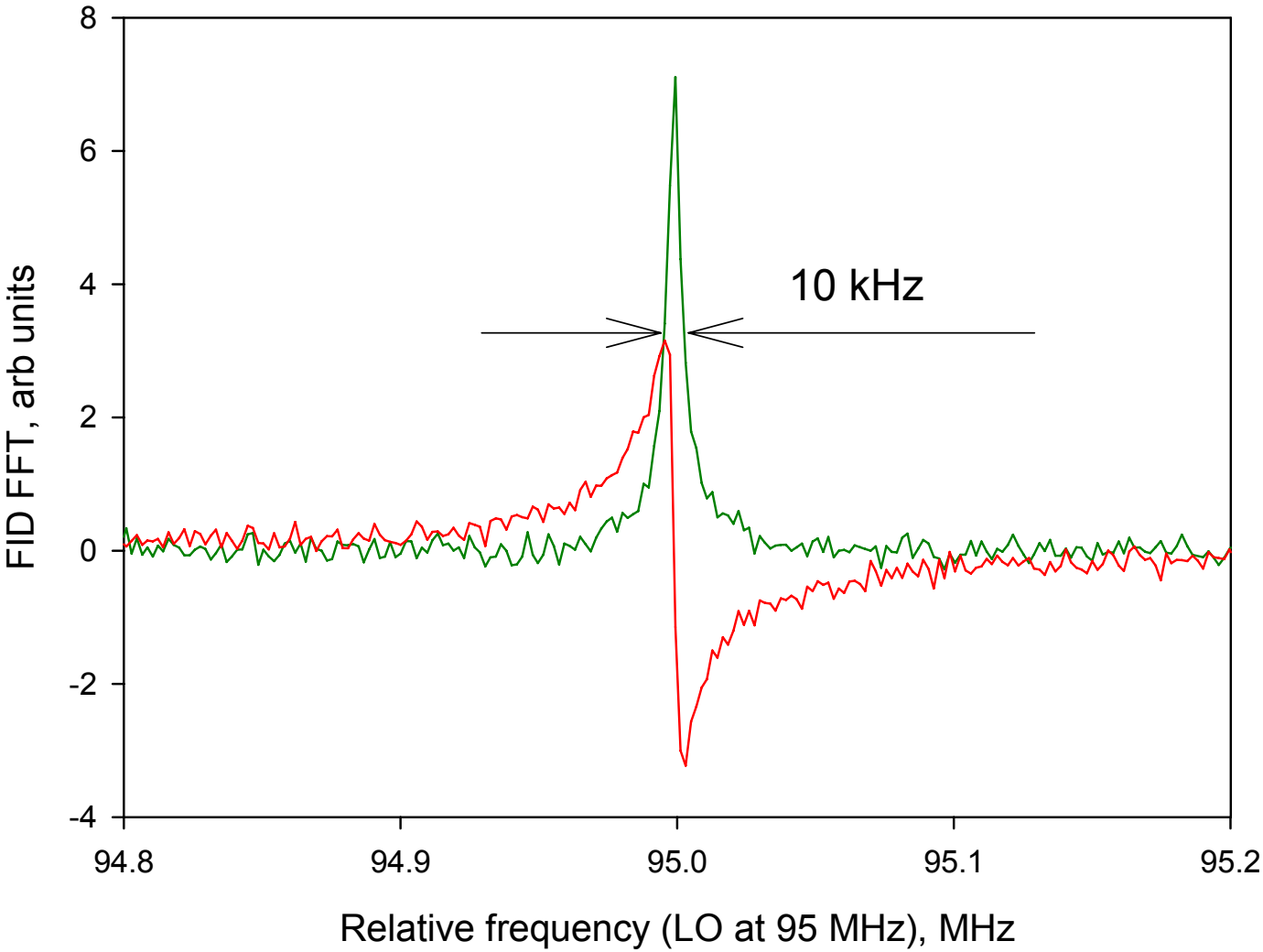


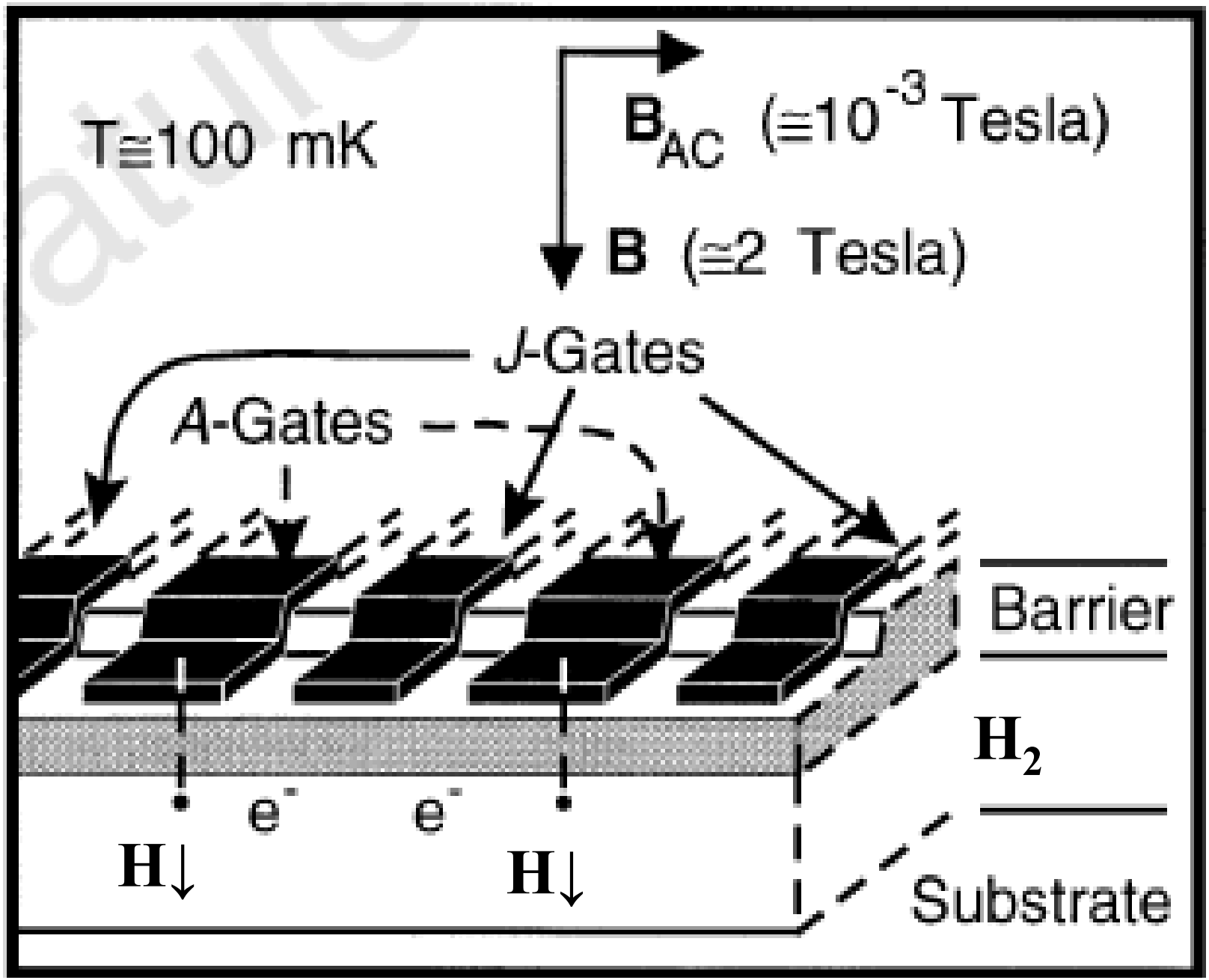


- Two narrow transitions shifted to the red from free atom resonance
- Homogeneous crystalline field

Pulsed ESR spectrum

Small tipping angle limit, Pulse width of 100 μs




T≅100 mK
B_{AC} (≅10^{-3} Tesla)
B (≅2 Tesla)
J-Gates
A-Gates
Barrier
H_2
e⁻
e⁻
H↓
H↓
Substrate