Observation of NCRI in Bulk Solid ^{4}He Confined in a Cylindrical Cavity

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Outline

1. Torsional Oscillator Study: Motivation and Aim
2. Experimental
3. Possible Observation of NCRI
4. Comparison with the PSU results
5. Discussion
6. Summary and Future Studies

Motivation and Aim

No other positive experiments for > 2 years since the PSU experiment

1. It is still worth reproducing the "supersolidity" by torsional oscillator technique.

2. Detailed torsional oscillator study
   Frequency, Geometry, Crystal Quality, ...

3. "Simultaneous" measurement of other properties (ultrasound, fourth sound, heat capacity) with torsional oscillator

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Torsional Oscillator: Strategy

1. Higher frequency: 1750 Hz

2. Simpler geometry and better crystal quality:
   Cylindrical bulk solid

3. Higher stability in frequency and amplitude:
   Aluminum alloy oscillator

"If you run after two hares, you will catch neither."
(Japanese proverb)

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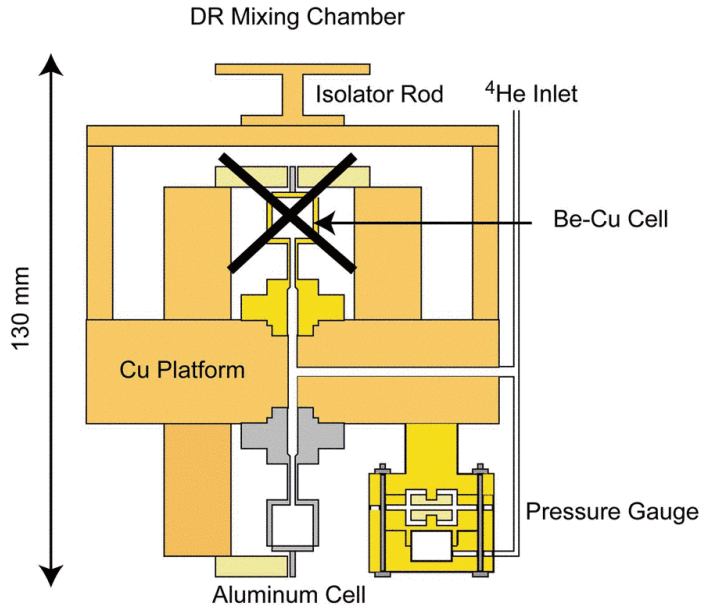
Torsional Oscillator: The Whole Setup



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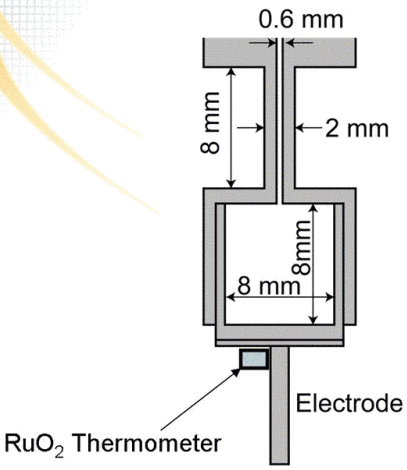
Sample Cell: Aluminum 5056 Cylinder



Empty Cell:
Low Q (1.8×10^5)
and poor stability in f

Bulk Solid ($P \sim 5.2$ MPa):
Q increased 4 times
f stability improved

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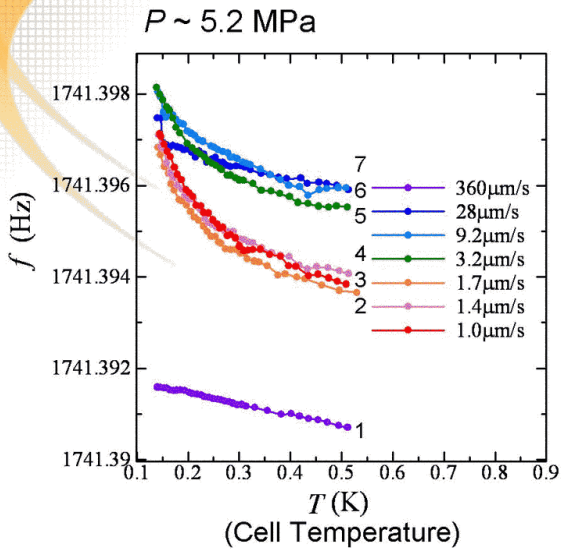
Frequency



Measurement limited to T > 0.14 K due to superconducting transition of the Al oscillator

Systematic drift
→Relaxation in solid ^{4}He?

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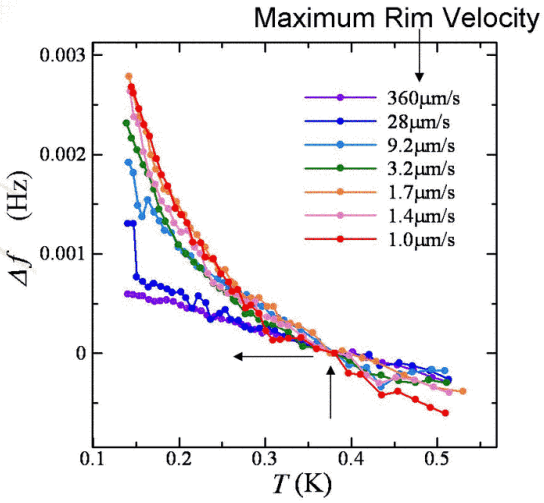
NCRI?



v < 3 μm/s
v > 28 μm/s

Little velocity dependence

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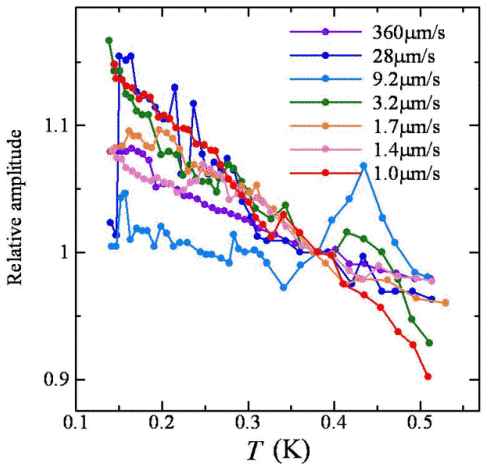
Oscillation Amplitude

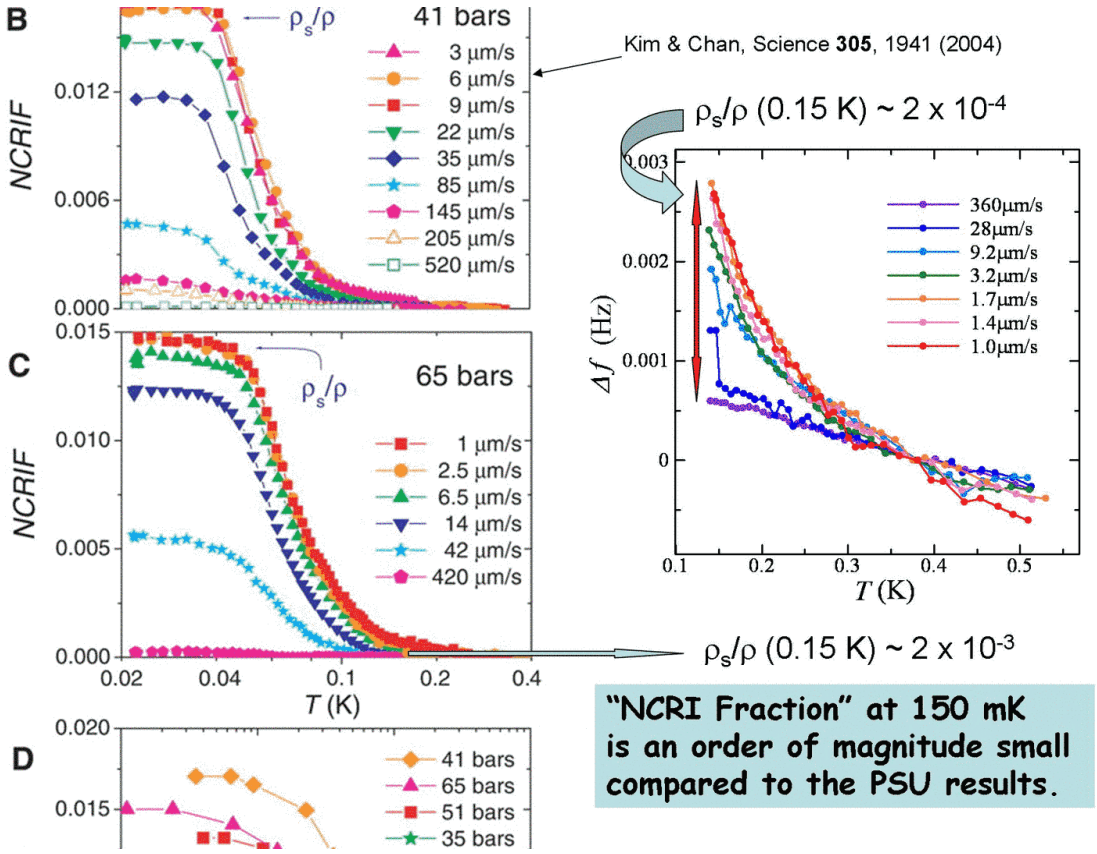


No systematic velocity dependence
No Dissipation Peaks associated with the NCRI

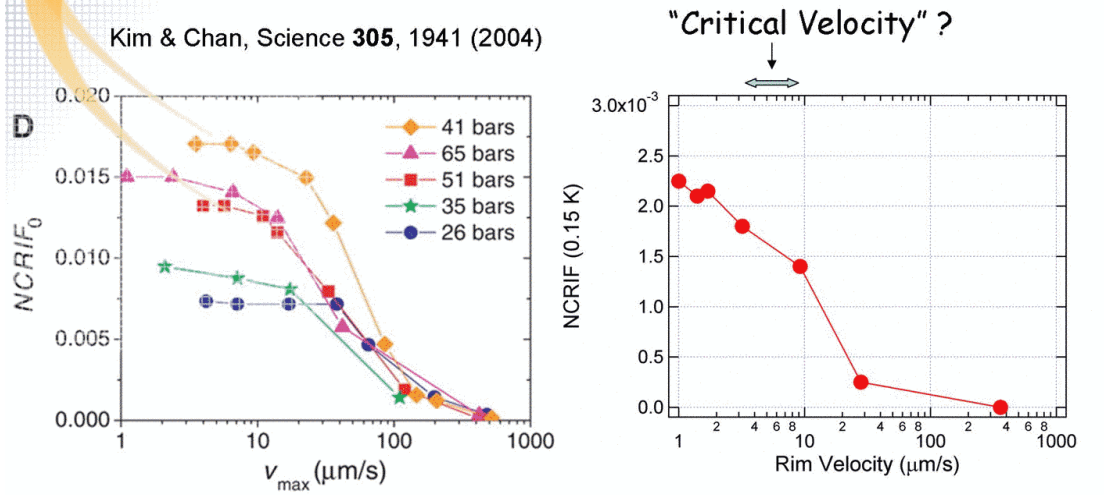
Comparison with the PSU Results

We assume that..
the observed changes in frequency has
the same physical origin as the PSU observation.

1. "NCRI Fraction"
2. Velocity Dependence
3. Discussion



Velocity Dependence



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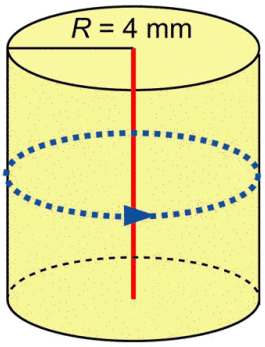
Discussion

1. Small "NCRI" Fraction:
   - Higher frequency (1750 Hz)
   - Cylindrical geometry
   - Crystal annealing was insufficient.

2. "Critical Rim Velocity" $3 < v_s < 10$ μm/sec



$$v_s = \frac{\kappa}{2\pi R} n \qquad \kappa \equiv \frac{h}{m} \qquad \Rightarrow \quad v_s = 4\ \mu\mathrm{m/s}$$

Summary

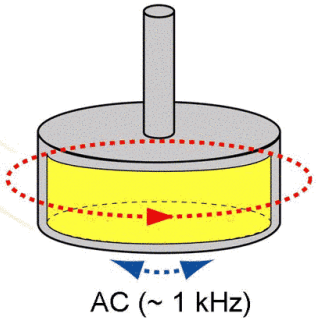
Velocity – dependent change in frequency
→ NCRI ?

- "NCRI fraction" : 2×10^{-4} at 0.15 K
- "Critical Velocity" : $3 < v_c < 10$ μs/sec

A new torsional oscillator experiment is underway.
- Be-Cu, 580 Hz, same cylinder size

Plan: Torsional Oscillator under DC Rotation

Collaboration with M. Kubota (ISSP)



DC (0 ~ 30 rad/s)

Rotating dilution refrigerator

AC (~ 1 kHz)

Note: "Critical rotation speed" $\Omega_c \sim 10\Omega_\oplus$ (the earth's rotation speed)

for R ~ 1 cm cell

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