Measurements of Leggett frequency of ^{3}He-B in aerogel

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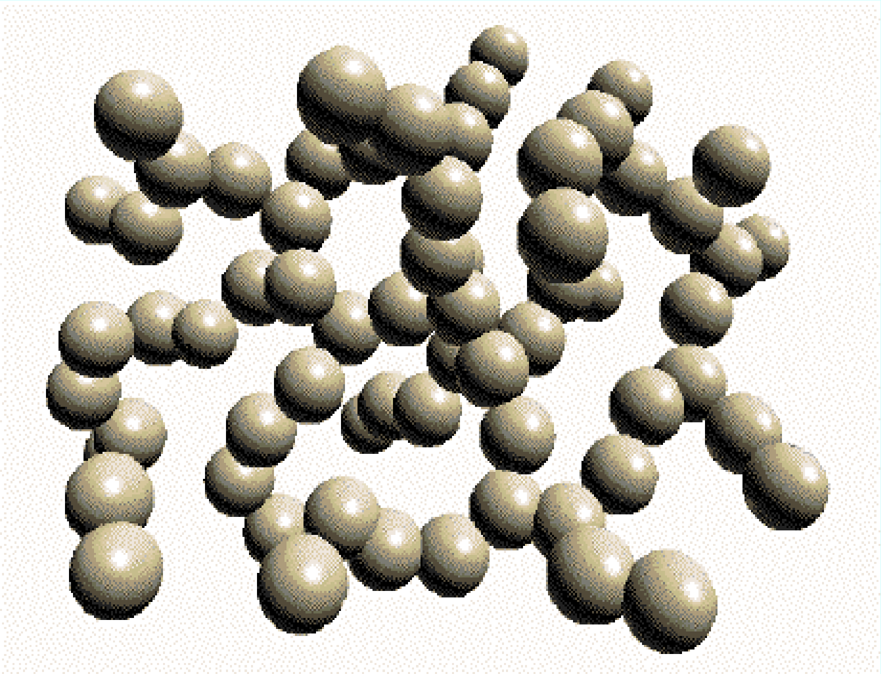
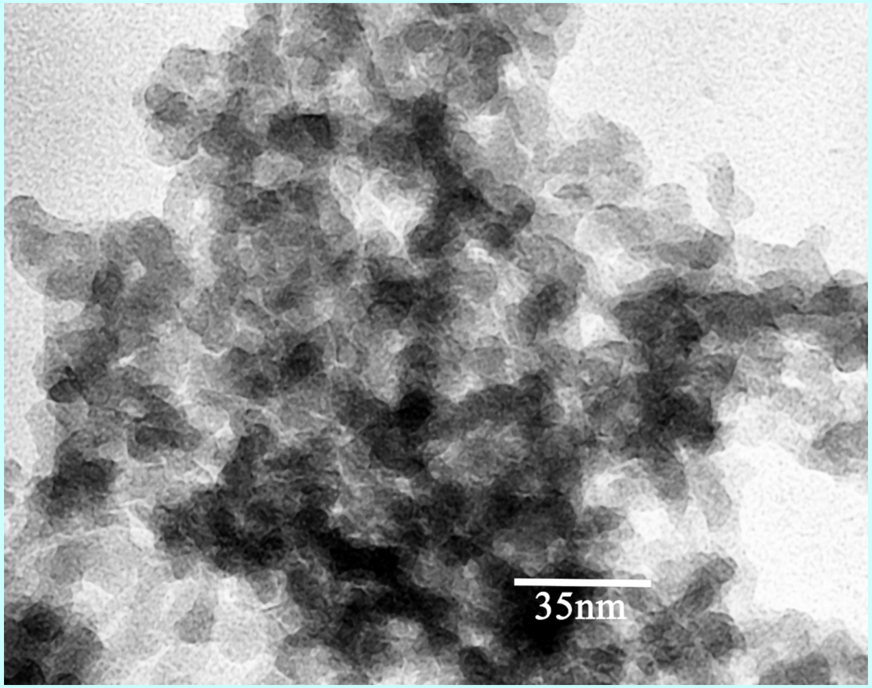
Aerogel structure



www.kp.dlr.de



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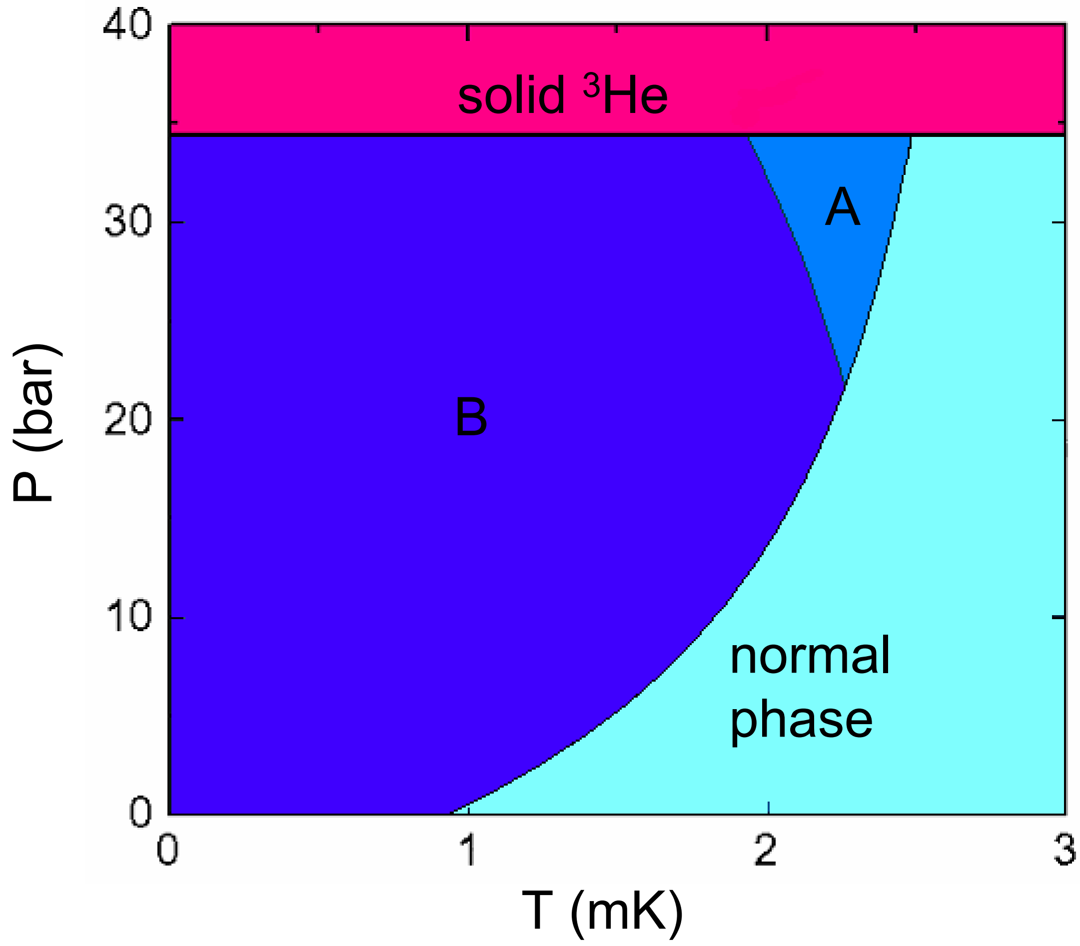
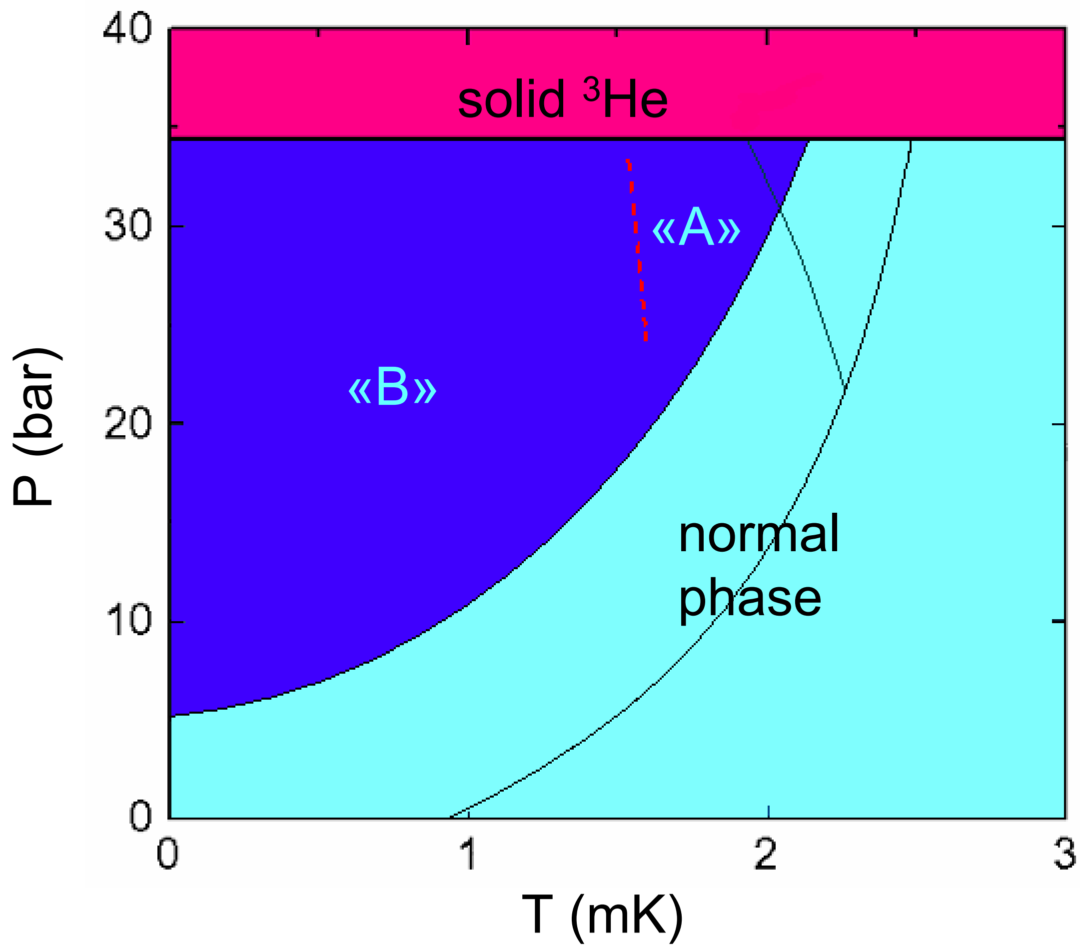
98% aerogel:

- diameter of strands ~3 nm
- distance between strands ~50-100 nm



40
30
20
10
0
0
1
2
3
P (bar)
T (mK)
solid ³He
A
B
normal
phase



solid ^{3}He
«A»
«B»
normal
phase
P (bar)
T (mK)
0
10
20
30
40
0
1
2
3

Pure ^{3}He + aerogel:
2 solid monolayers of ^{3}He on strands surface.

$$\chi = \frac{c}{T-\theta} \quad (\theta \approx 0.5\ \text{mK}) \qquad \omega = \frac{\omega_\ell M_\ell + \omega_s M_s}{M_\ell + M_s}$$

^{4}He replaces ^{3}He atoms at surface:

$$\omega = \omega_\ell$$

$\chi = \text{const}$ NMR signal is determined only by liquid ^{3}He

B.I.Barker, PhD thesis:

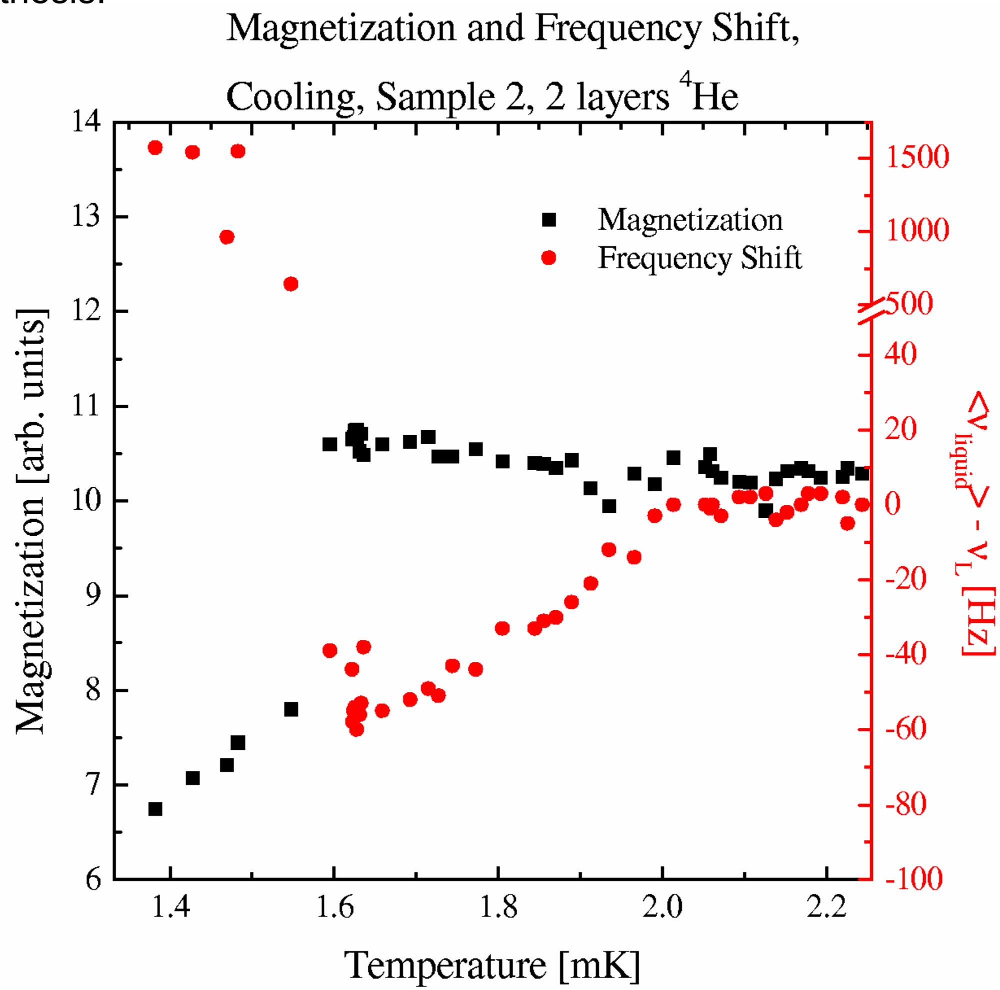
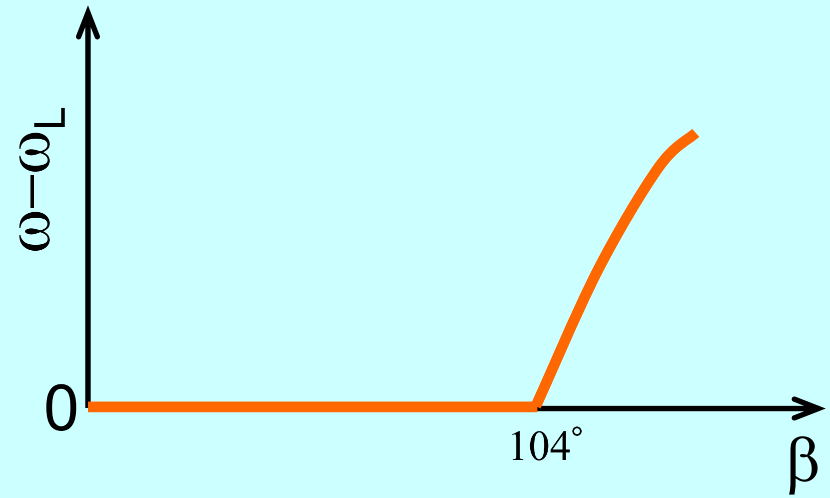


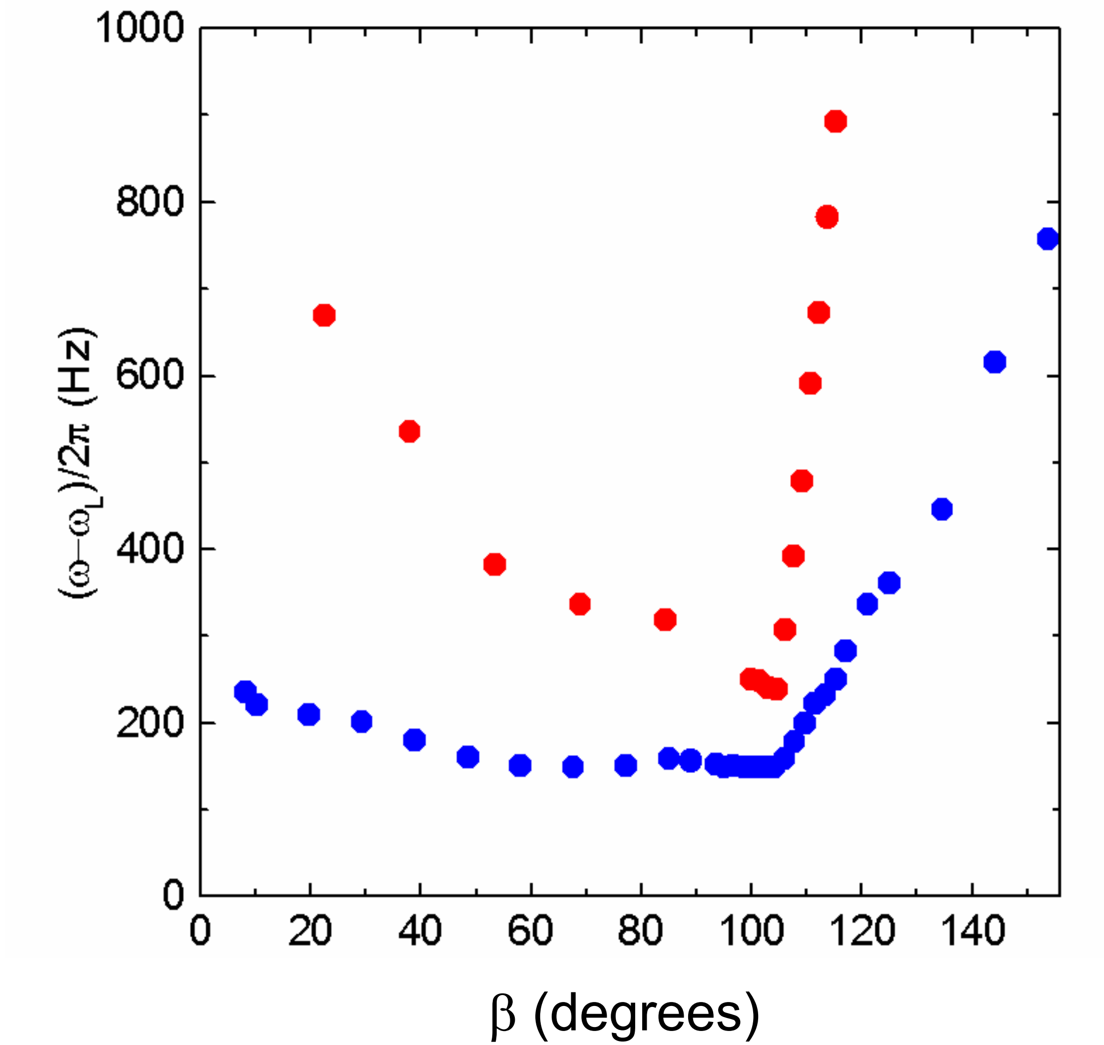
Figure 4.14: Magnetization and Frequency Shift for Sample 2 on Cooling. Note the negative frequency shift occurs before the decrease in magnetization. This supports our identification of an AB transition in aerogel. Notice the break in the right ordinate between 50 and 500 Hz and the change in scale on either side of the break.

"Usual bulk" superfluid ^{3}He-B

B-phase:

$$\omega = \begin{cases} \omega_L = \gamma H, & \beta < 104^\circ \\ \omega_L - \dfrac{4}{15}\dfrac{\Omega_B^2}{\omega_L}(1 + 4\cos\beta), & \beta > 104^\circ \end{cases}$$

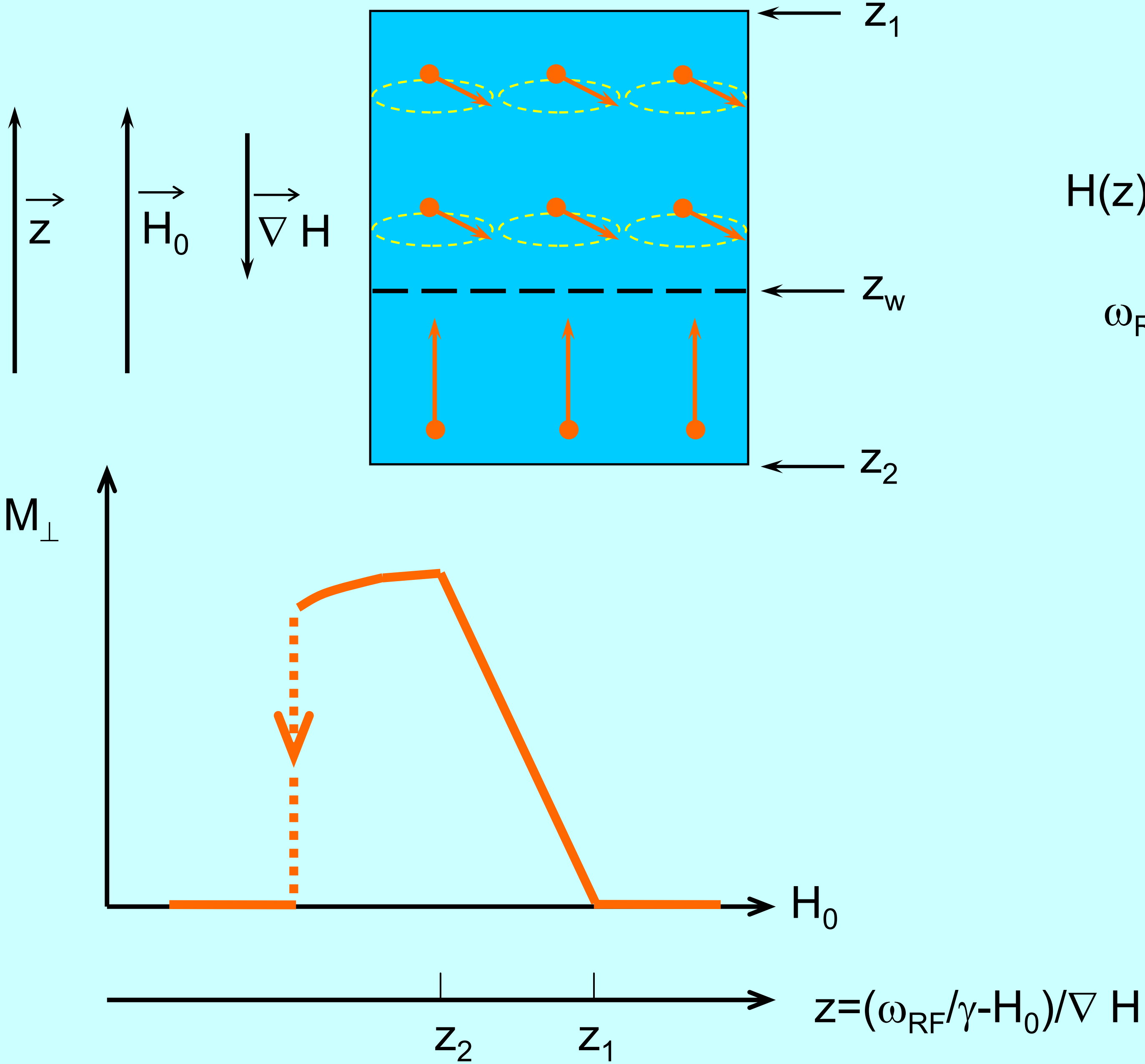




P=25.5 bar

-- H=285 Oe, T=0.78 T_{CA}

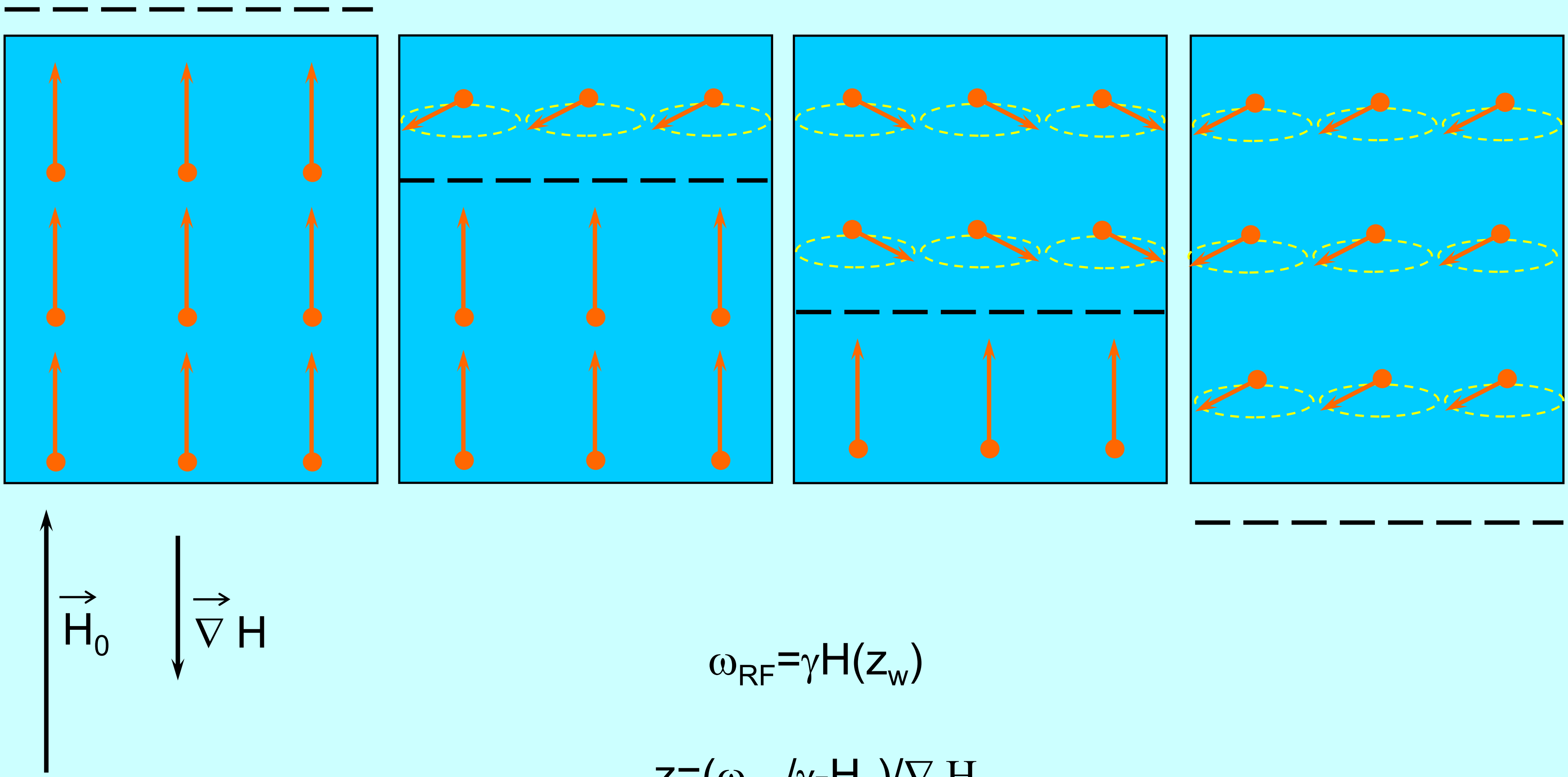
-- H=1010 Oe, T=0.83 T_{CA}



$$H(z)=H_0+\nabla\, H\cdot z$$

$$\omega_{RF}=\gamma H(z_w)$$

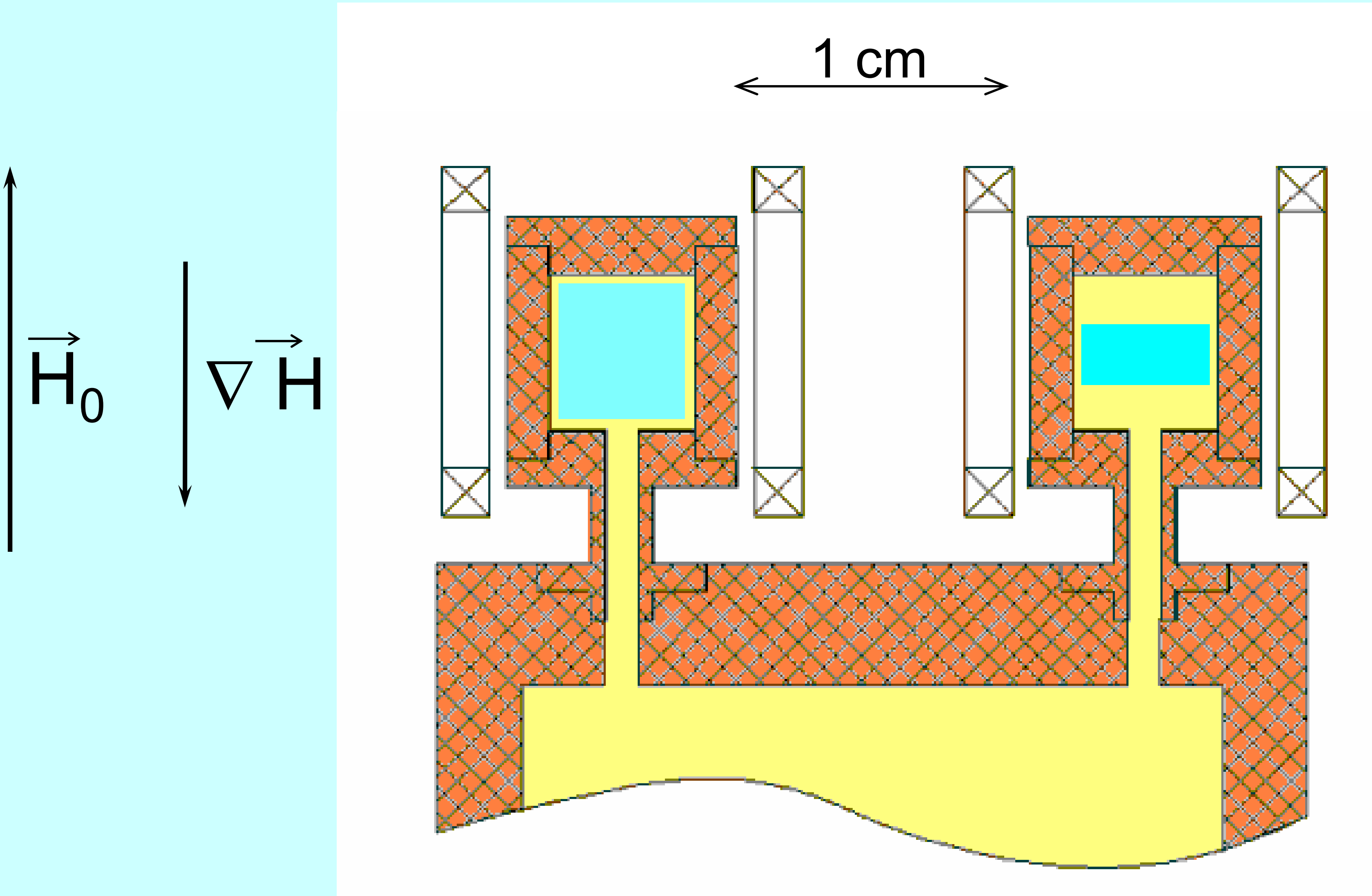
HPD formation in CW NMR

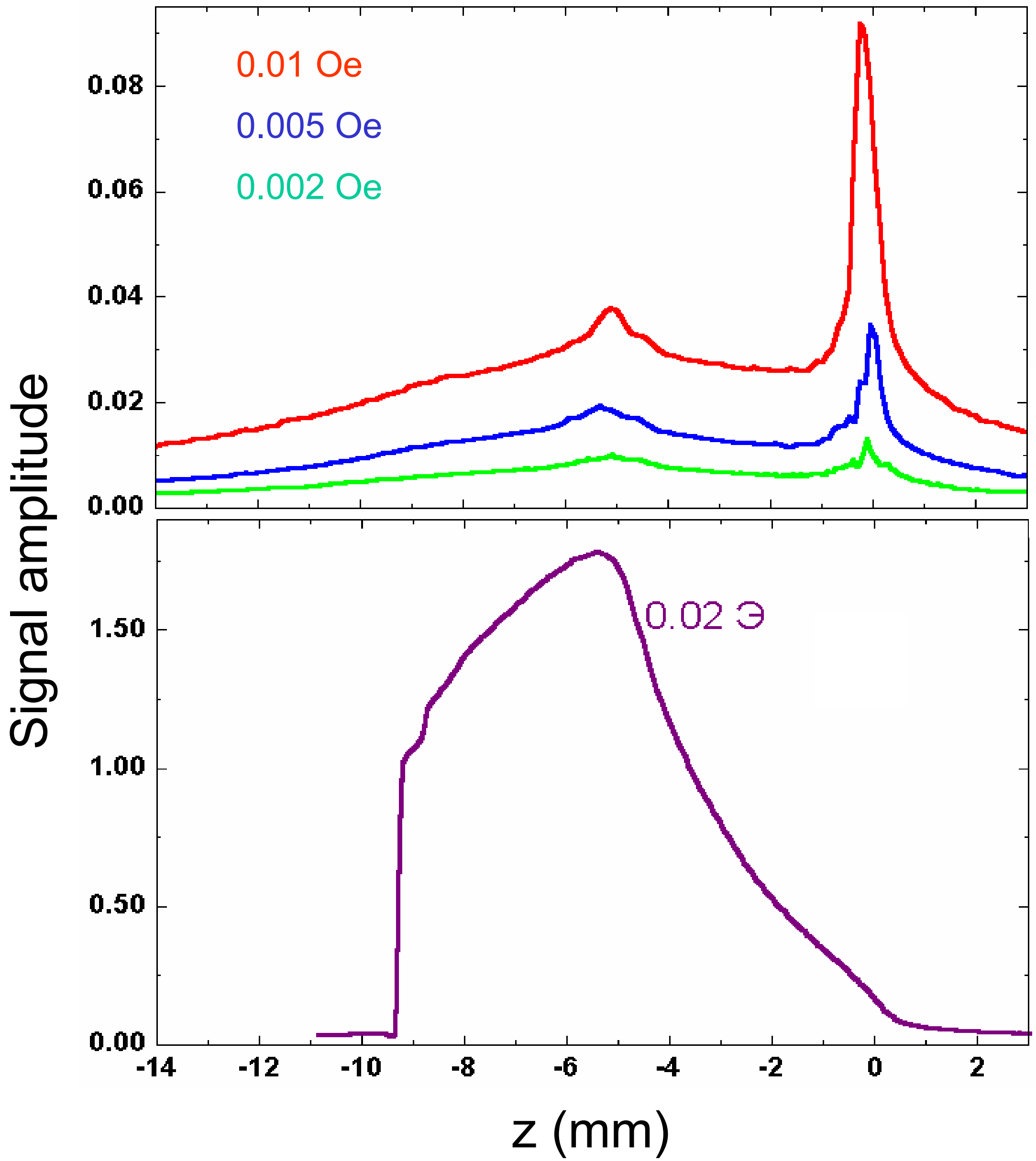


$$\omega_{RF} = \gamma H(z_w)$$

$$z = (\omega_{RF}/\gamma - H_0)/\nabla H$$

Experimental cells





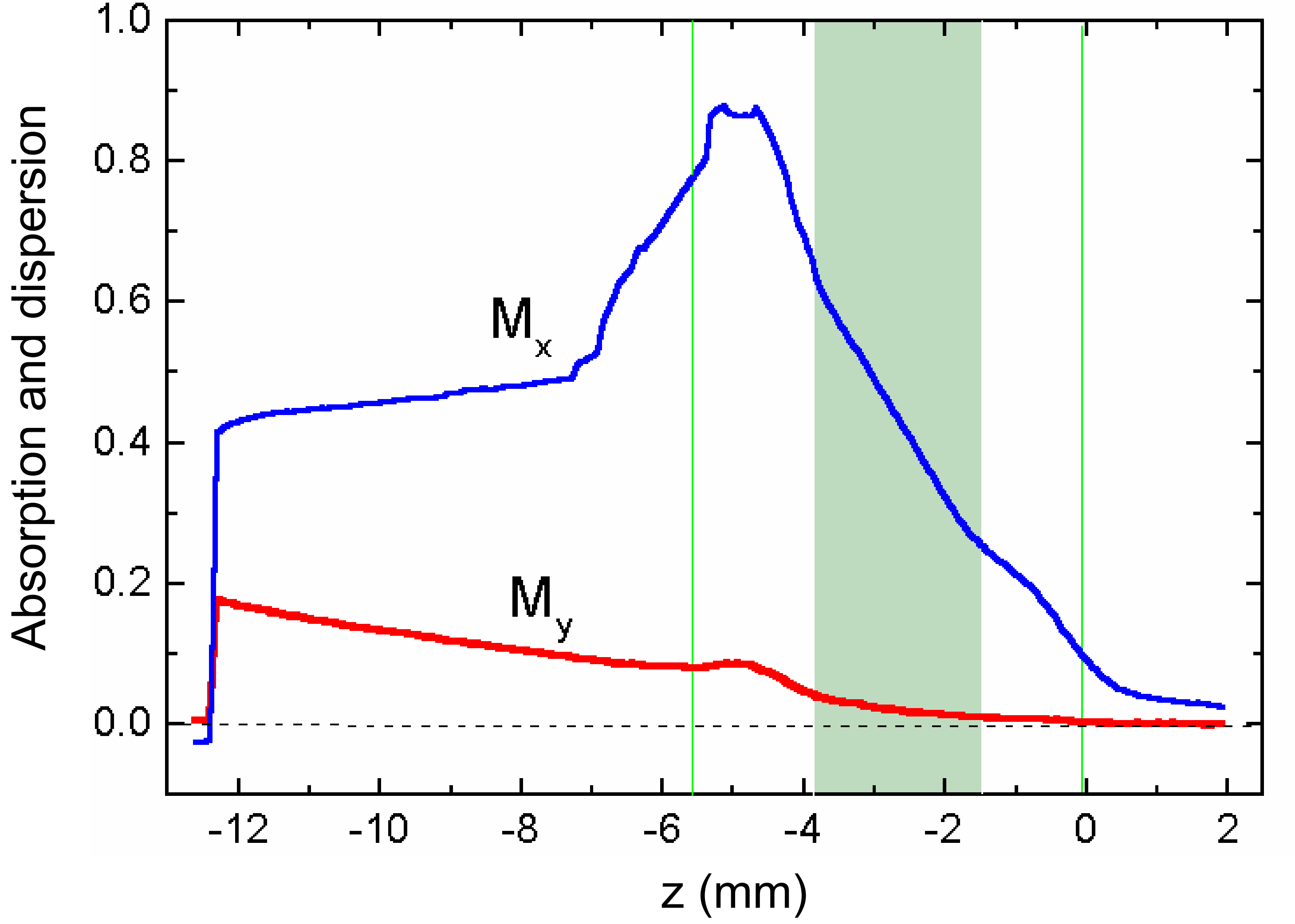
P=25.5 bar

H=284 Oe

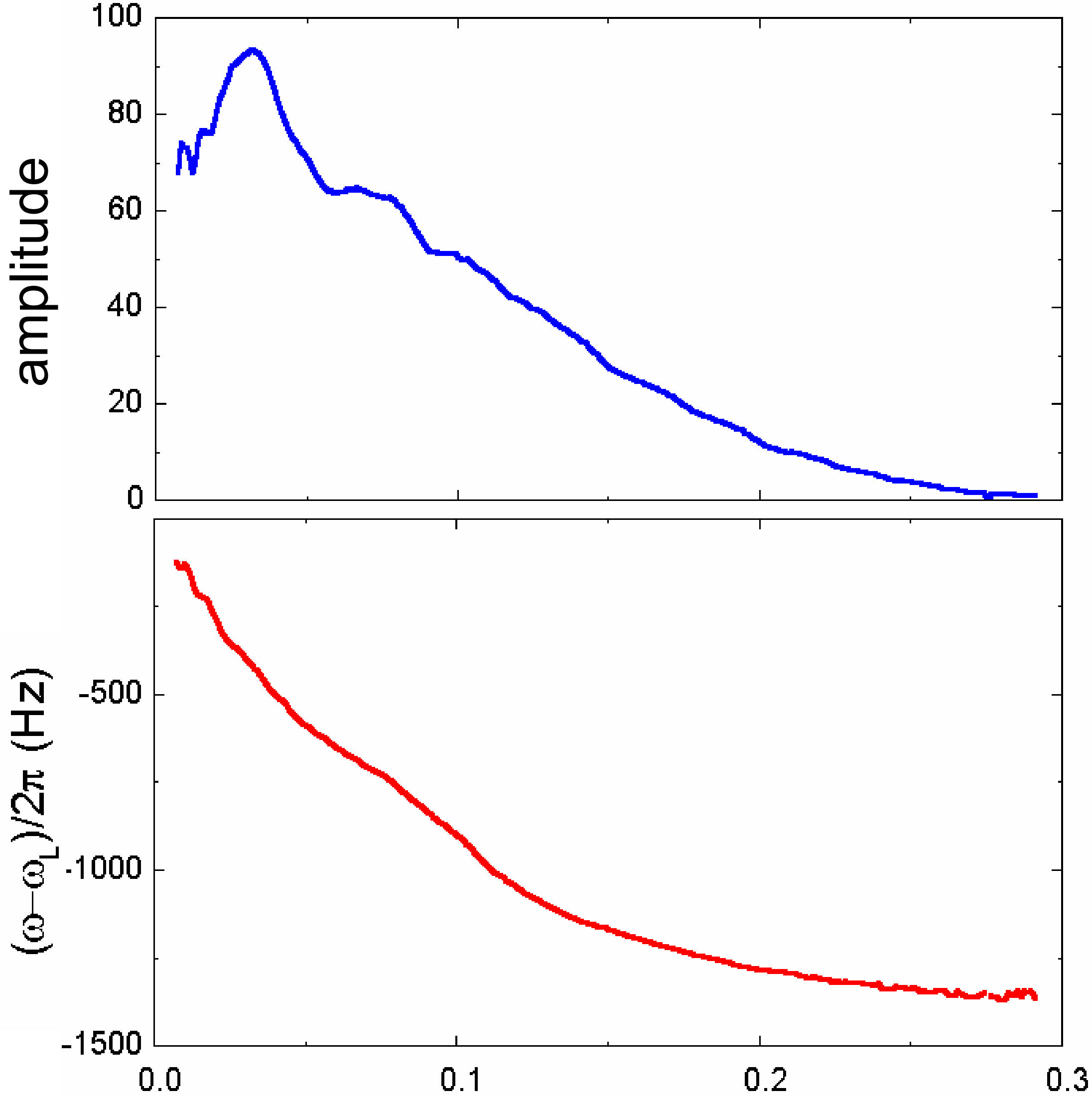
∇ H= -1 Oe/cm

T=0.67 T_{CA}

$z=(\omega_{RF}/\gamma - H_0)/\nabla H$



H=284 Oe, ∇ H= -0.94 Oe/cm, T = 0.66 T_{CA}, h_{RF}= 0.01 Oe



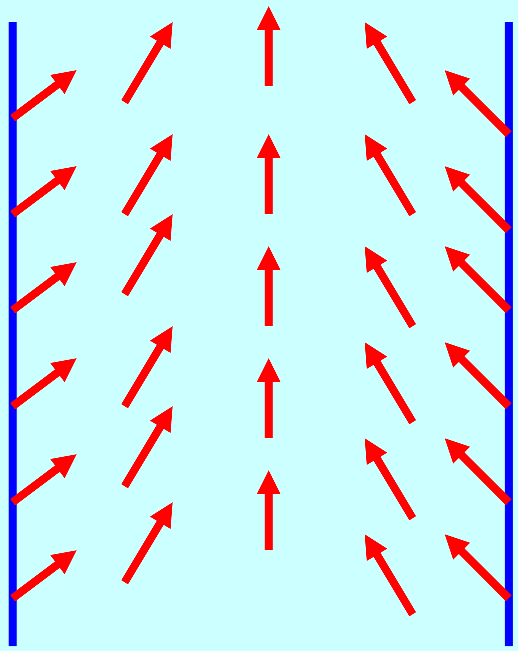
H= 284 Oe

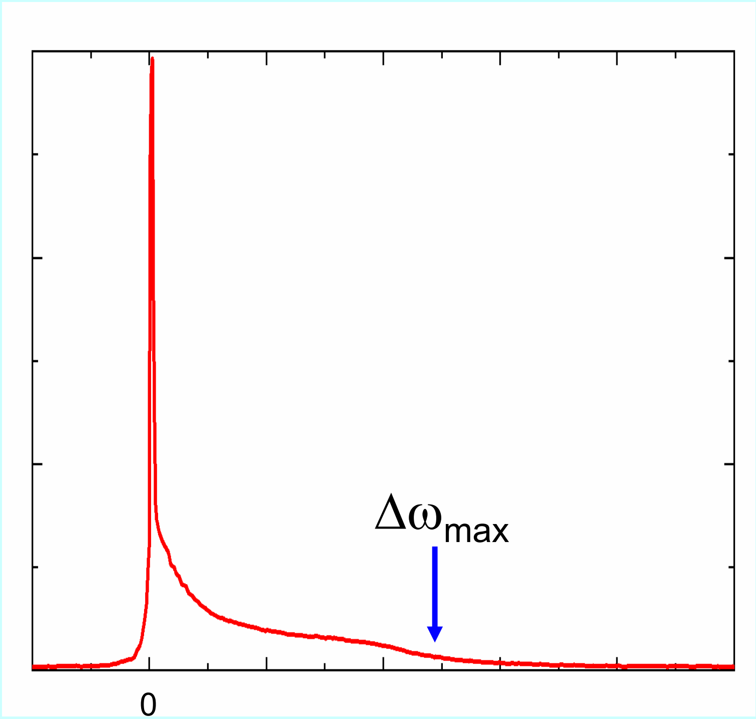
∇ H= -0.94 Oe/cm

T= 0.66 T_{CA}

L_{HPD}= 4.7 mm

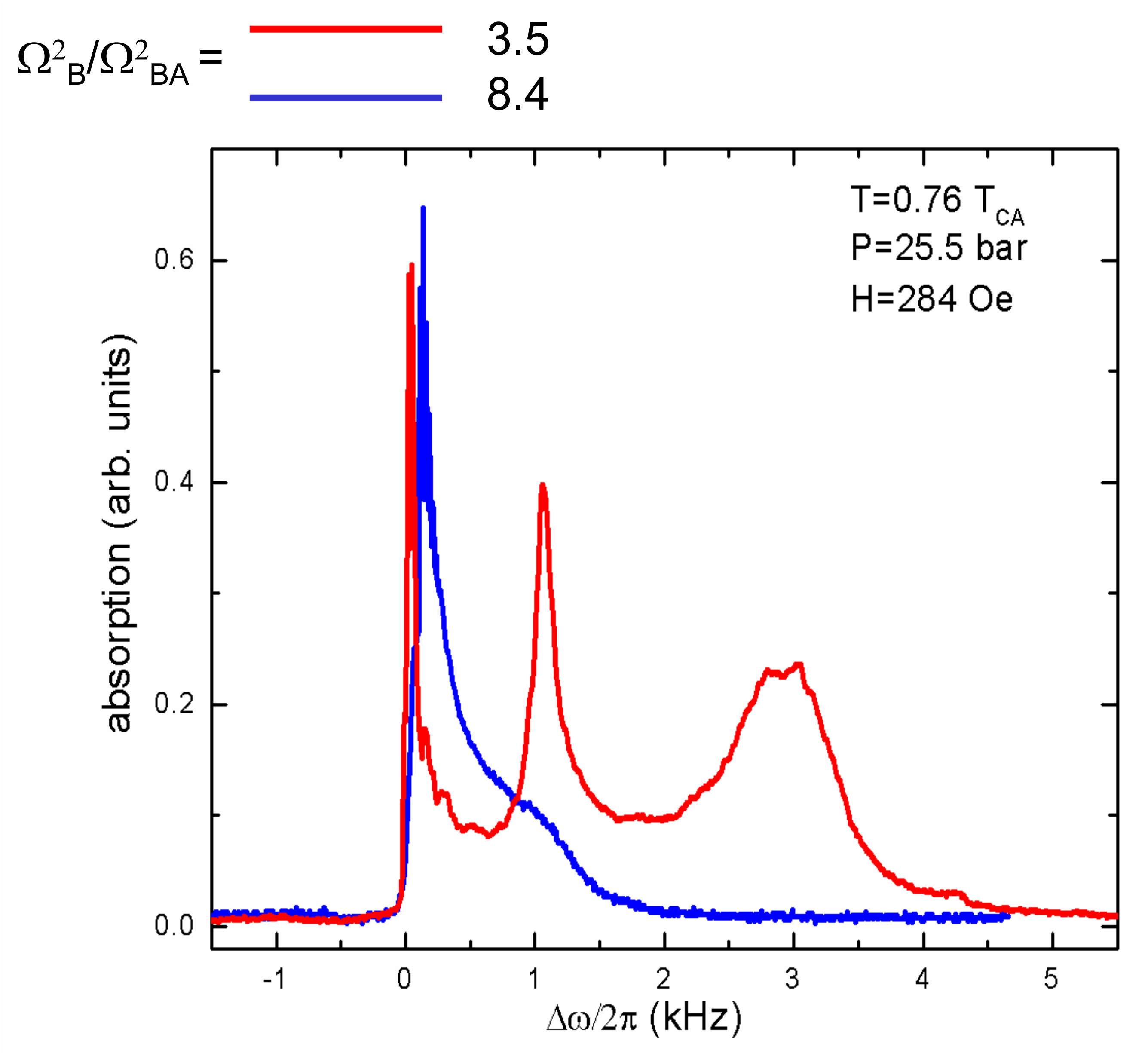
Low excitation CW NMR in ^{3}He-B:
the form of the line is defined by distribution of vector **n**





$$\Delta\omega = \Omega^2_B/2\omega_L \sin^2\gamma$$

$$\Delta\omega_{max} = 2\Omega^2_B/5\omega_L$$


Ω^2_B/Ω^2_{BA} =
3.5
8.4
T=0.76 T_{CA}
P=25.5 bar
H=284 Oe
absorption (arb. units)
0.0
0.2
0.4
0.6
-1
0
1
2
3
4
5
$\Delta\omega/2\pi$ (kHz)

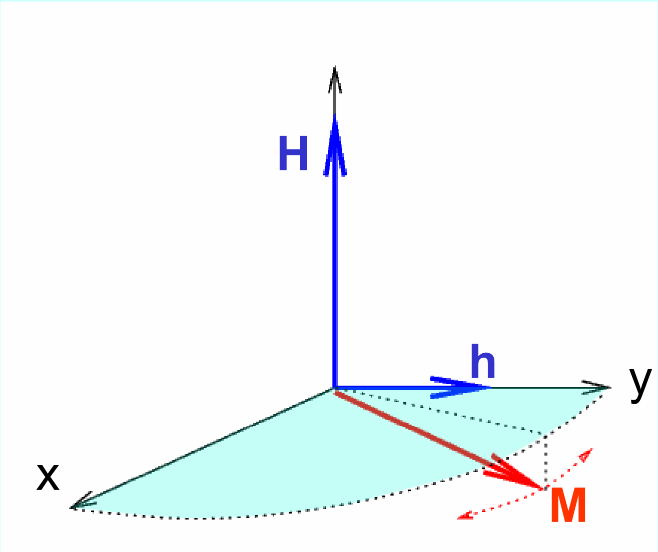
Spatially homogeneous modes of oscillations of the HPD

Rotating frame:

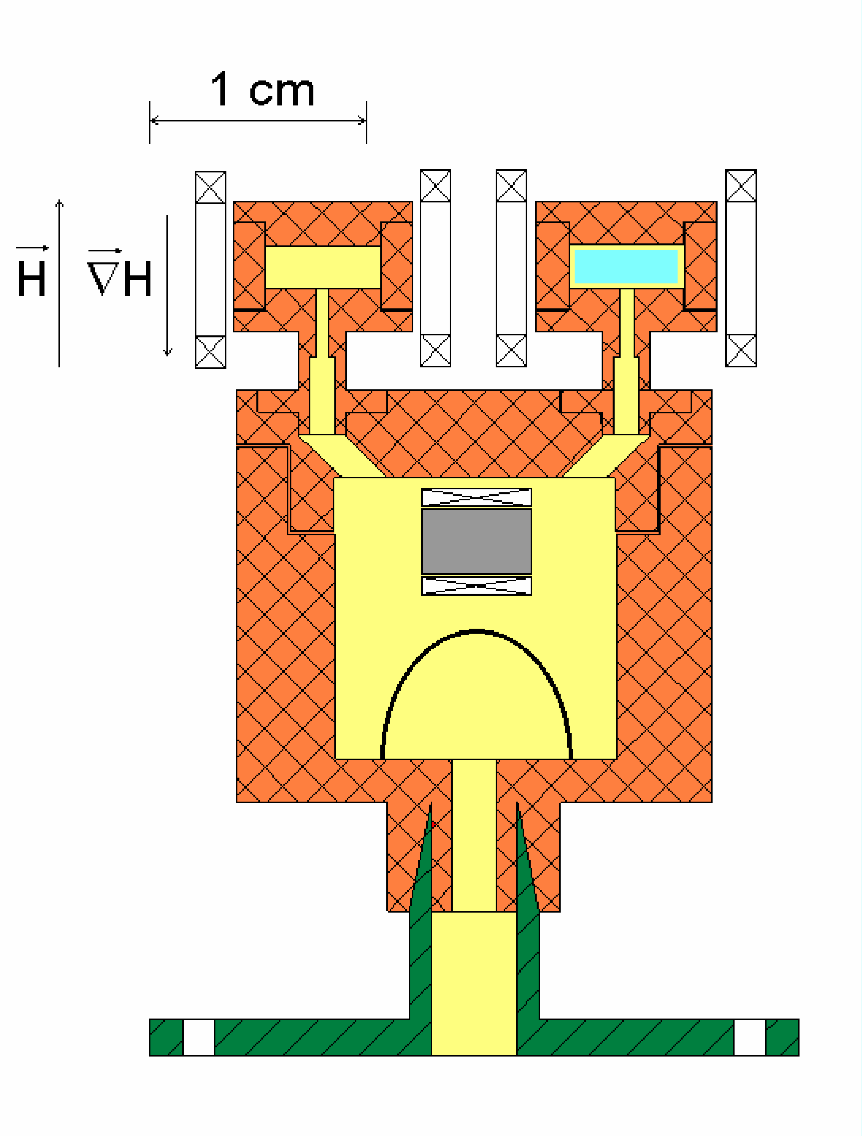
$$\Omega^2 \approx \omega_L^2 + \Omega_B^2$$

$$\Omega^2 \approx \frac{3}{8}\omega_L \Delta\omega$$

$$\Omega^2 = \frac{4}{\sqrt{15}} \frac{\gamma h}{\omega_L} \frac{\Omega_B^2}{1 + 8\Omega_B^2 / 3\omega_L^2}$$

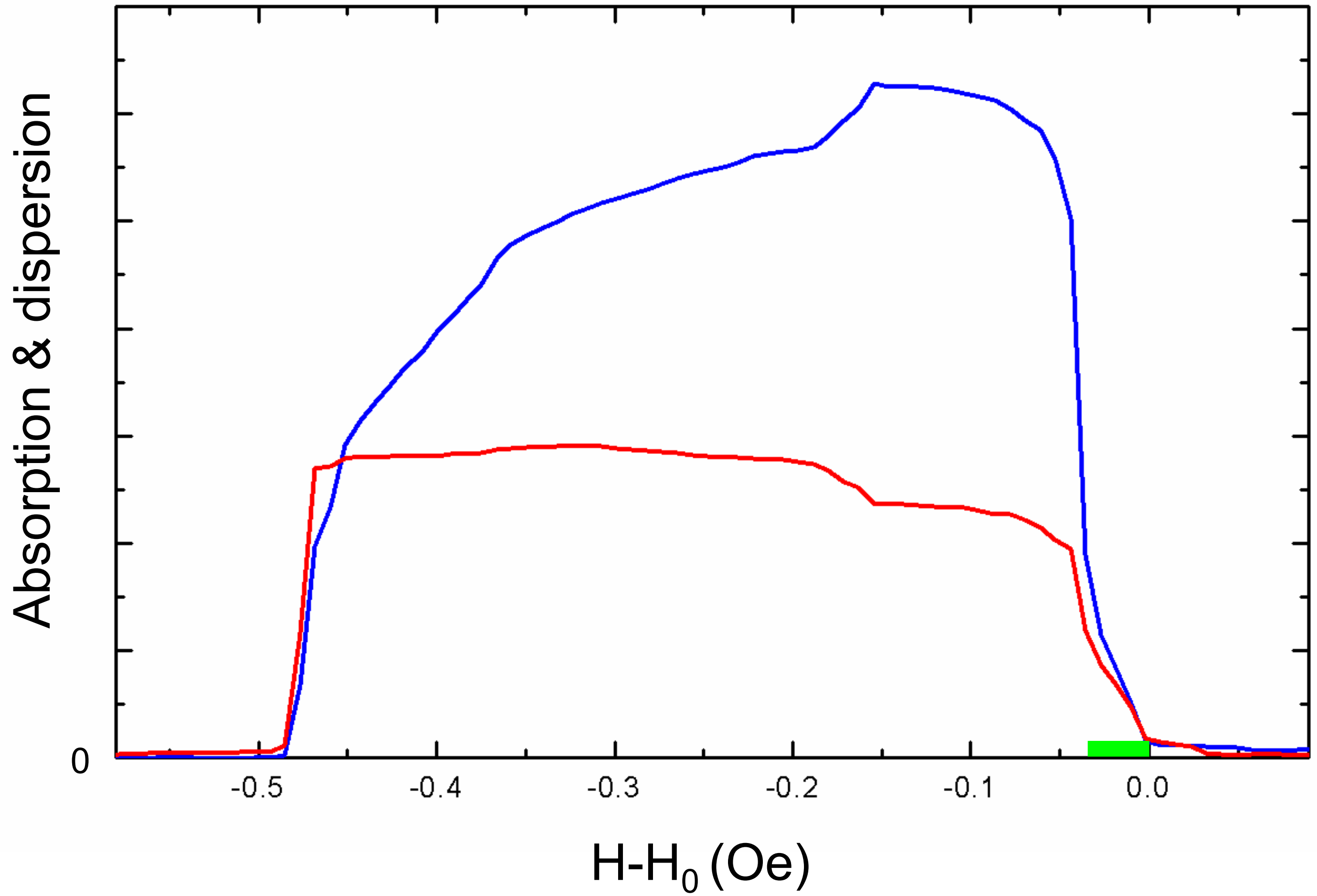


Experimental cell for studies of low frequency HPD oscillations



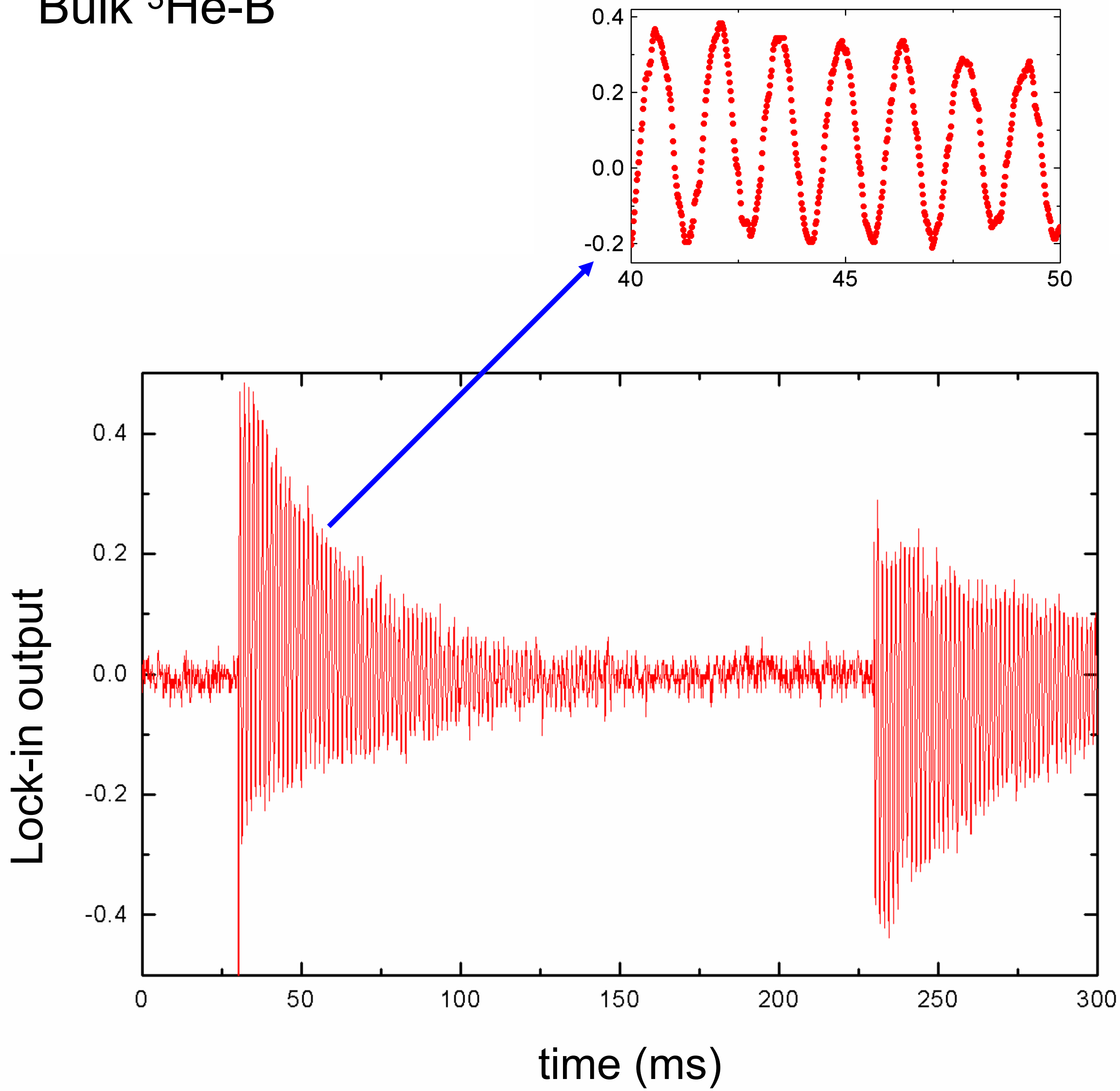
H=284 Oe
P=19.5 bar
h~0.01 Oe
dH~0.03 Oe

HPD formation in cell with aerogel



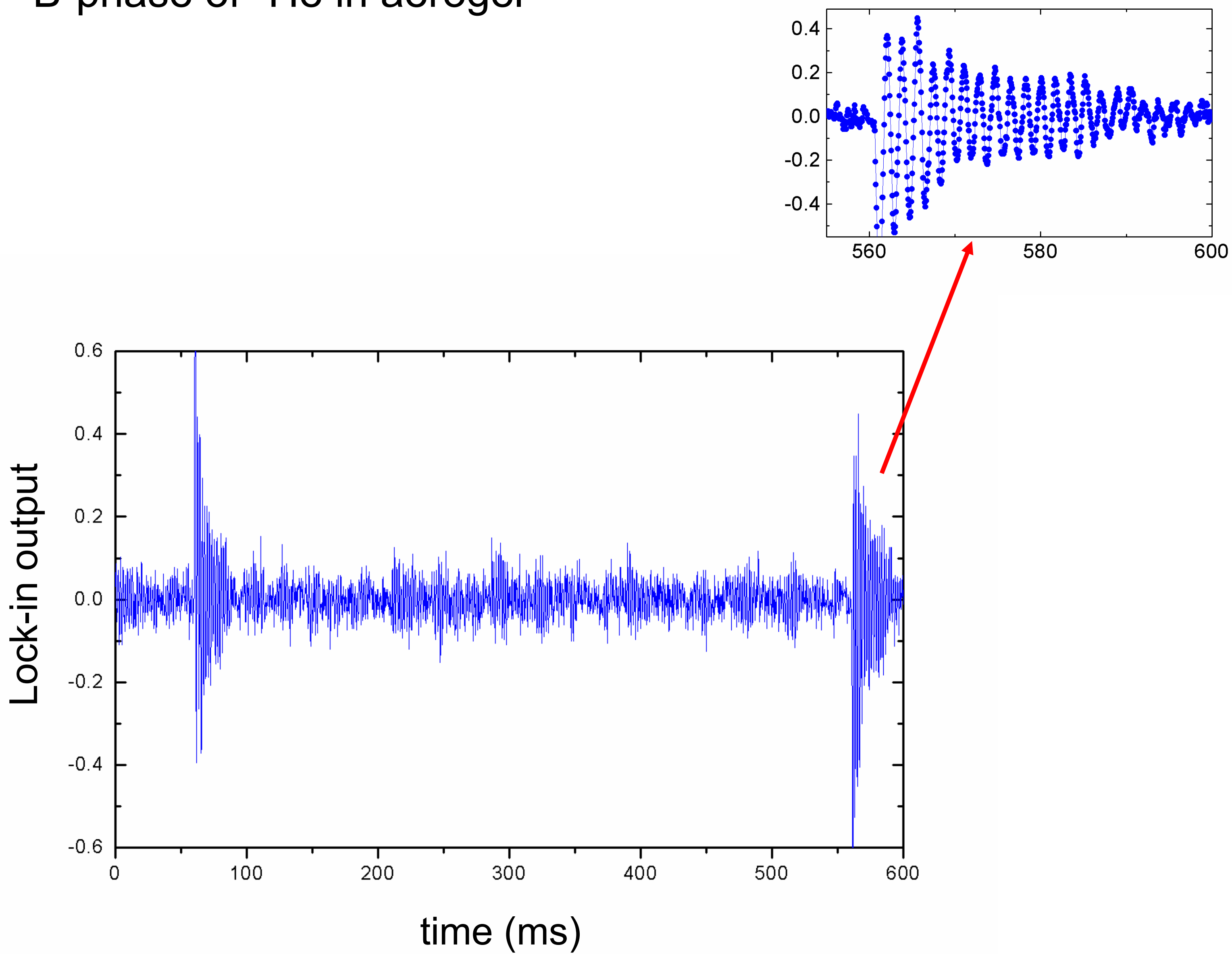
H_0=284 Oe, ∇ H=0.2 Oe/cm

Bulk ^{3}He-B



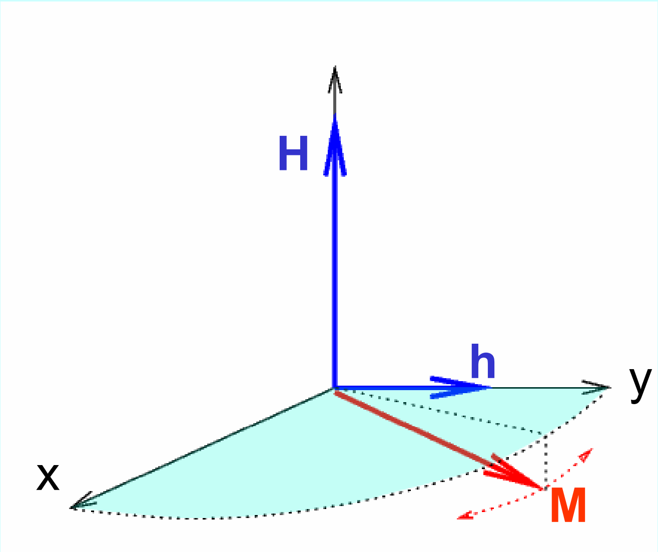
0.4
0.2
0.0
-0.2
40
45
50
0.4
0.2
0.0
-0.2
-0.4
0
50
100
150
200
250
300
Lock-in output
time (ms)

B-phase of ^3He in aerogel

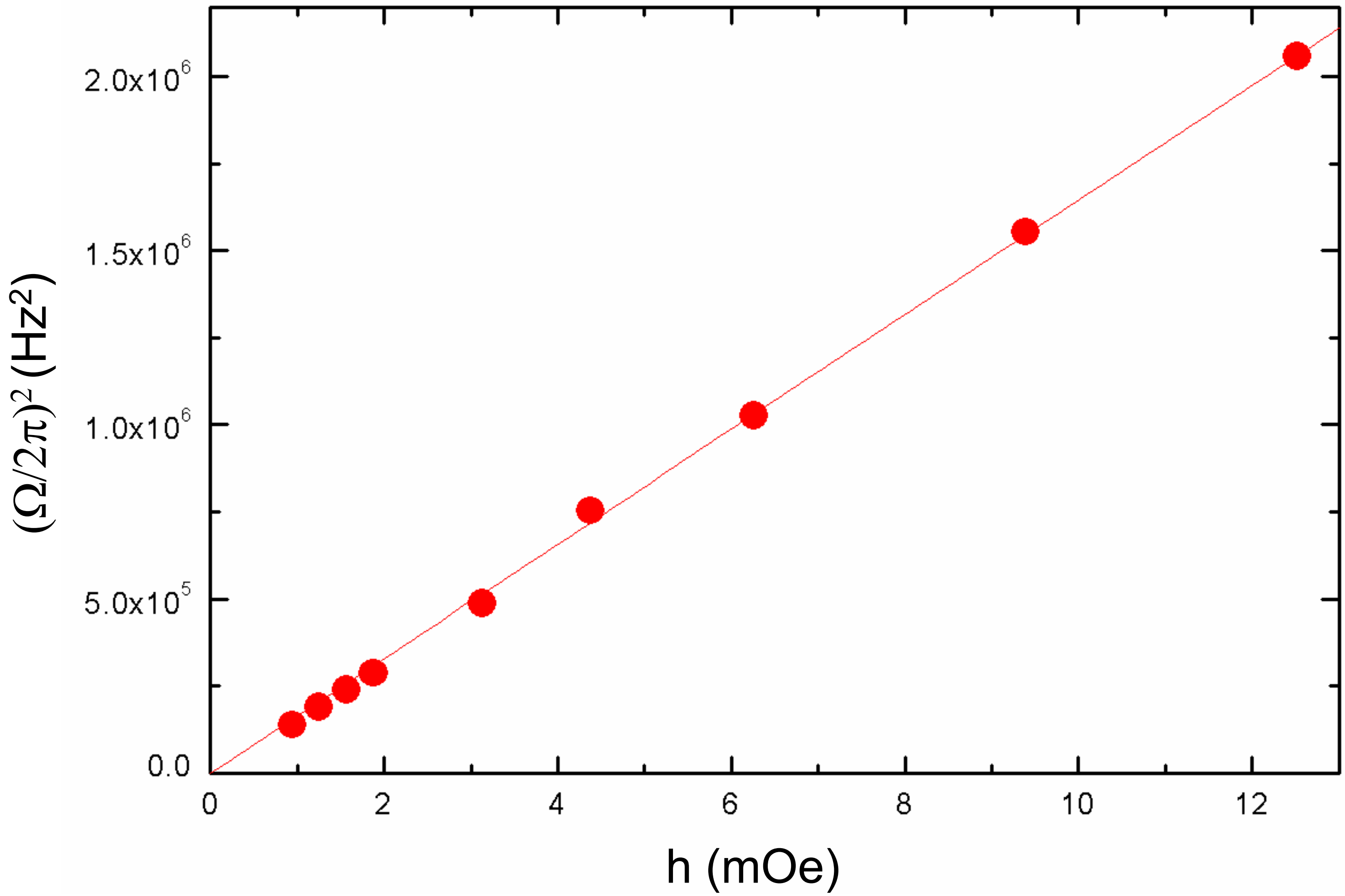


Rotating frame:

$$\Omega^2 = \frac{4}{\sqrt{15}} \frac{\gamma h}{\omega_L} \frac{\Omega_B^2}{1 + 8\Omega_B^2 / 3\omega_L^2}$$



Oscillations frequency vs RF-field amplitude

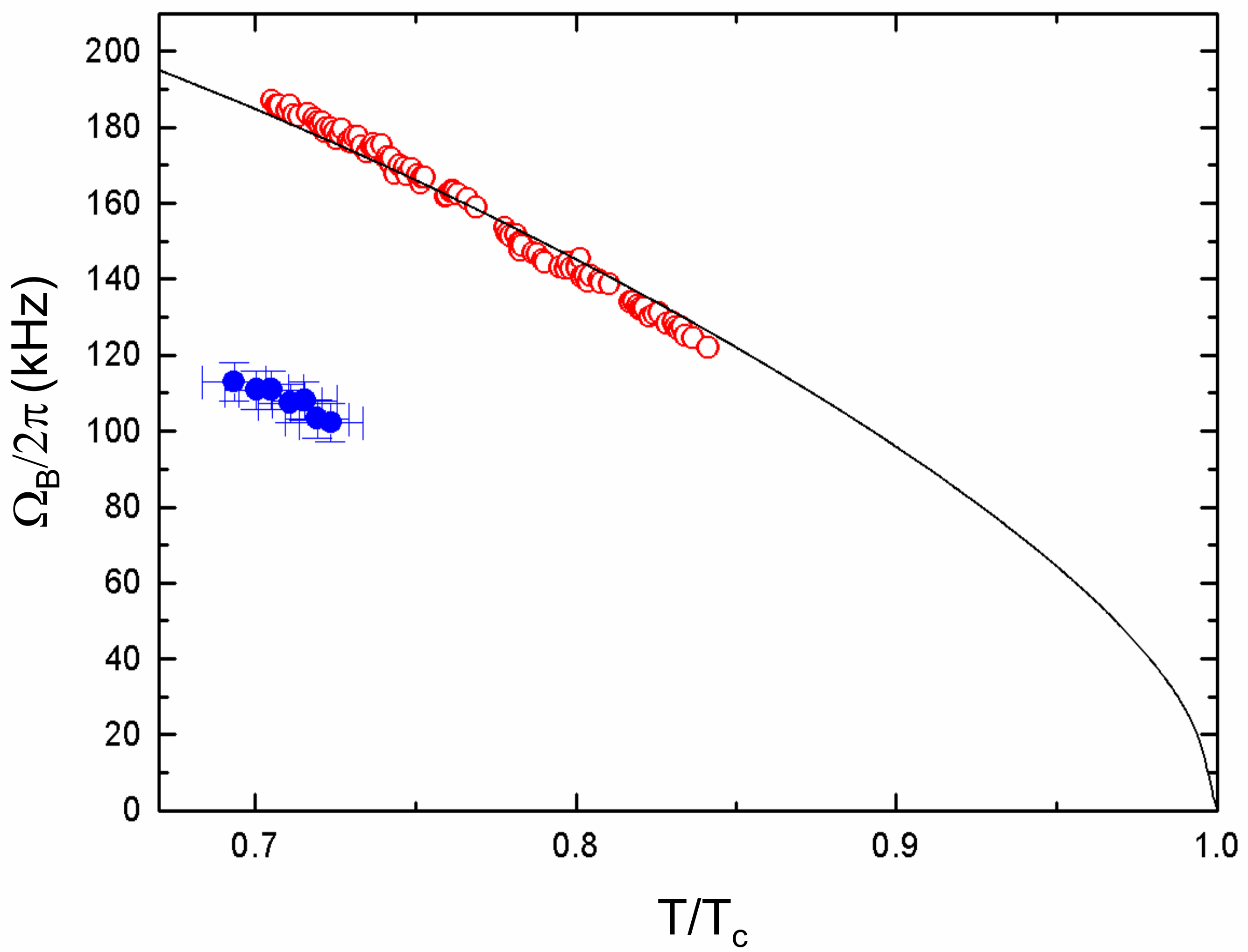


^{3}He-B bulk. T=0.606 T_c

Leggett frequency in bulk ^{3}He and in ^{3}He confined with aerogel
(solid line: P.J.Hakonen et.al., JLTP, **76**, 225 (1989))

P=19.5 bar

Ω^2_B/Ω^2_{BA} =2.8



Conclusions

1. New mode of the HPD oscillations has been found theoretically, experimentally and by numerical simulations.

2. This mode allows to measure the Leggett frequency