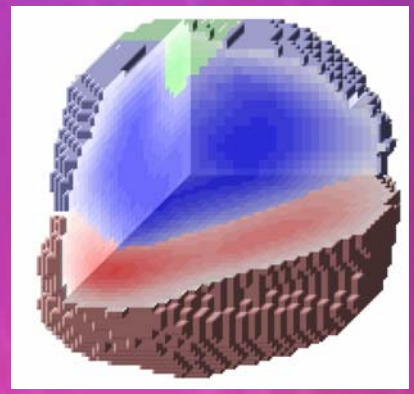
Nuclear Ordered Solid ^{3}He

:Experimental Study at Kyoto University

(T. Mizusaki Group)



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and

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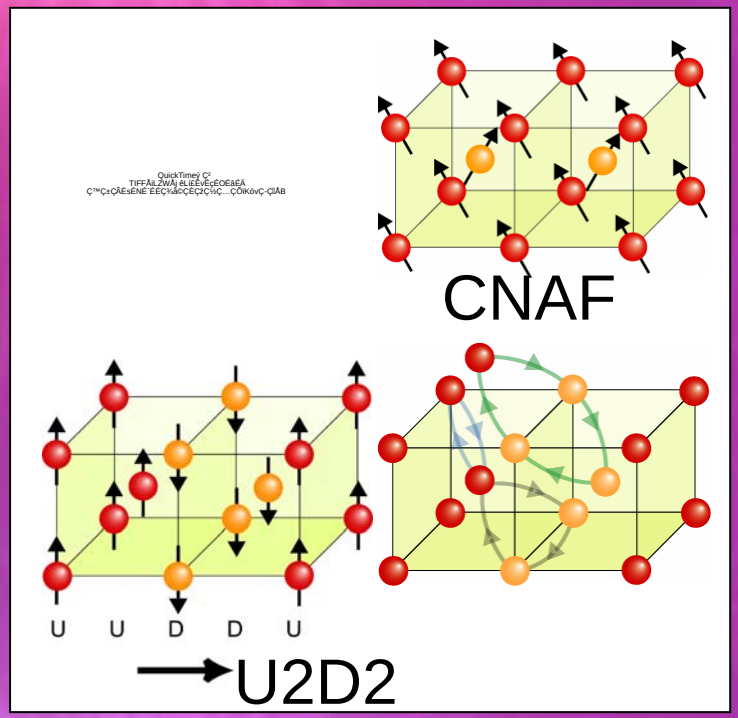
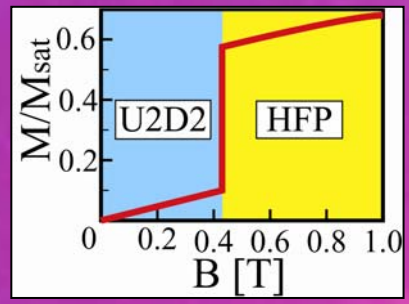
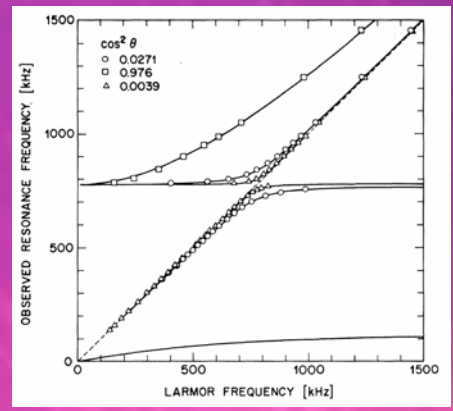
What's nuclear ordered solid helium-3.



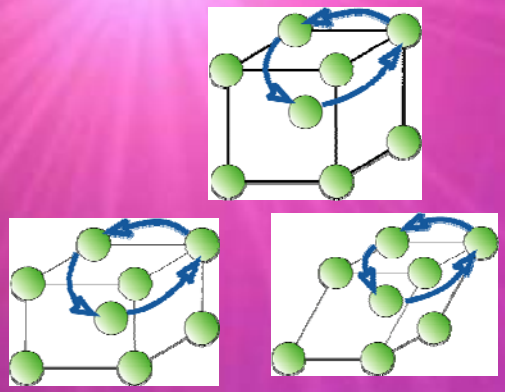
$$H_{spin} = -\frac{1}{2}\sum_{n=1}^{3} J_n \sum_{(i,j)} S_i \cdot S_j$$

$$-\frac{1}{4}K_P \sum_{(i,j,k,l)} \left[(S_i \cdot S_j)(S_k \cdot S_l) + (S_i \cdot S_l)(S_k \cdot S_j) + (S_i \cdot S_k)(S_j \cdot S_l) \right]$$



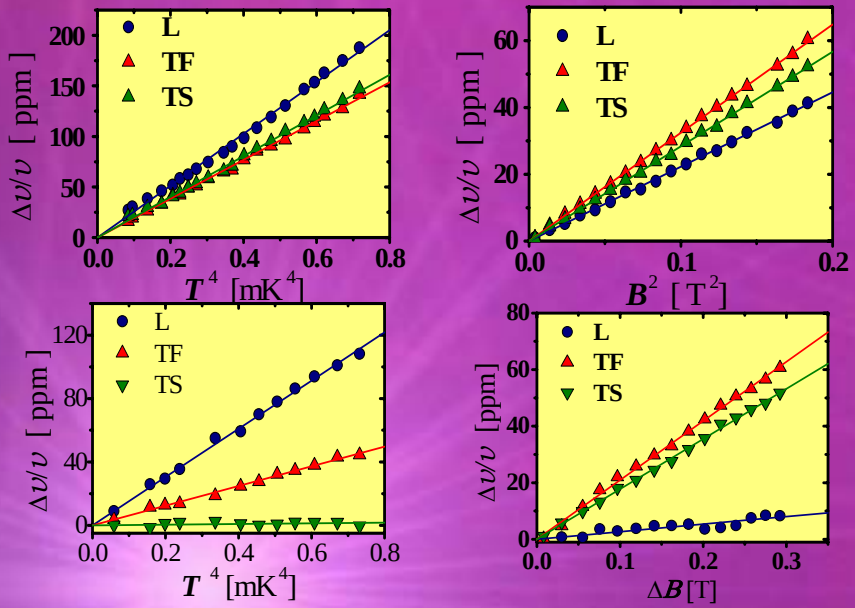


Ultrasound study



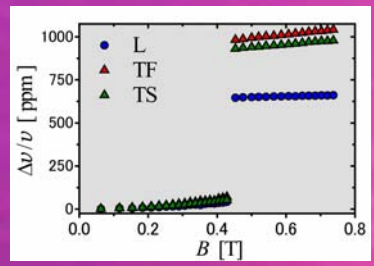
$$C_{ij} = \frac{\partial U}{\partial e_i \partial e_j} \propto \mathrm{v}^2$$

$$\Delta C_{ij}^{\mathrm{N}}(T,B) = \Gamma_{ij}^{X} \Delta U^{\mathrm{N}}(T,B) \cong \gamma_i^X \gamma_j^X \Delta U^{\mathrm{N}}(T,B)$$



$$\Delta \mathrm{v}(B)/\mathrm{v} = a B^2,\ a' \Delta B \rightarrow \gamma_i^{\chi}$$

$$\Delta \mathrm{v}(T)/\mathrm{v} = b T^4 \rightarrow \gamma_i^{c}$$



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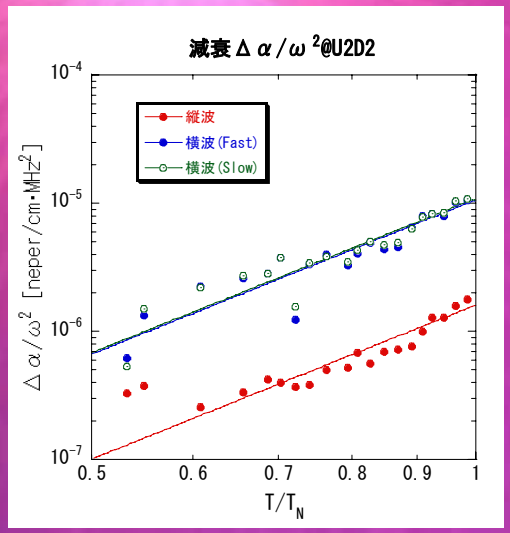
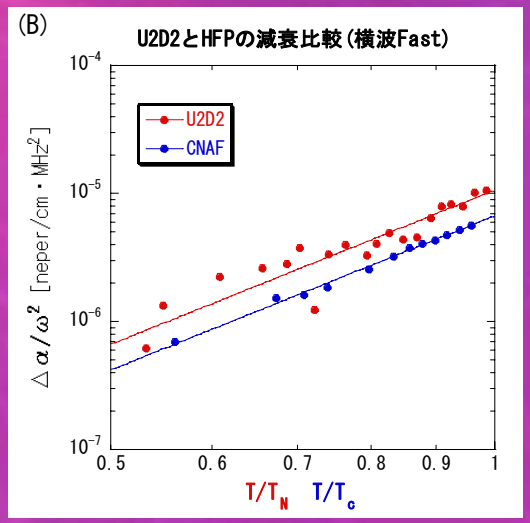
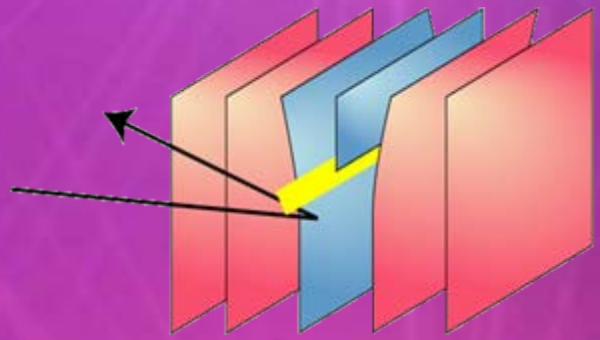
Ultrasound study 2





$$\alpha \propto \omega^2 T^4 / c^3$$

indep. of field



QuickTimeý Ç²
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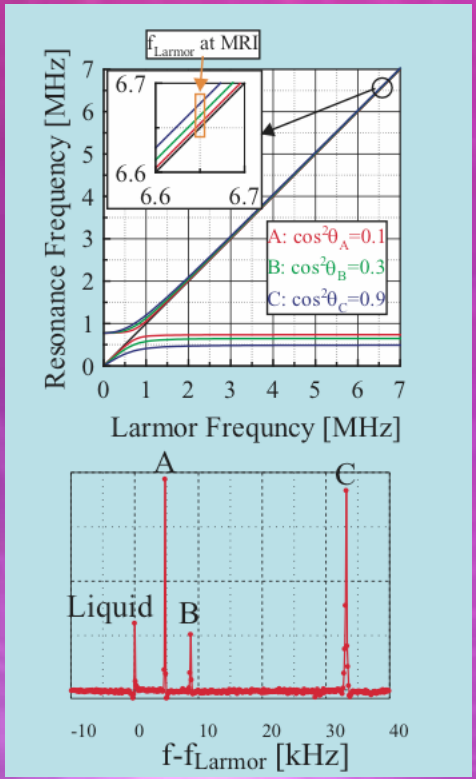
Coupling to Optical mode was observed here

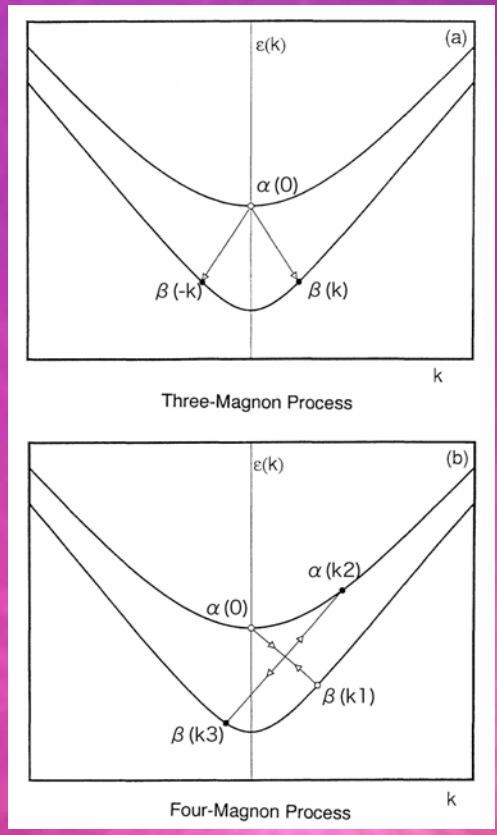
NMR study

- Non Linear spin dynamic equations (OCF eqs)
- Tipping angle dependent frequency shift

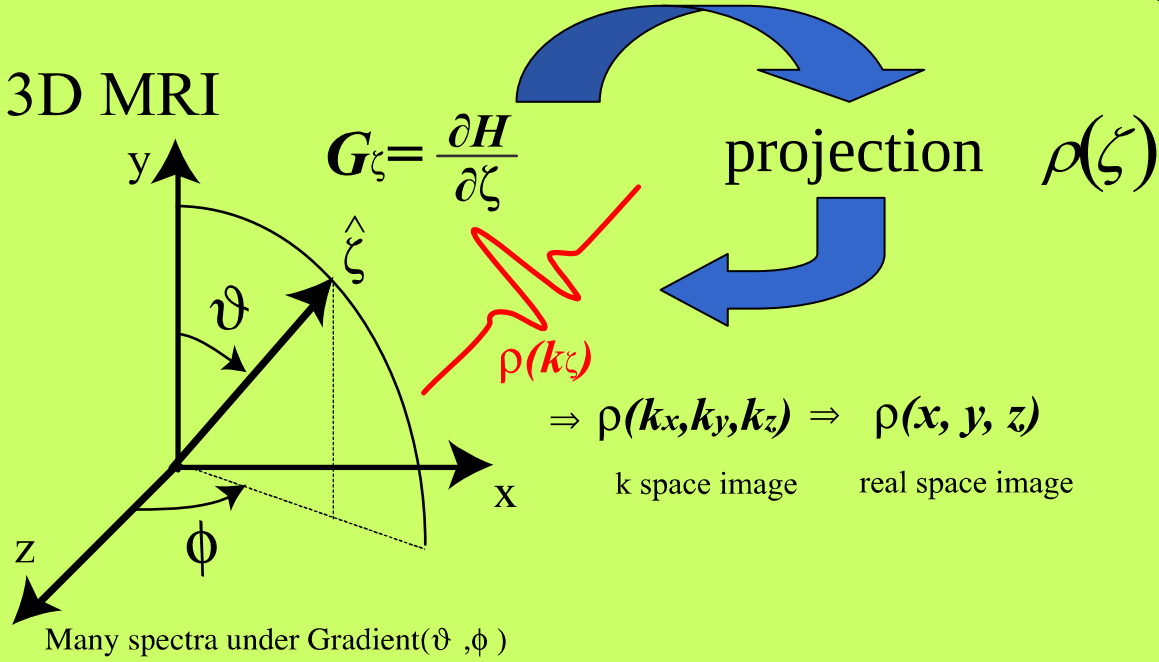
- Multimagnon spin relaxation
- Negative frequency shift
- Tipping angle dependent frequency shift and spin relaxation



$\omega_L >> \Omega_0(\sim 1MHz)$
Small tipping angle
RF pulse and FID



3DMRI



Typically 32x32 directions of $\hat{\zeta}$ in 1/2 space

$$\theta = n \cdot \frac{\pi}{32}, \phi = m \cdot \frac{\pi}{32} \quad (n,m = 0 \ldots 31)$$

T=550μK ; Coolest Images in the world!

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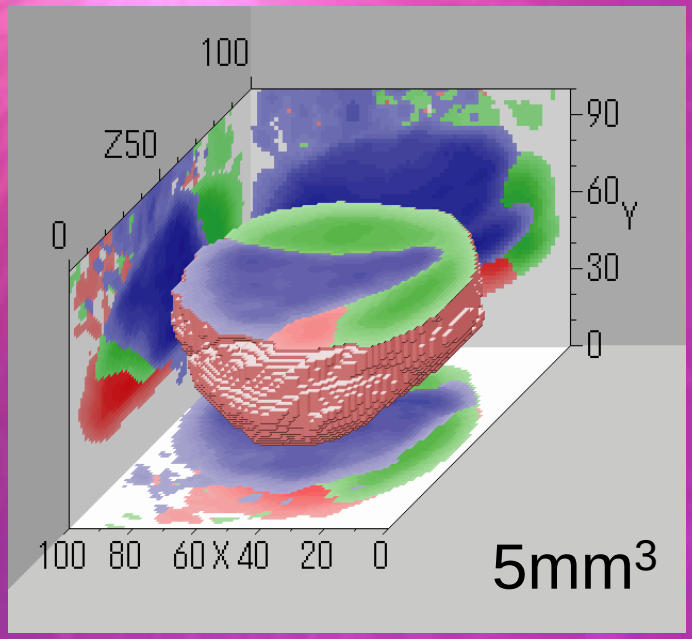
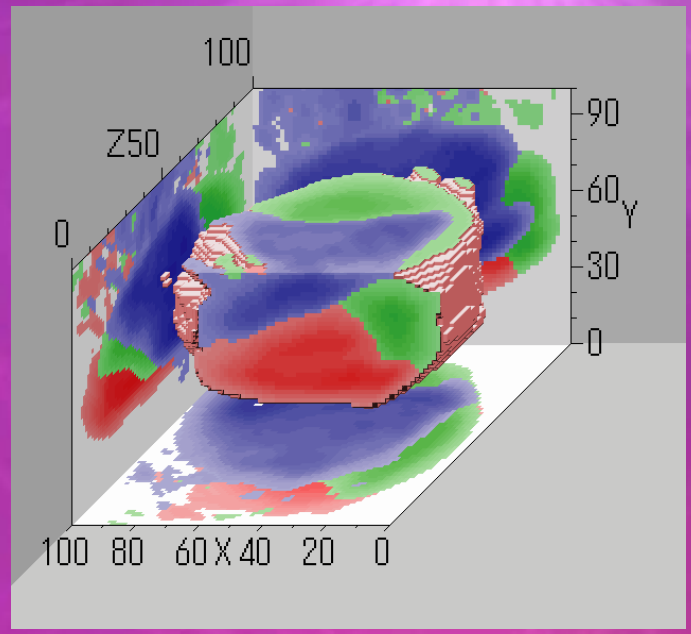
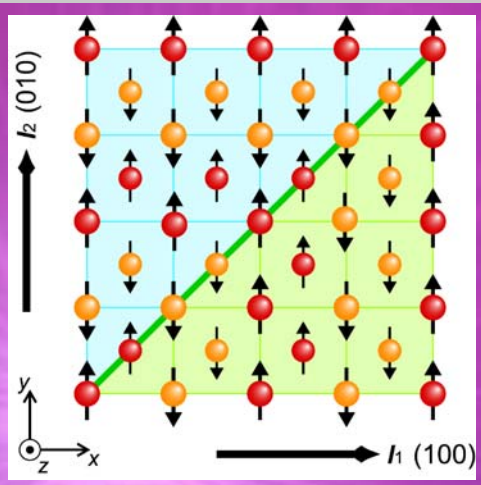
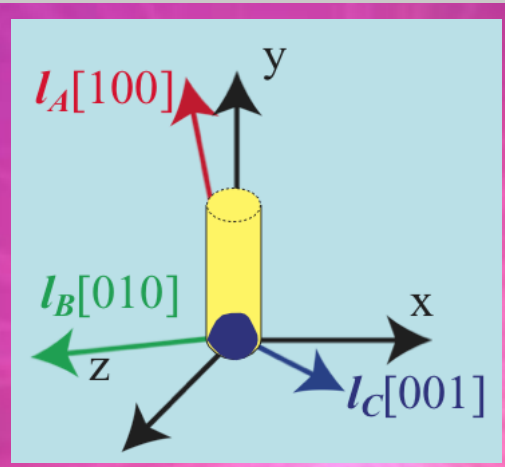
3D images of U2D2 ^{3}He



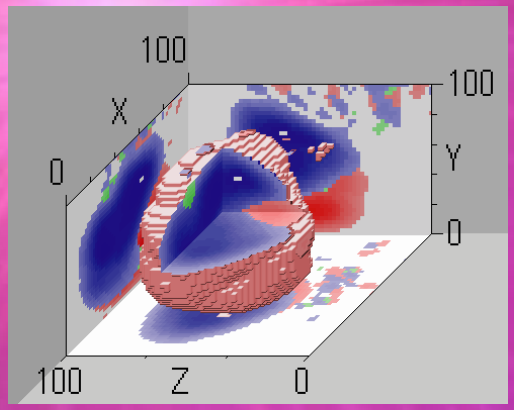




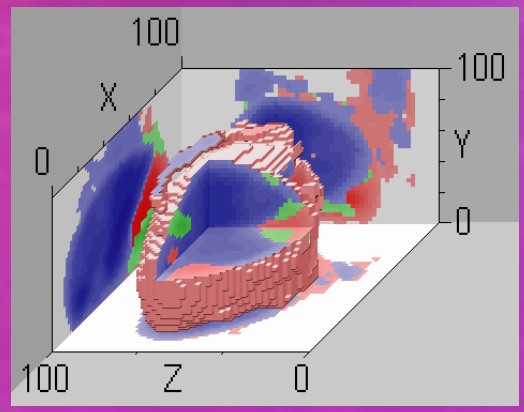
(110) Domain wall
1986 M. Tsubota

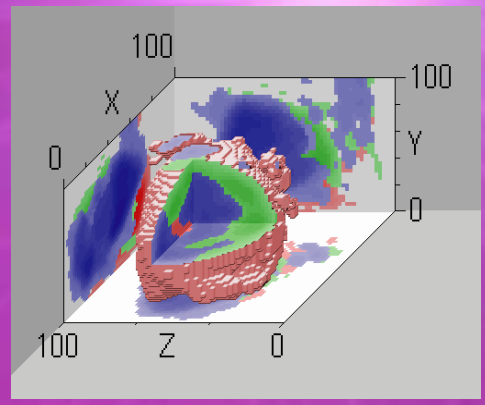


Memory effect

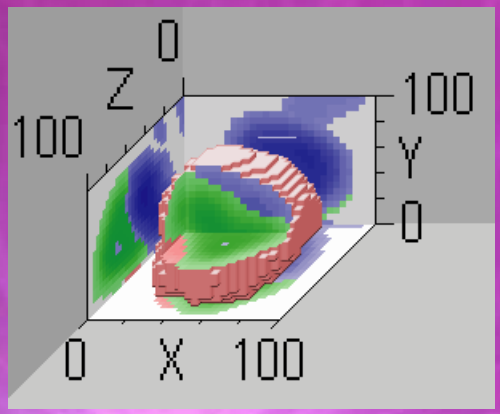


5mm³

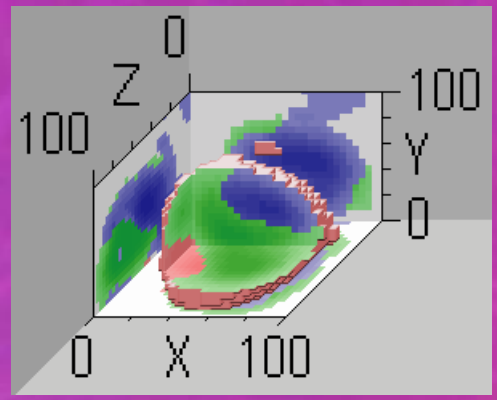


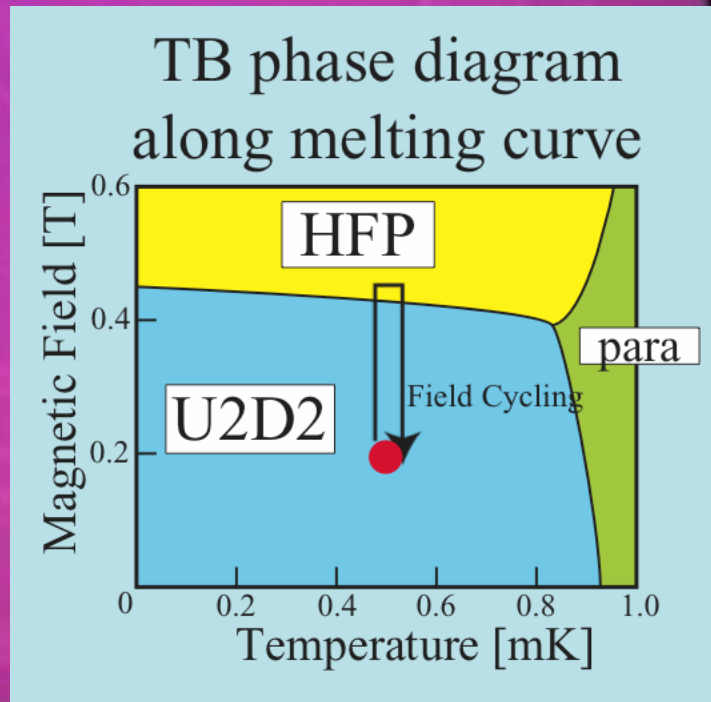


Field Cycling

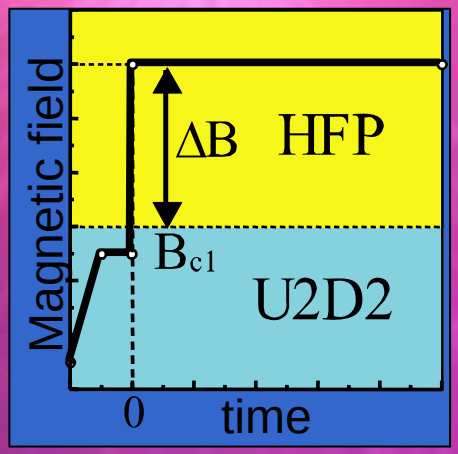


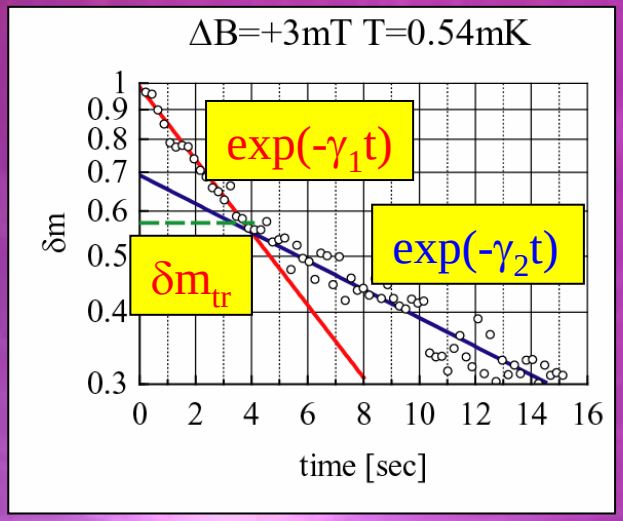
20mm³

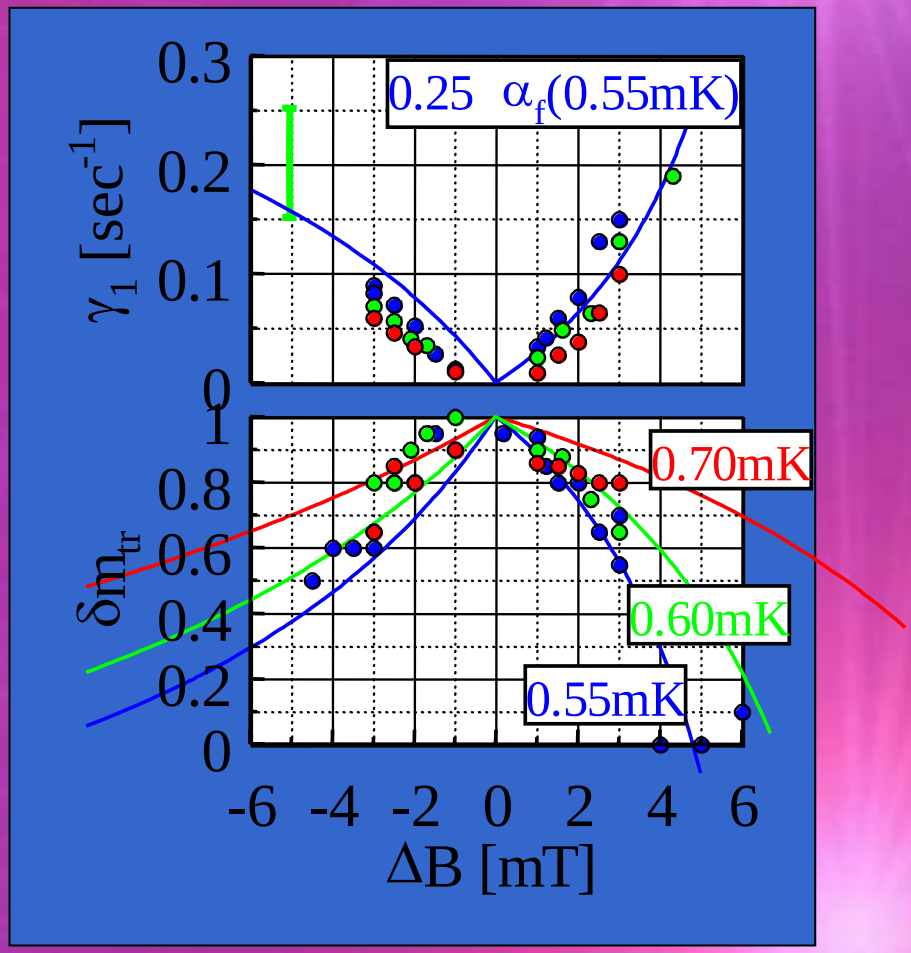




Dynamics of Magnetic Field Induced Phase Transition

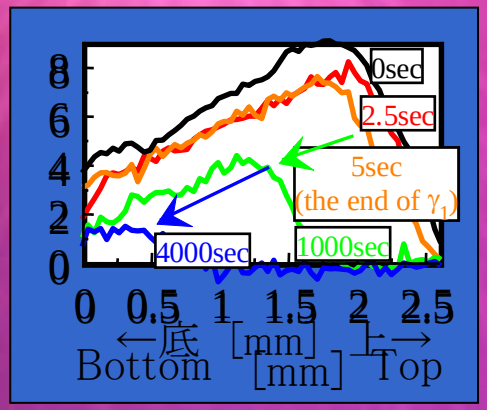


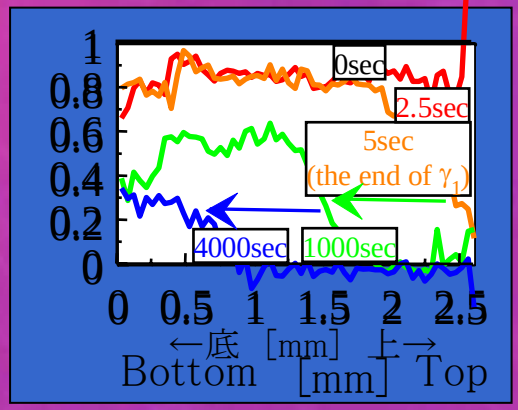


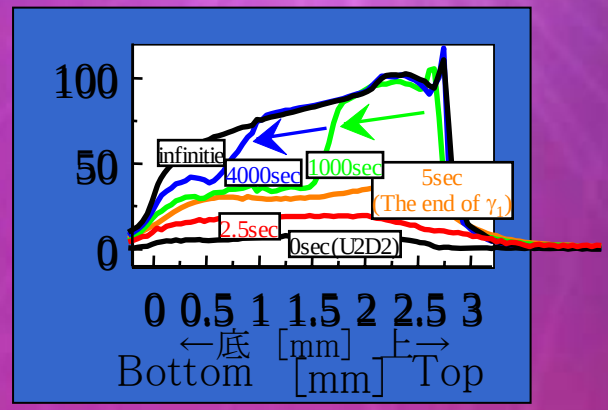


ynamics of Magnetic Field Induced Phase Transition 2

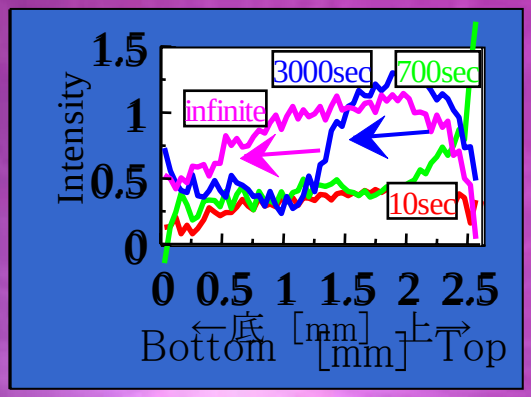
U2D2 >> HFP

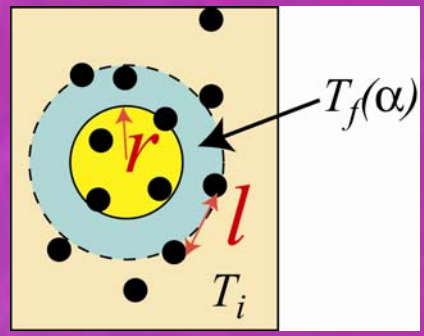


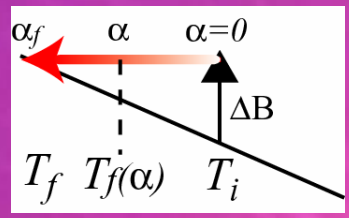


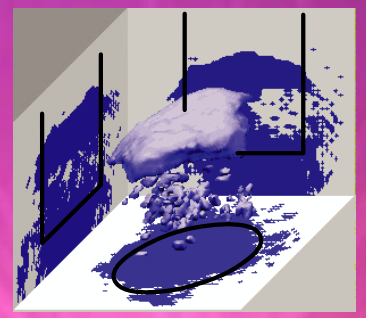


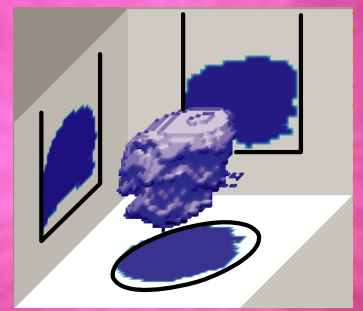
HFP >> U2D2











$$S_{meta}(T_i)=\alpha S_{stable}(T_f)+(1-\alpha)S_{meta}(T_f)$$

$$\alpha_f = \left(\frac{a_{stable}}{a_{metastable}}-1\right)^{-1}\left\{\left(1-\frac{\Delta B}{92T_i^4}\right)^{-3/4}-1\right\}$$

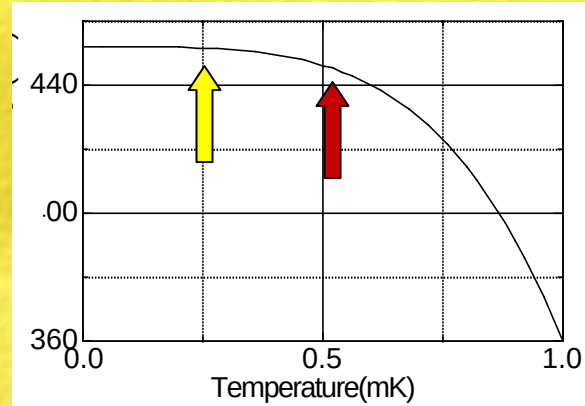
What will come in the near future

Origin of domain structure and Memory effect

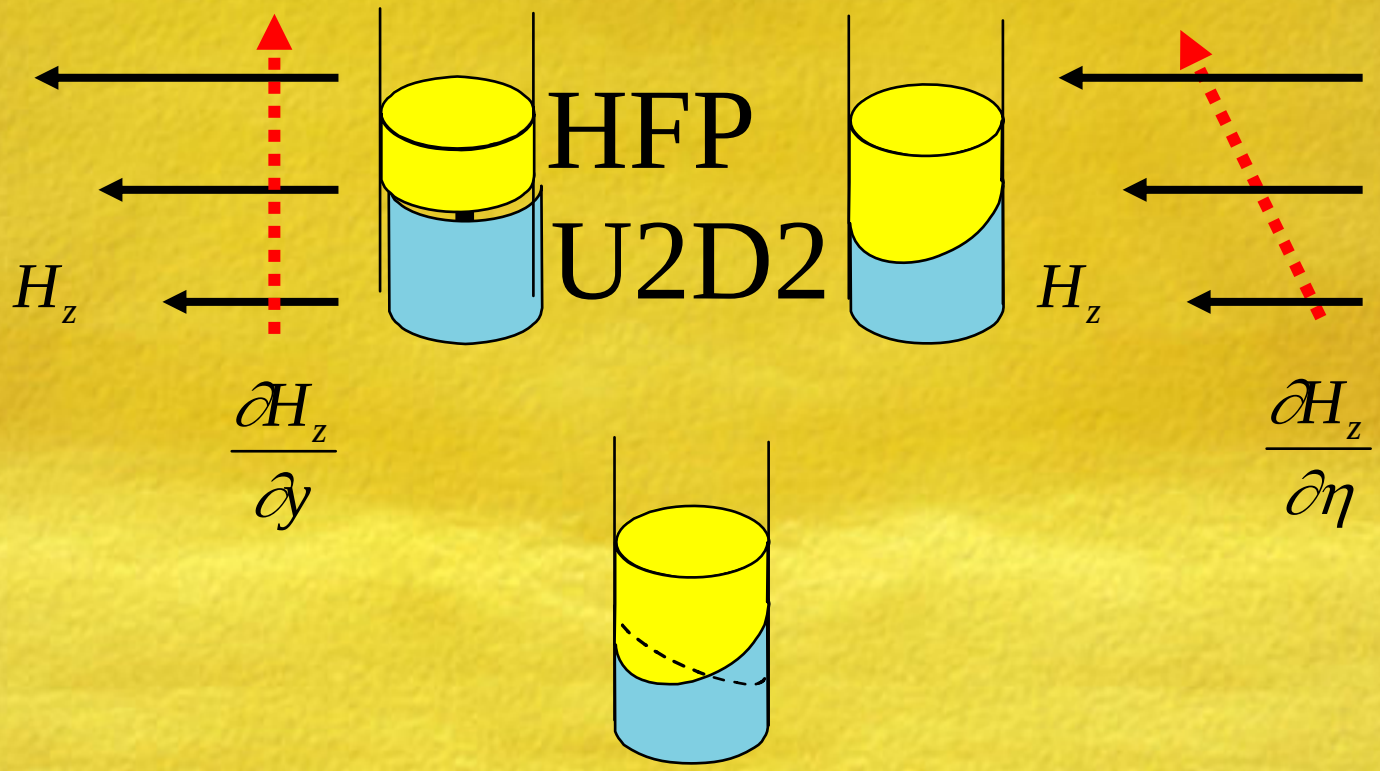
Precise measurement of $\Omega_0(B)$ and negative frequency shift

What's next

Lower temperature >> no latent heat transport problem

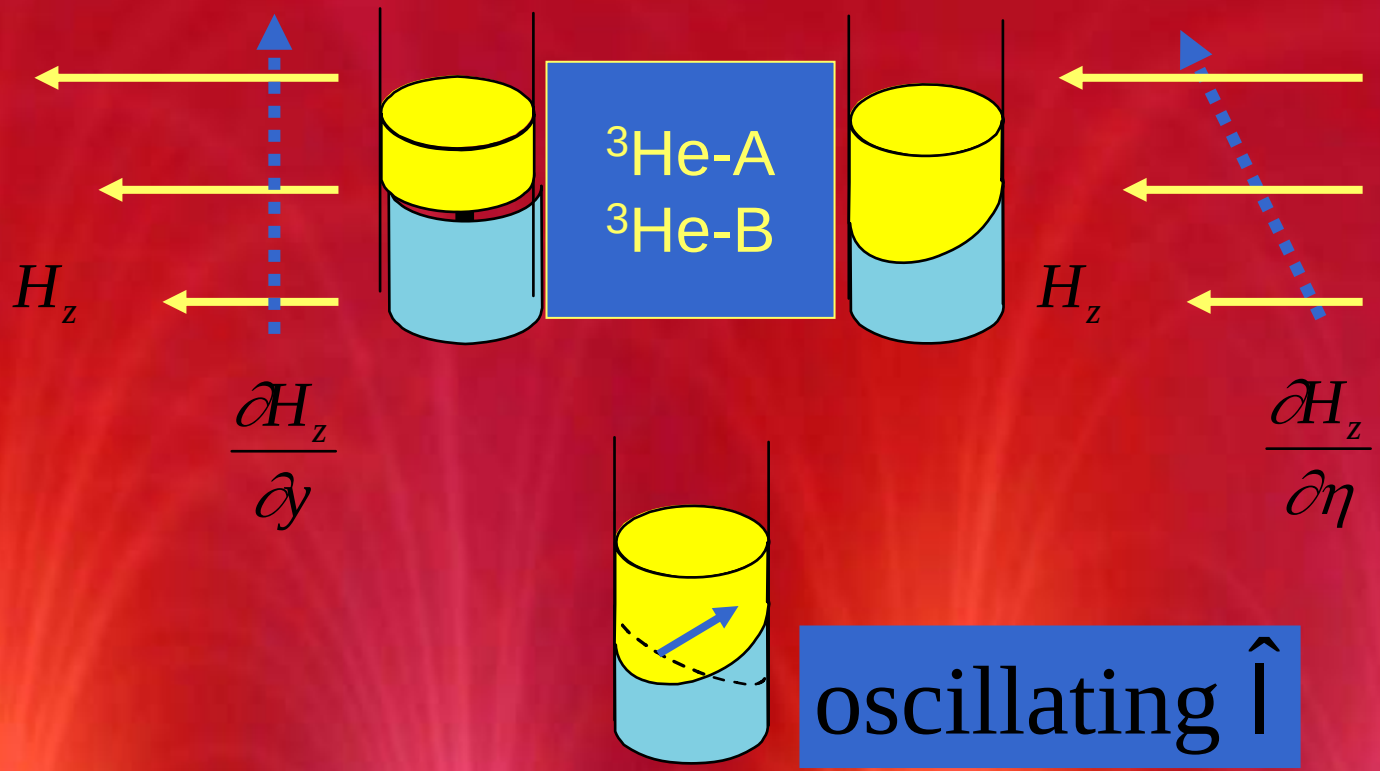


Interface kinetics

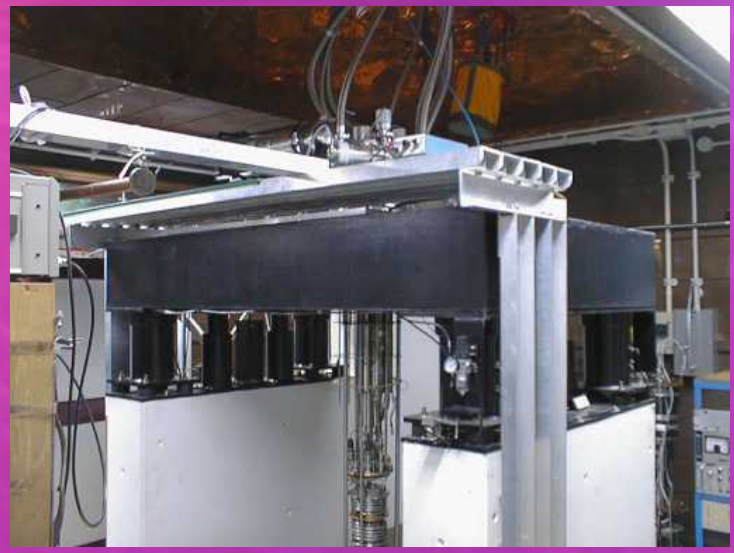


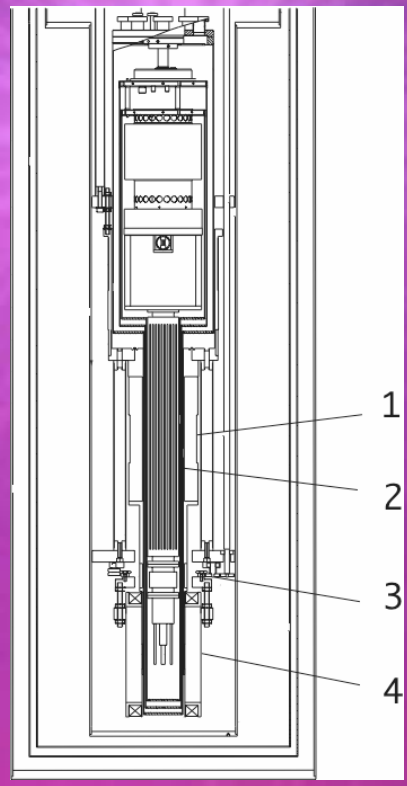
Oscillating Interface

Order Parameter Wave



ULT-Magnetic Resonance Microscope





Dilution Refrigerator
~10mK
Adiabatic Demagnetization
~100 μ K
NMR field
1T, 10ppm
Field Gradient
1T/m (max)

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