



Low Temperature Laboratory



Aalto University

## Homogeneously precessing domain in $^3\text{He-B}$

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# Superfluid $^3\text{He}$

Fermi liquid.

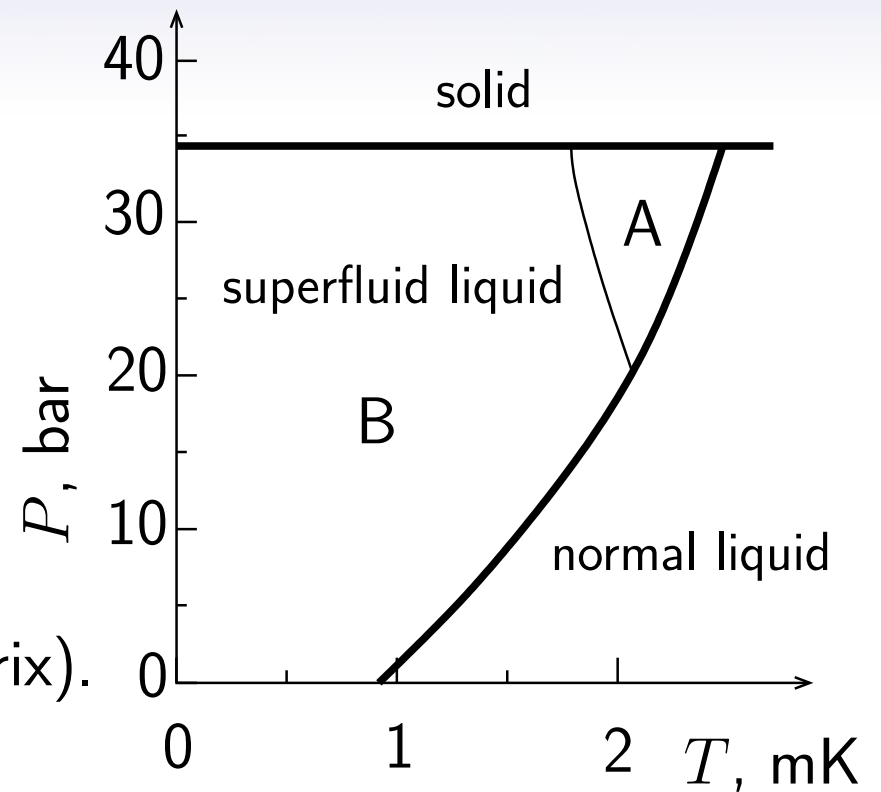
Superfluid transition at  $\sim 1$  mK.

Cooper pairing with  $L = 1$  and  $S = 1$ .

Order parameter:  $3 \times 3$  complex matrix.

B phase:  $A_{jk} = \Delta e^{i\phi} R_{jk}$ .

( $\Delta$  – gap,  $\phi$  – phase,  $R_{jk}$  – rotation matrix).



Oscillations of the order parameter: 18 modes,  
4 phase (Nambu-Goldstone) modes – gapless,  
14 amplitude (Higgs) modes – gap  $\sim \Delta$ .

# Texture and spin waves

Leggett equations:

$$\dot{S}_a = [\mathbf{S} \times \gamma \mathbf{H}]_a + T_a(R),$$

$$\dot{R}_{aj} = e_{abc} R_{cj} \left( \frac{\gamma^2}{\chi_B} \mathbf{S} - \gamma \mathbf{H} \right)_b,$$

Gradient energy

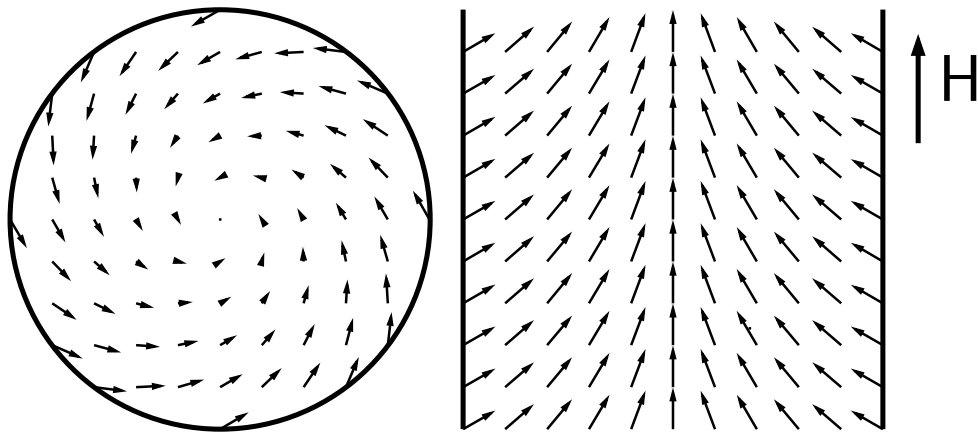
Spin-orbit interaction,  $\Omega_B$

Interaction with walls

Equilibrium distribution of  $R(\hat{\mathbf{n}}, \vartheta)$  – texture.

Motion of  $R(\hat{\mathbf{n}}, \vartheta)$  – spin waves.

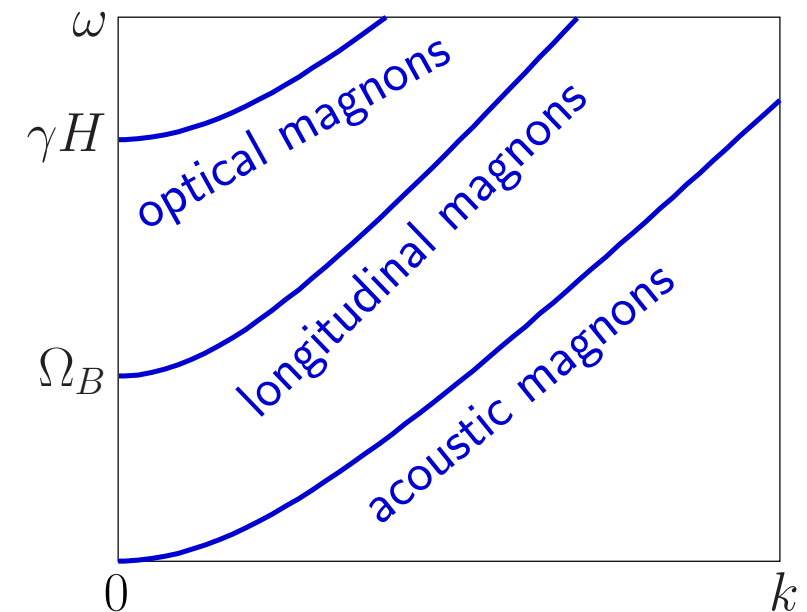
Flare-out texture in a cylindrical cell



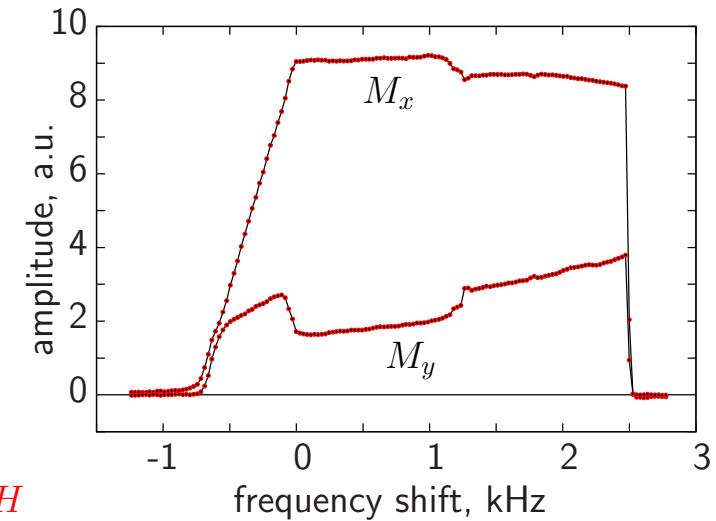
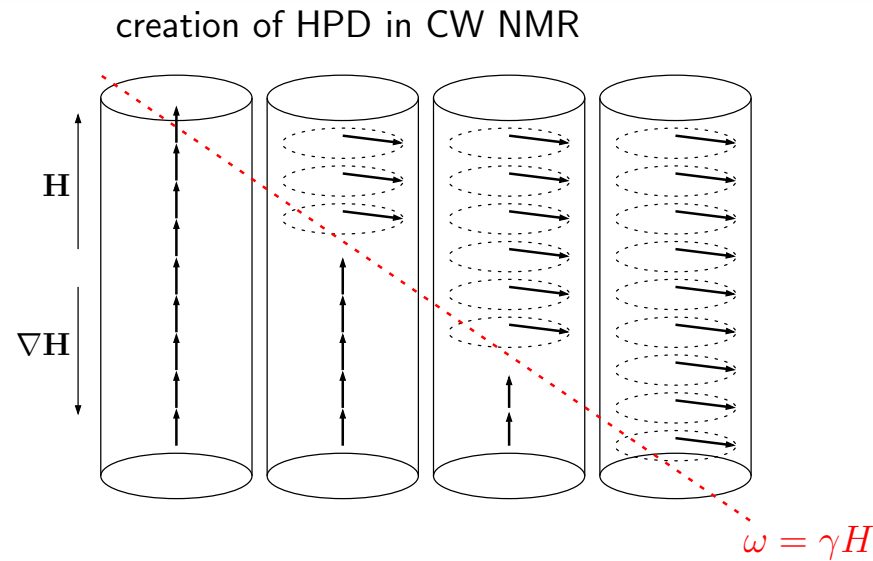
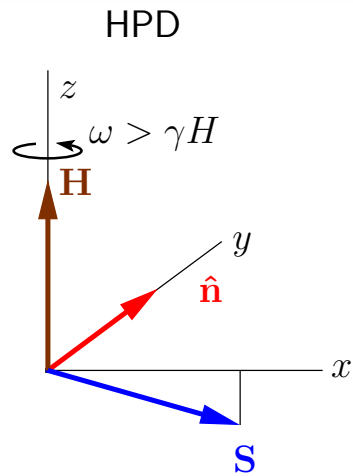
$$\vartheta = 104^\circ$$

(Leggett angle, minimum of spin-orbit interaction)

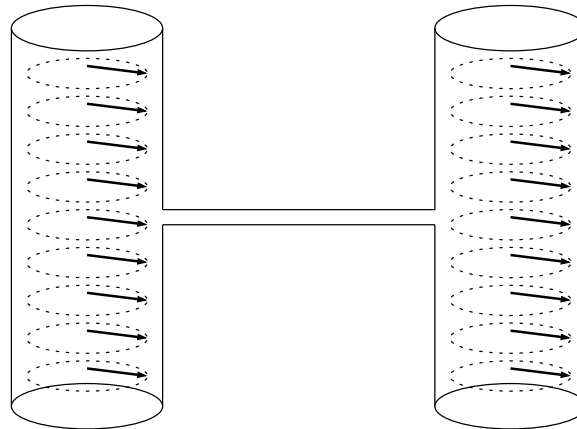
Linear NMR,  $\Omega_B \ll \gamma H$ ,  $\hat{\mathbf{n}} \parallel \mathbf{H}$



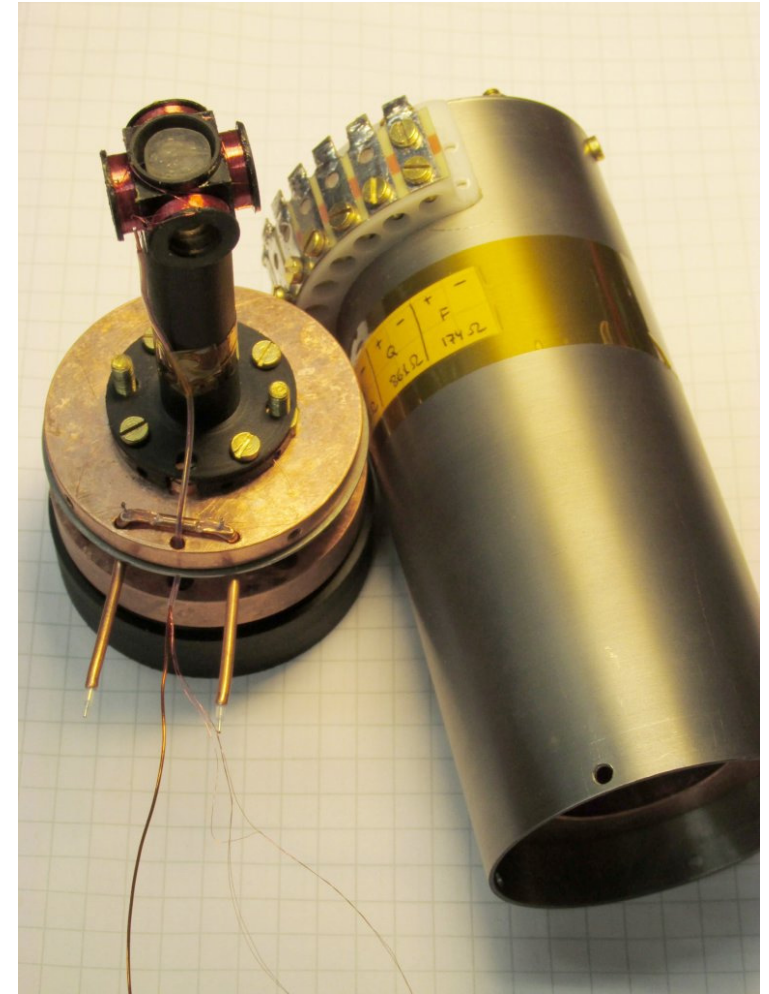
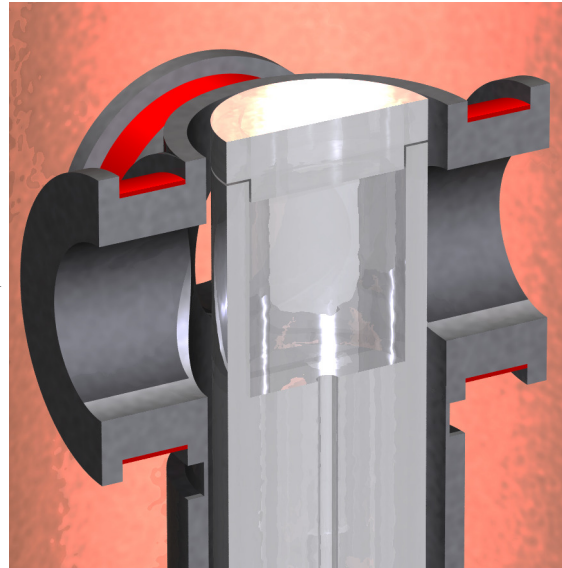
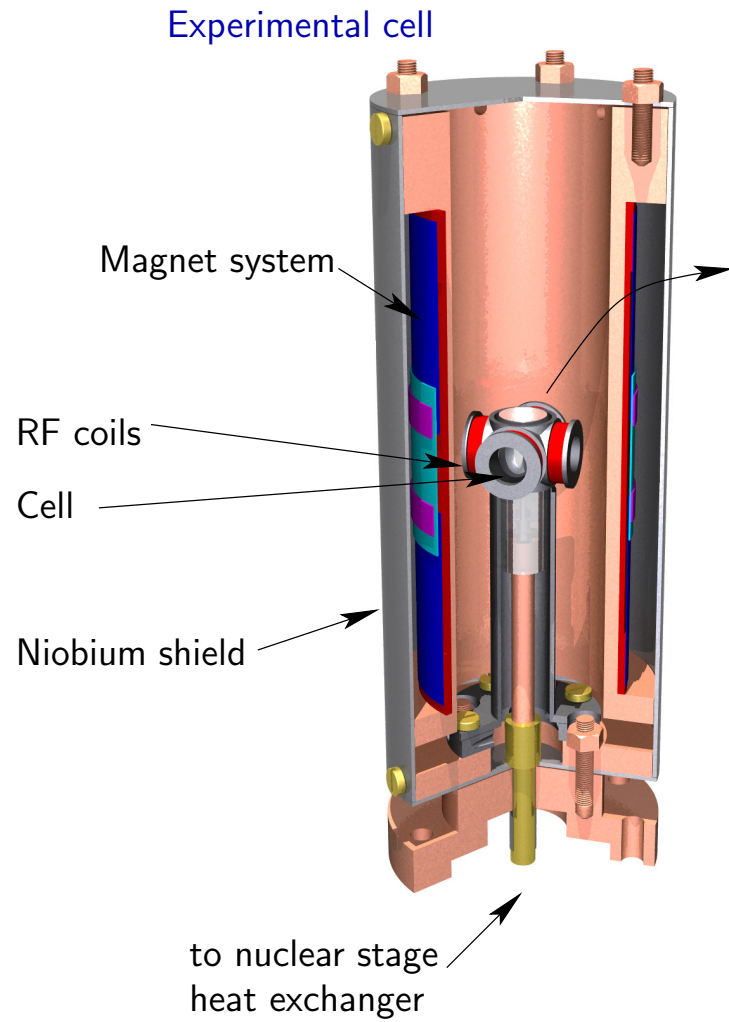
# Homogeneously precessing domain (HPD)



Experiment with two HPDs (Moscow, 1987)



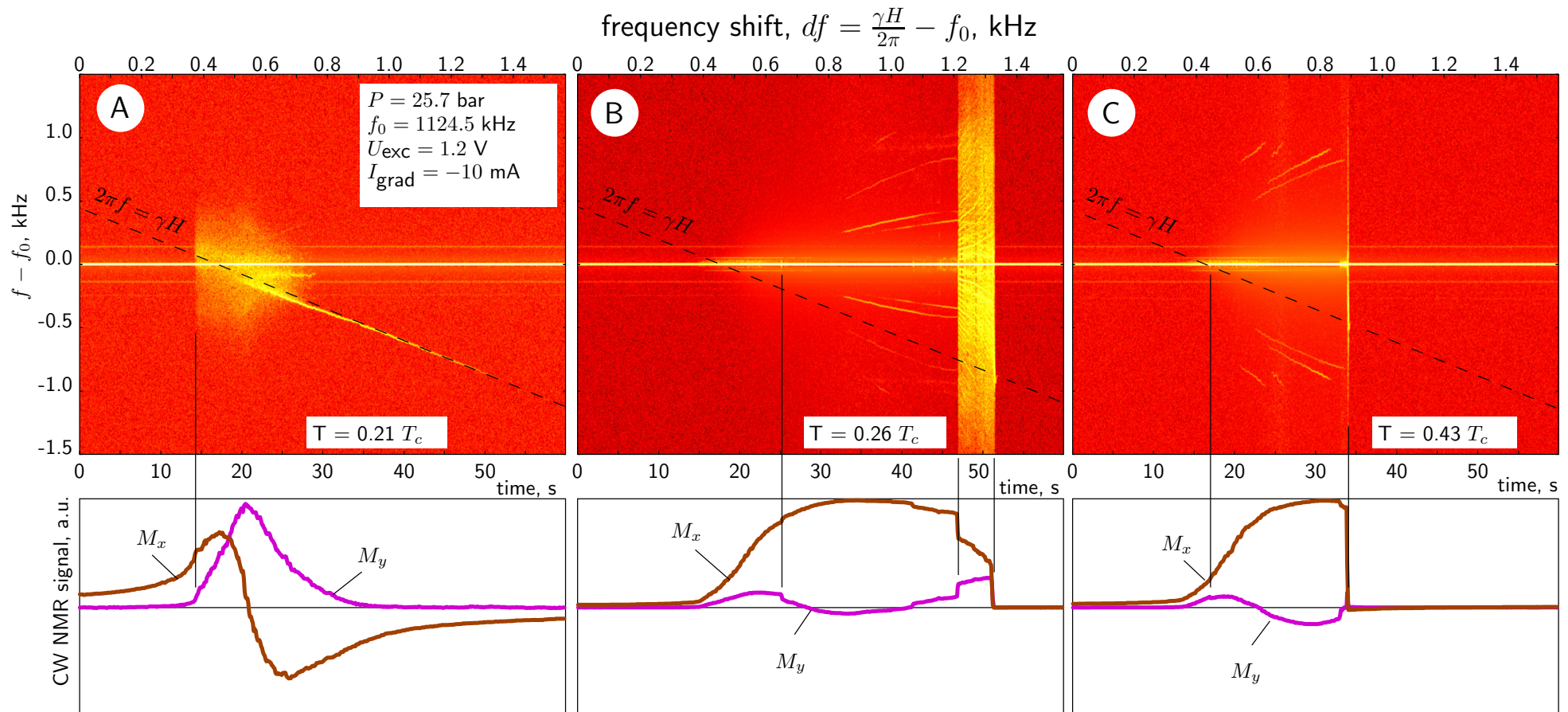
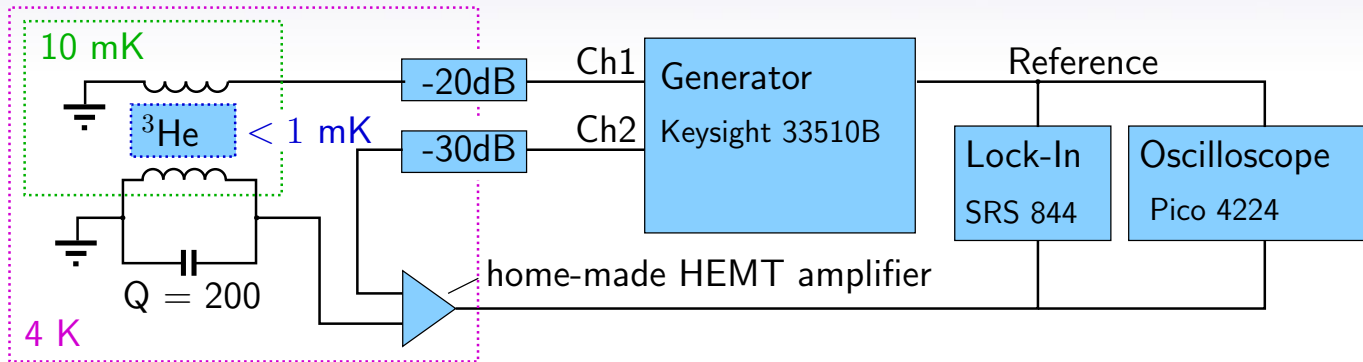
# Experimental cell



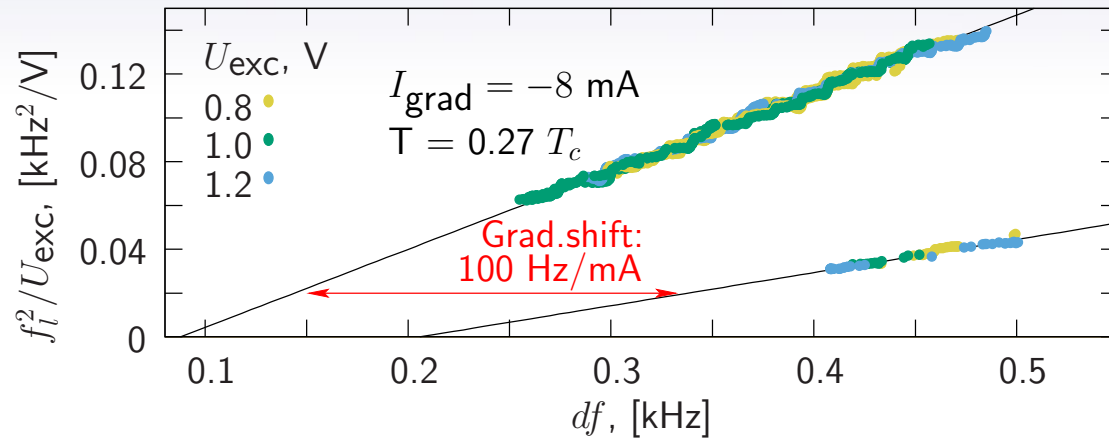


# Experiment

## NMR spectrometer

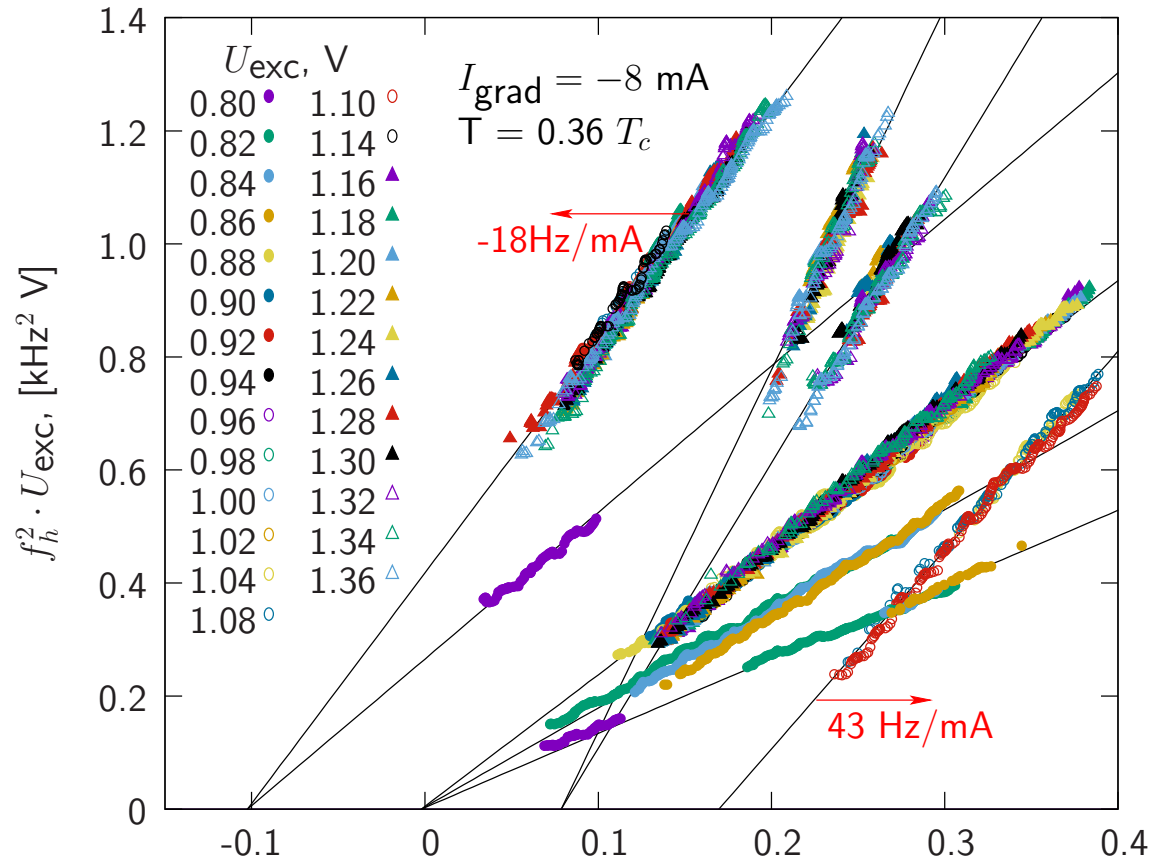


# Results



"Low-temperature" modes:

$$f^2 \propto (\omega - \gamma H) \cdot H_{\text{RF}}$$



"High-temperature" modes:

$$f^2 \propto (\omega - \gamma H) / H_{\text{RF}}$$

Gradient dependence: oscillations are localized in different parts of the cell.

Parameters:

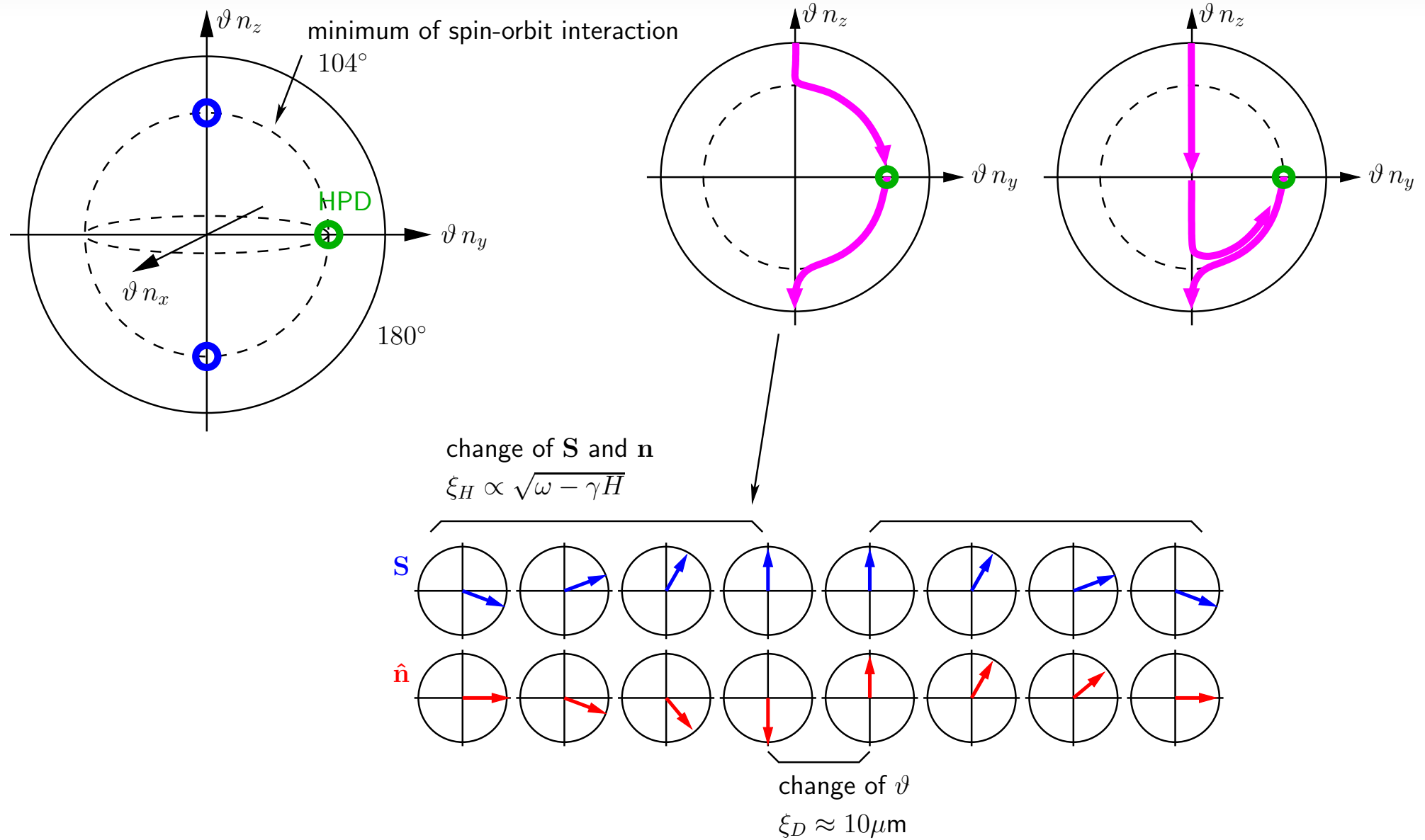
$$\gamma H_0 / 2\pi = 1.12 \text{ MHz}$$

$$\gamma H_{\text{RF}} / 2\pi = 5 \dots 8 \text{ Hz}$$

$$(\omega - \gamma H_0) / 2\pi = 0 \dots 400 \text{ Hz}$$

# $\vartheta$ -solitons

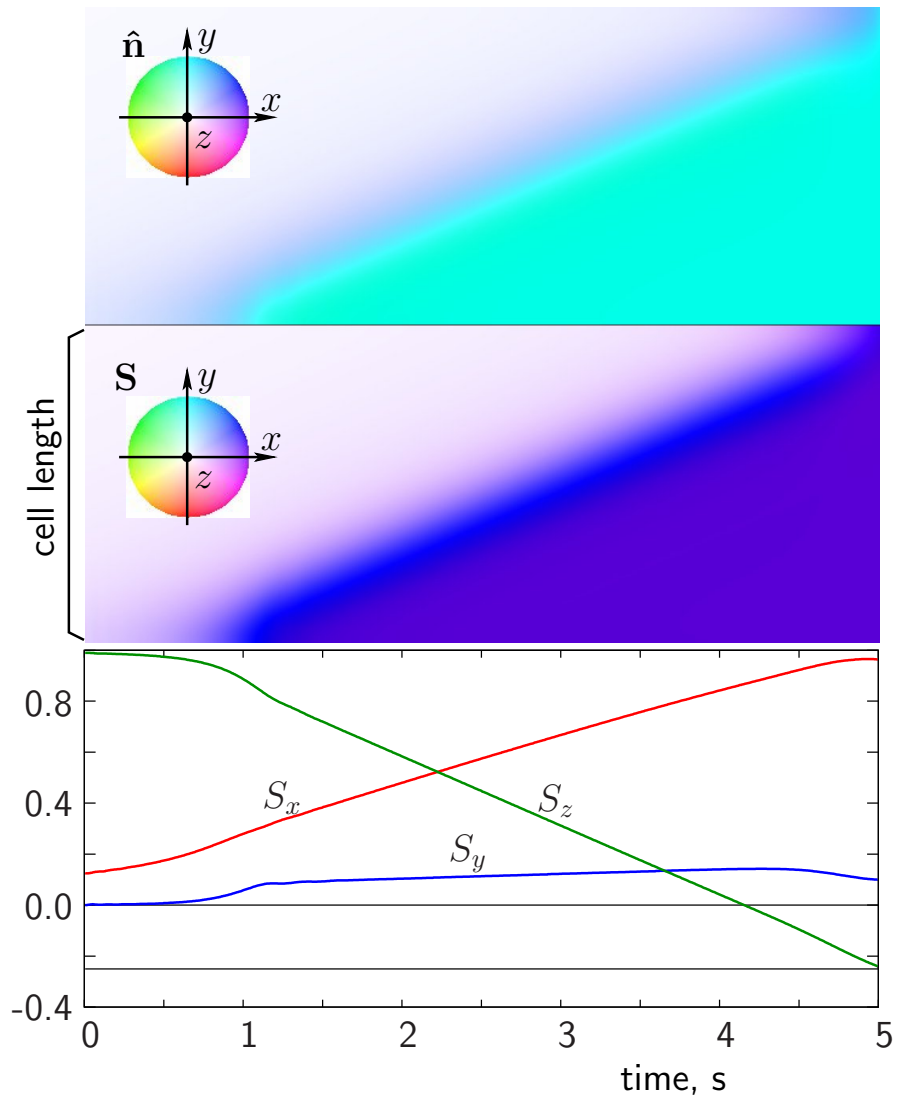
$\vartheta \hat{\mathbf{n}}$  coordinates:



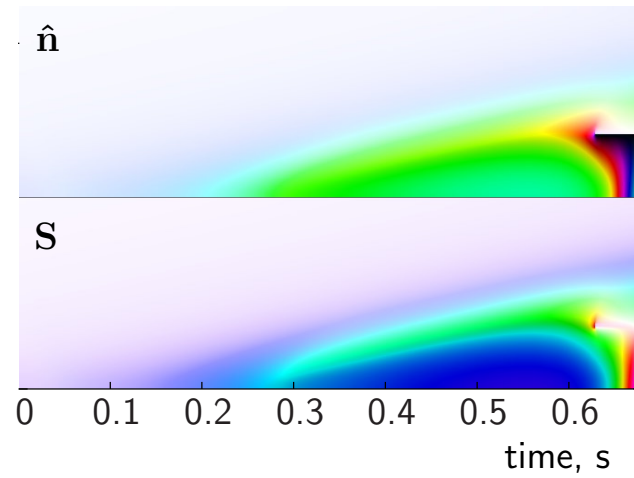


# Numerical simulations

## Creation of HPD in CW NMR



## Instability of the HPD boundary



## Soliton oscillations

