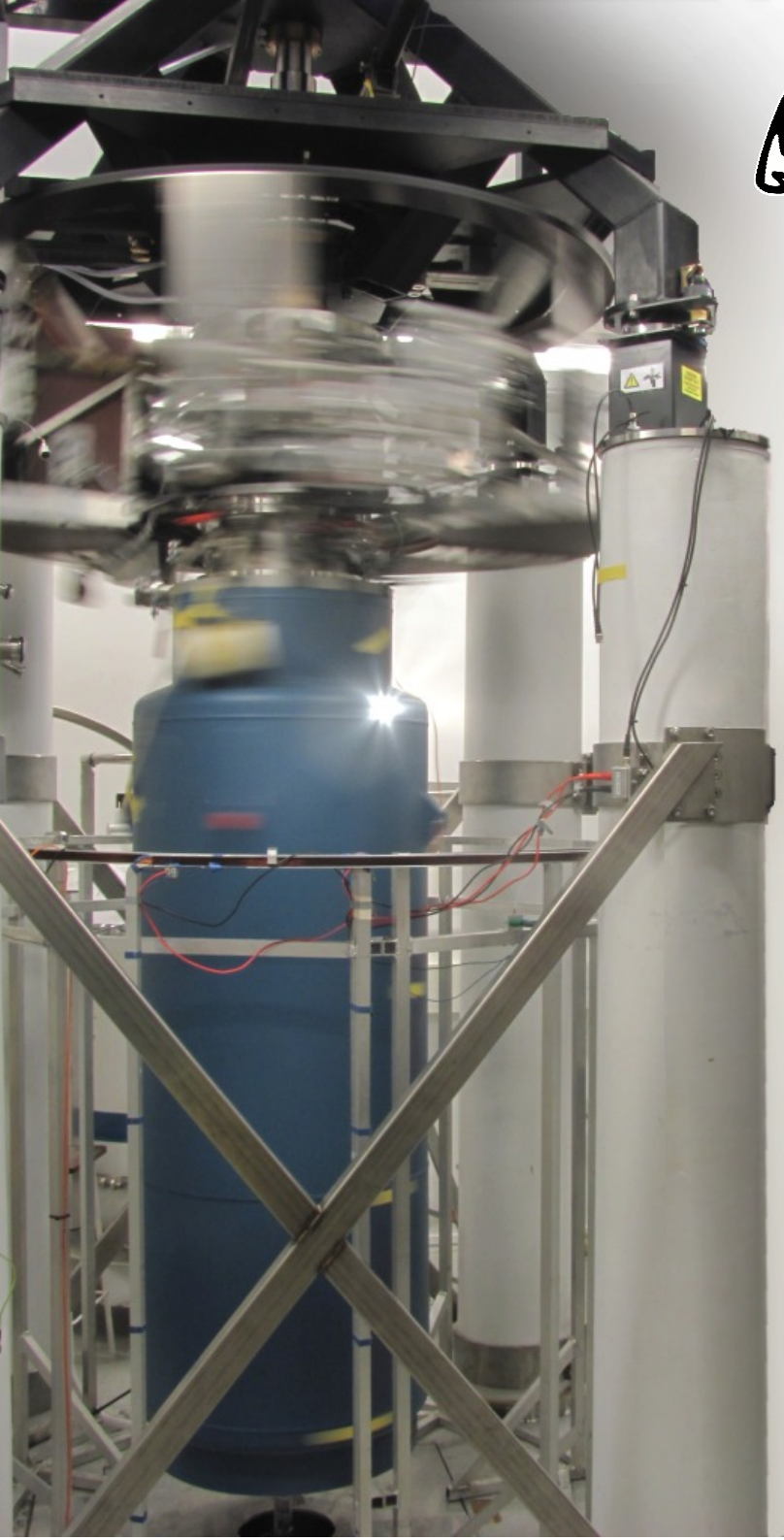

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Magnon condensate in ^{3}He-B

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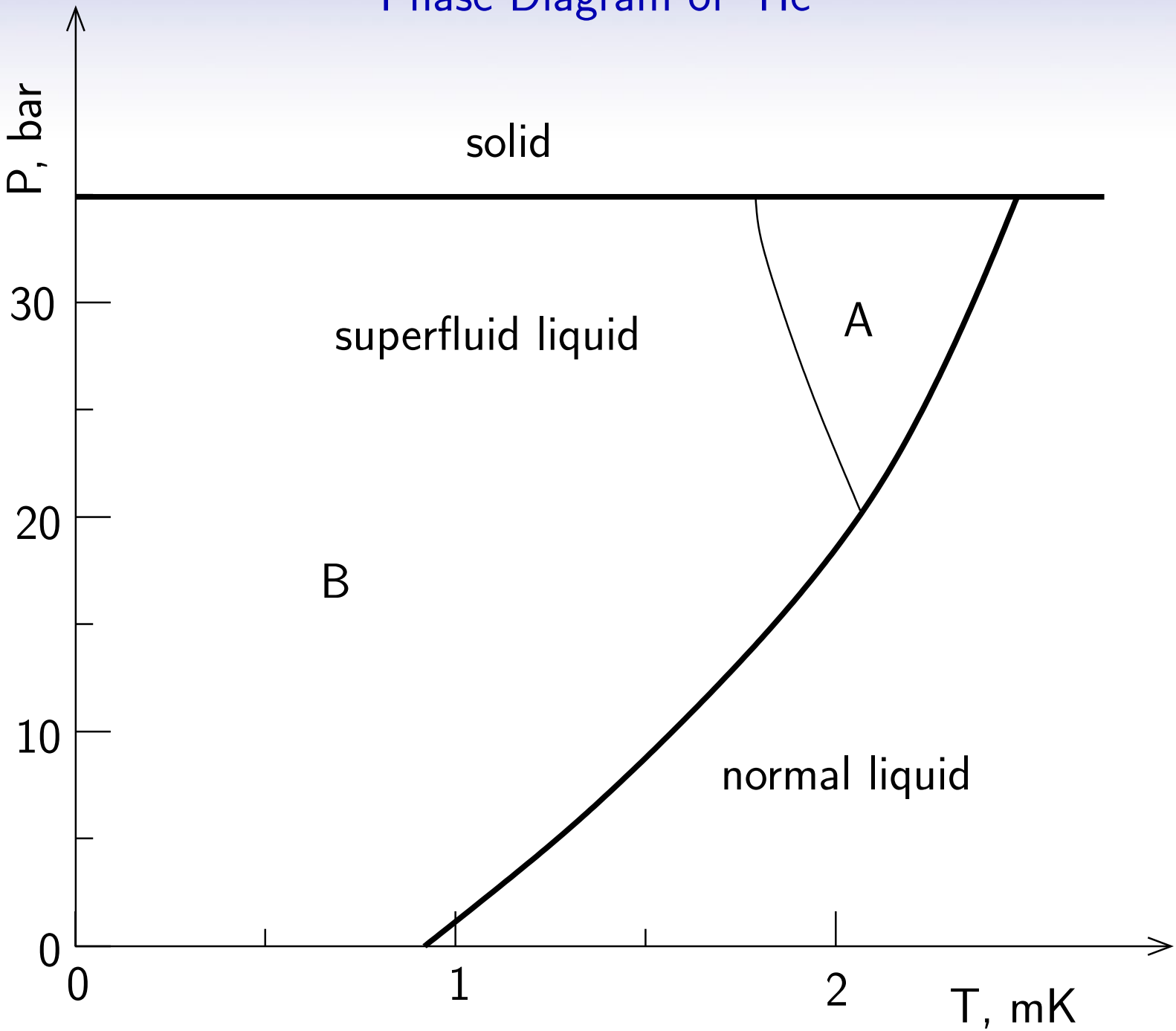
2012

Phase Diagram of ^{3}He



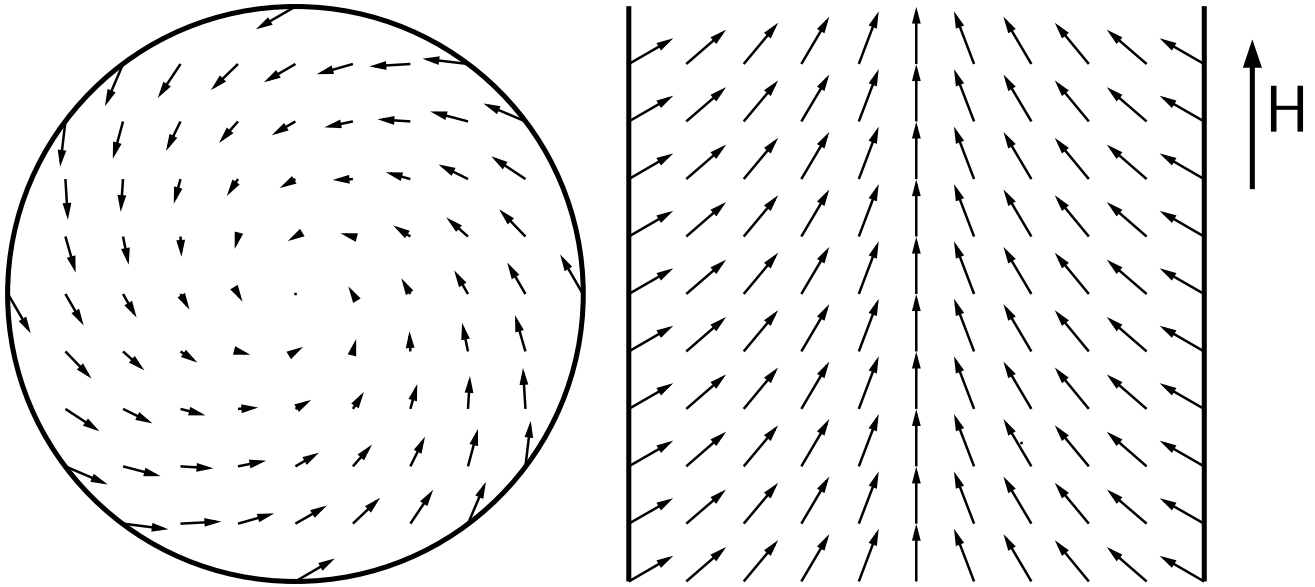
Texture of order parameter in ^{3}He-B

Order parameter:

$A_{jk} = \Delta(P,T)\ e^{i\phi}\ R_{jk}(\mathbf{n},\theta).$

Energy of spin-orbit interaction $\sim \left(\cos\theta + \frac{1}{4}\right)^2$, angle $\theta \approx 104.5^\circ$

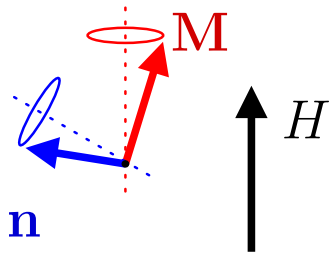
Distribution of vector $\mathbf{n}$ in a cylindrical cell:



Linear NMR in ^{3}He-B, spin waves

NMR: precession of magnetization

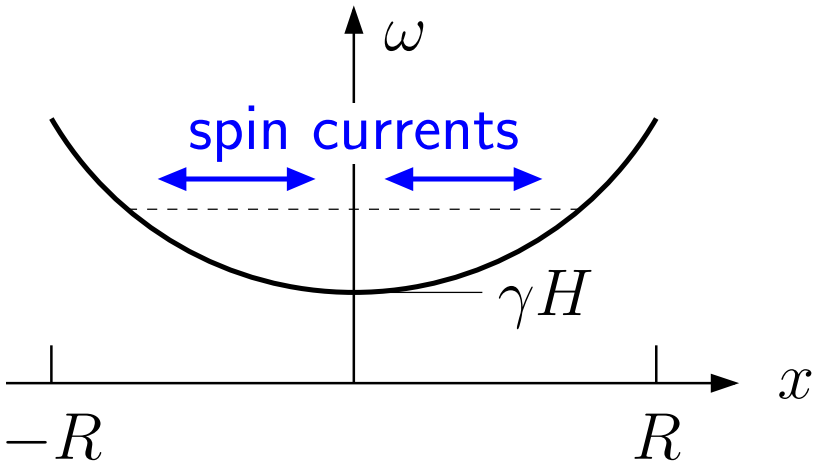
depends on the texture



$$\omega = \gamma H + \Delta\omega$$

frequency profile

in the radial direction:



Magnons:

⋆ tipping angle and phase → wave function

⋆ frequency → energy

⋆ standing spin wave → Bose condensate

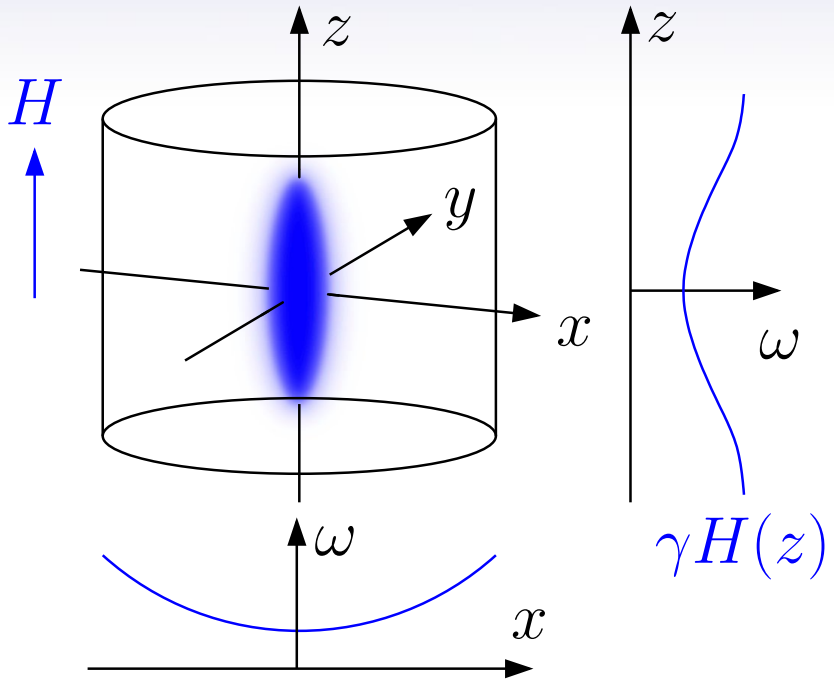
Volovik, JLTP 153 (2008)

Energy levels in a cylindrical trap

Energy trap:

radial minimum - texture

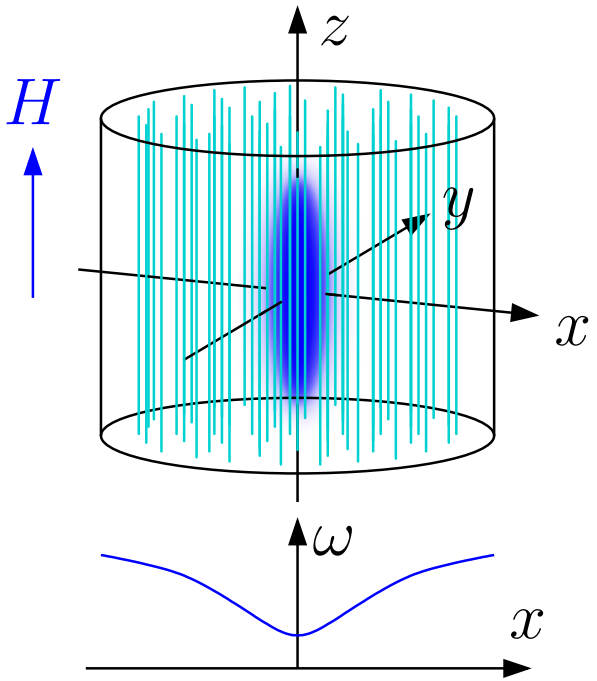
axial minimum - external magnetic field



Harmonic cylindrical trap:

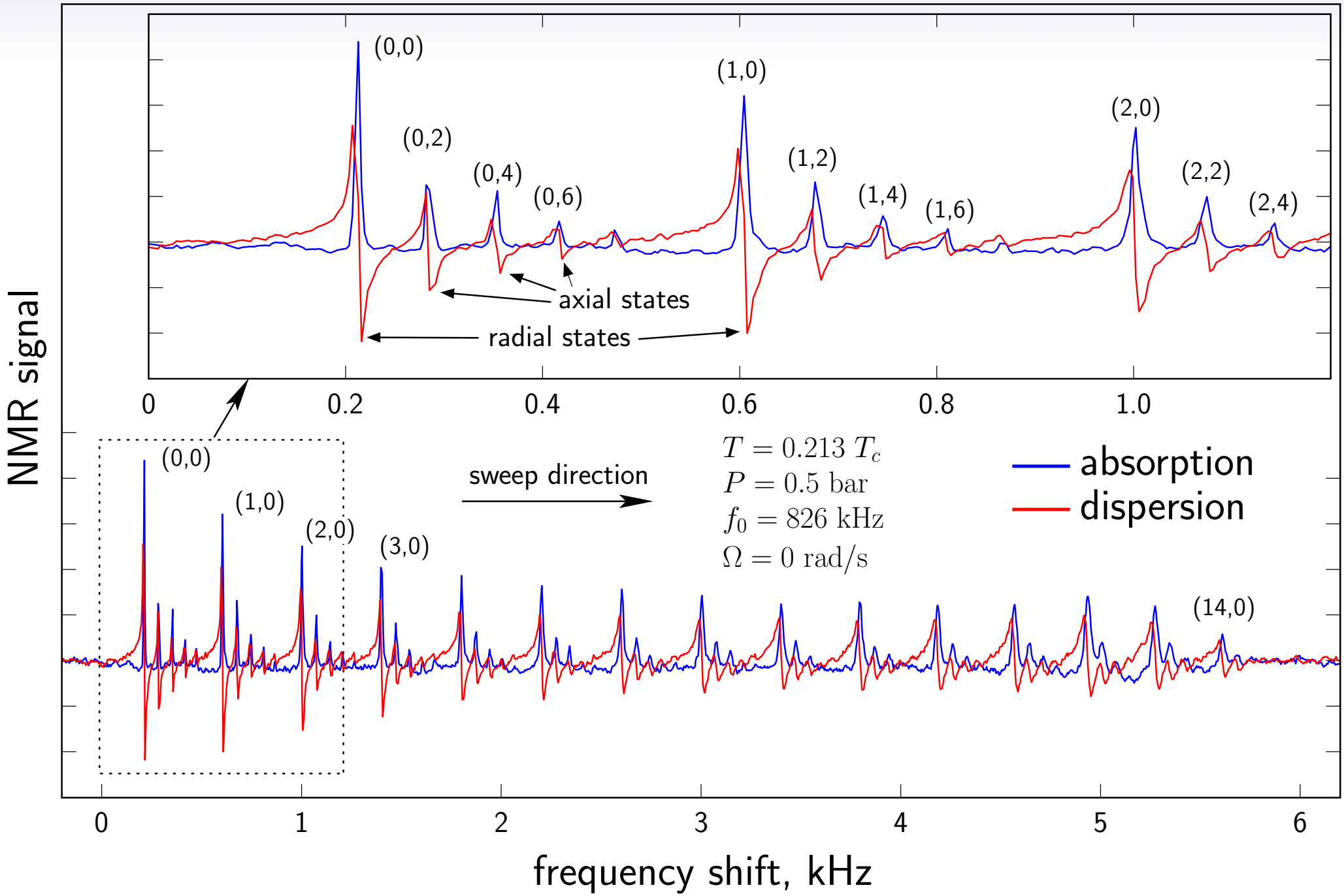
$$E = (2n_r + n_\phi + 1)E_r + (n_z + 1/2)E_z$$

visible states: $n_\phi = 0, \quad n_z = 0, 2, 4...$

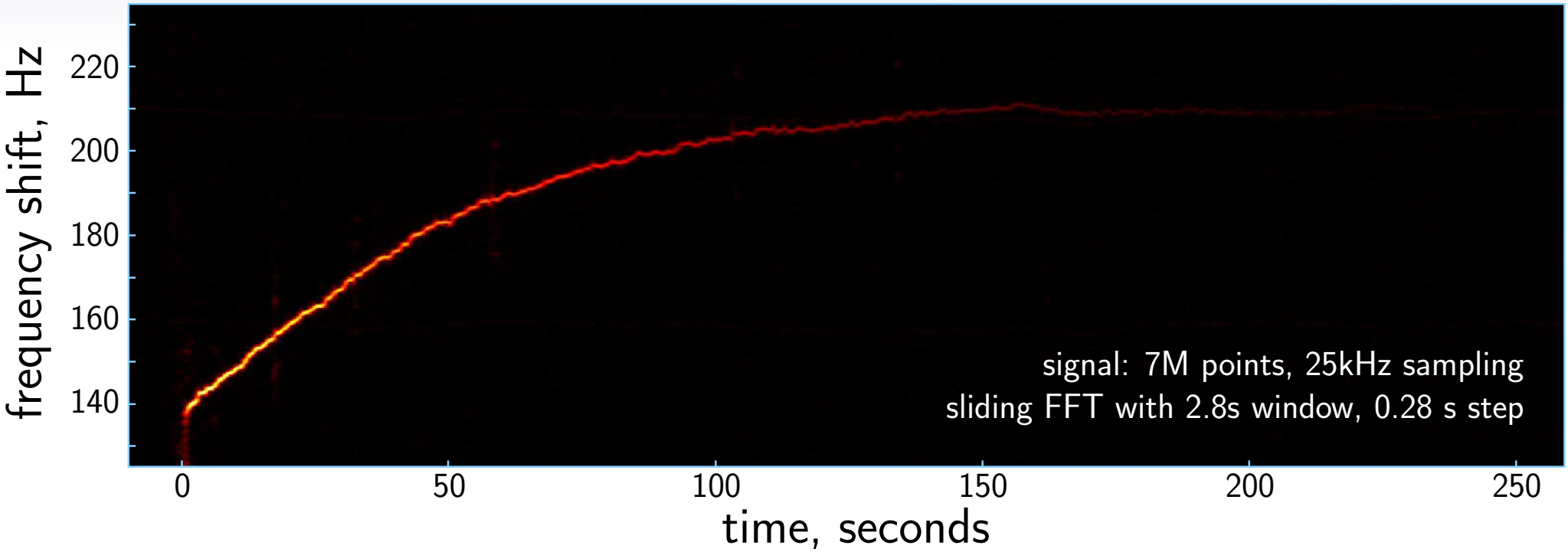


In rotation vortices change the texture

CW NMR


(0,0)
(0,2)
(0,4)
(0,6)
(1,0)
(1,2)
(1,4)
(1,6)
(2,0)
(2,2)
(2,4)
axial states
radial states
0
0.2
0.4
0.6
0.8
1.0
(0,0)
(1,0)
(2,0)
(3,0)
(14,0)
sweep direction
$T = 0.213\ T_c$
$P = 0.5$ bar
$f_0 = 826$ kHz
$\Omega = 0$ rad/s
absorption
dispersion
NMR signal
0
1
2
3
4
5
6
frequency shift, kHz

Pulsed NMR

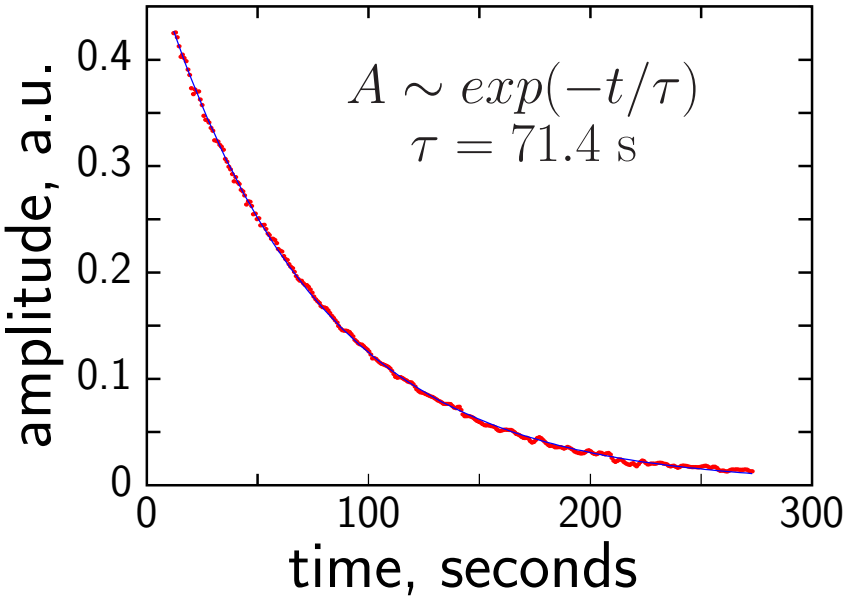


$P = 15.6$ bar

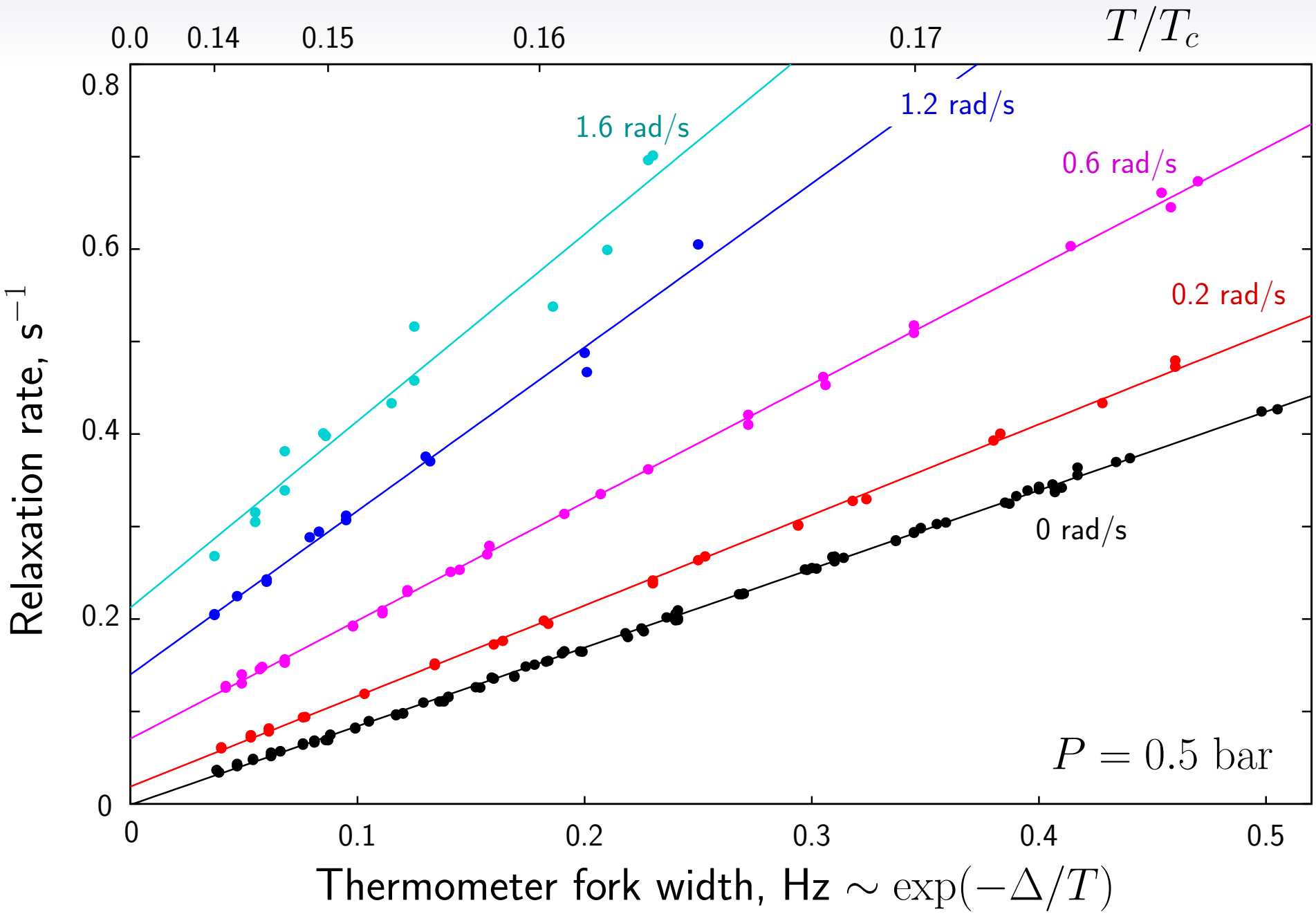
$T = 0.130\ T_c$

$f_0 = 826$ kHz

$\Omega = 0$ rad/s

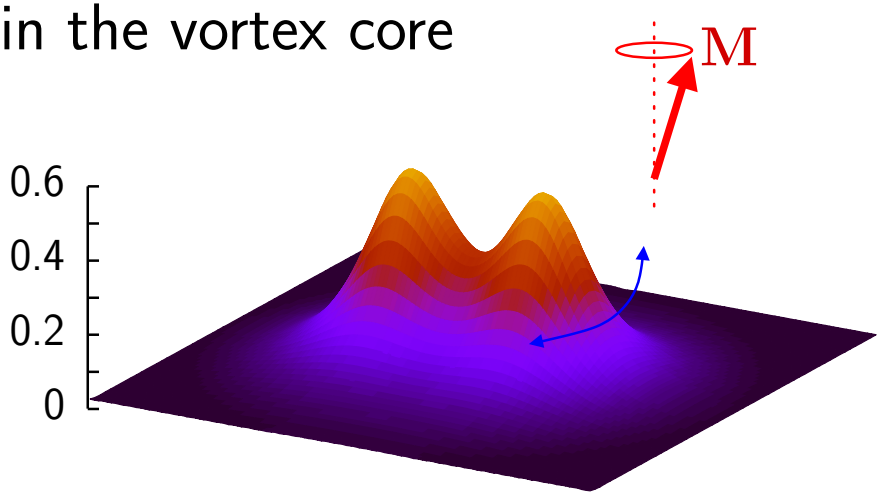


Relaxation vs temperature



Relaxation at zero temperature

normal component density
in the vortex core



vortex oscillations

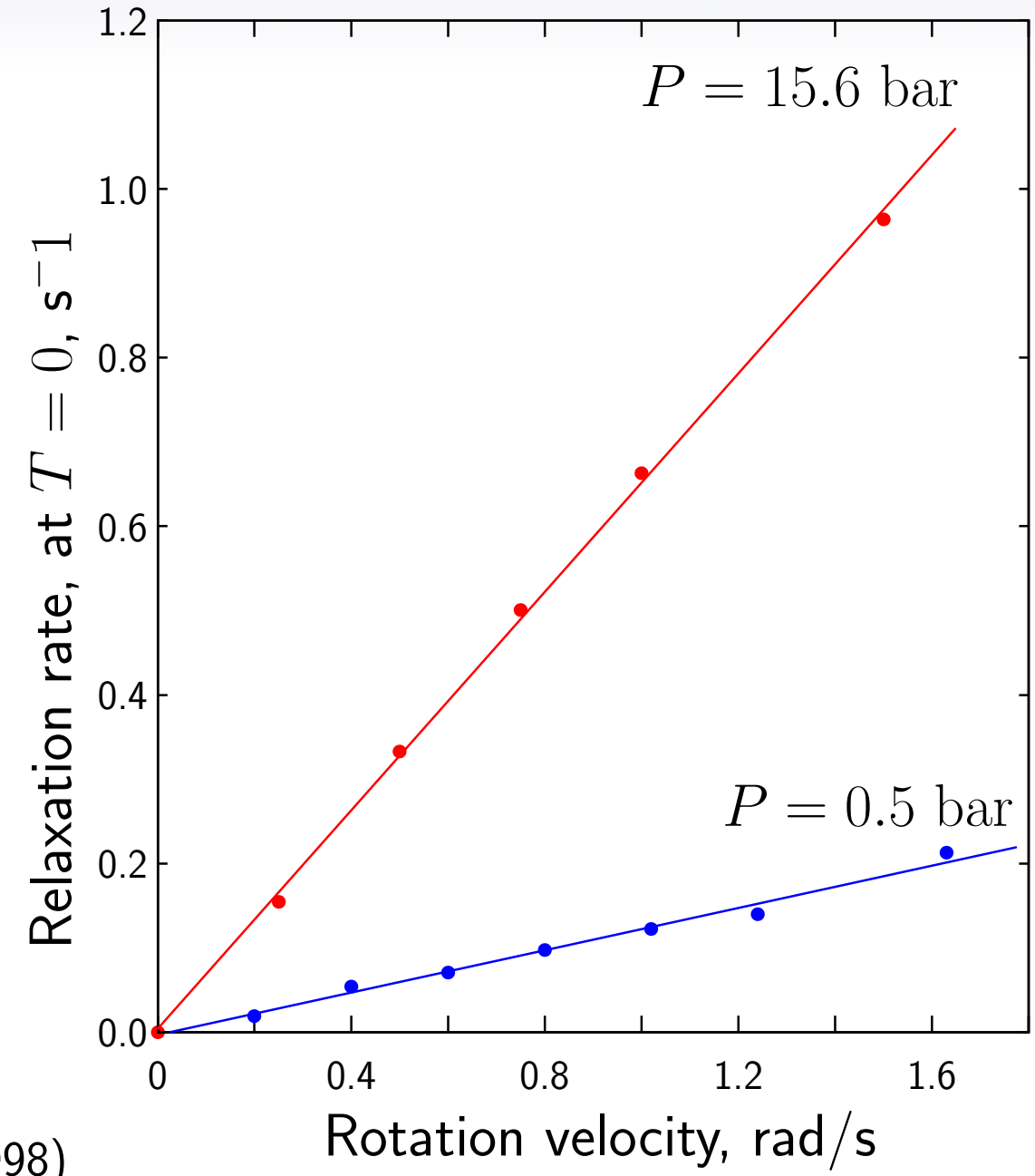
↓

transitions between core bound fermion states

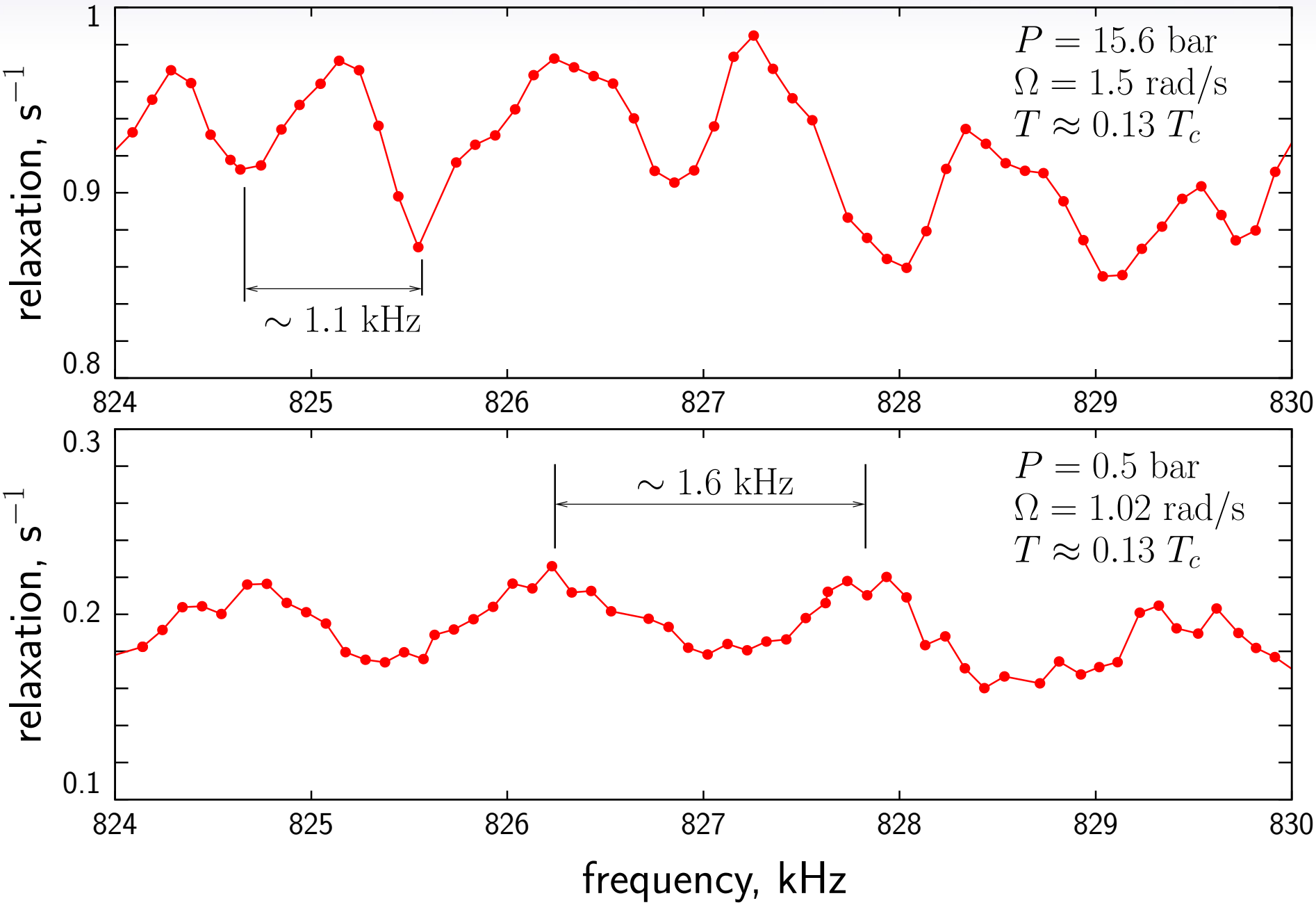
↓

dissipation

Kopnin, Volovik, PRB 57(14) 8526 (1998)



Relaxation vs frequency



Conclusions

1. Long-living Bose condensate of magnon quasiparticles in ^{3}He-B can exists in the trap made by texture and external magnetic field.
2. CW NMR spectrum of magnon condensate states can be used for probing the order parameter texture.
3. Relaxation rate of magnon condensate depends on temperate and trap size as expected for spin diffusion mechanism.
4. In rotation there is a contribution to relaxation, proportional to the density of vortices. It is probably connected to the fermions bound to vortex core, coupled to spin precession via motion of vortices.

Magnon condensate spectrum vs minimum field