Overview of Supersolid Research at Cornell

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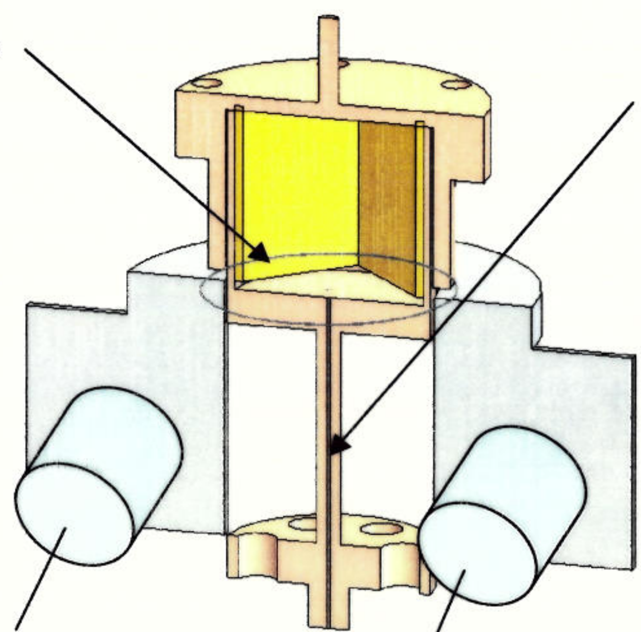
Cell Geometries

- Cylindrical Vol = 1.8 cm^{-3}
- Cubic Vol = 1.4 cm^{-3}
- Annular Vol = 0.159 and 0.080 cm^{-3}

Experimental Setup



f_{res} = 185 Hz

$Q = 1 \times 10^6$

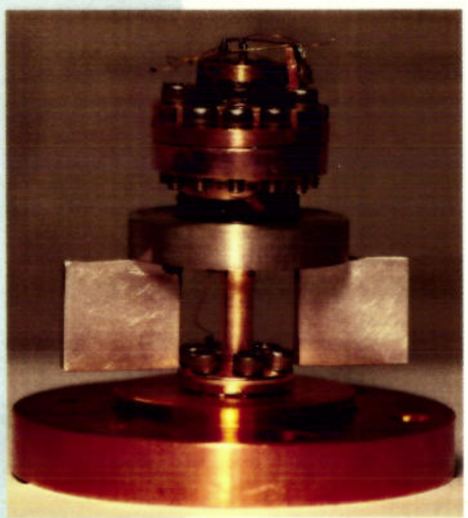
- Oscillator includes a capacitance strain gauge on top of cell
- Q is determined by ringdown above the transition
- The samples are grown with the blocked capillary technique (constant volume)

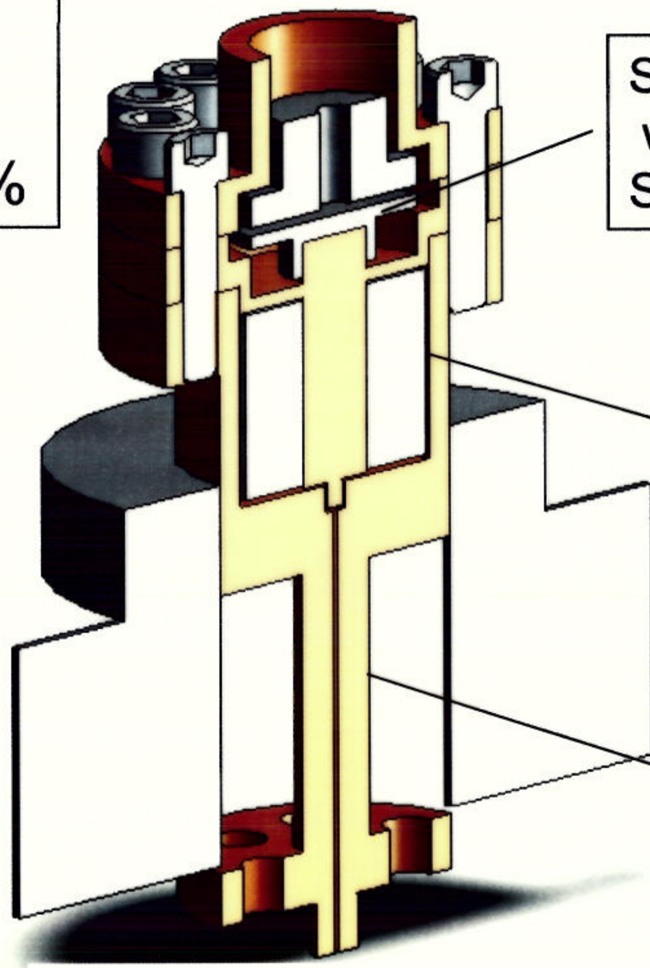
Experimental setup

f_{res} = 874 Hz

$Q_{4K} = 4 \times 10^5$

Resolution: 0.01 %



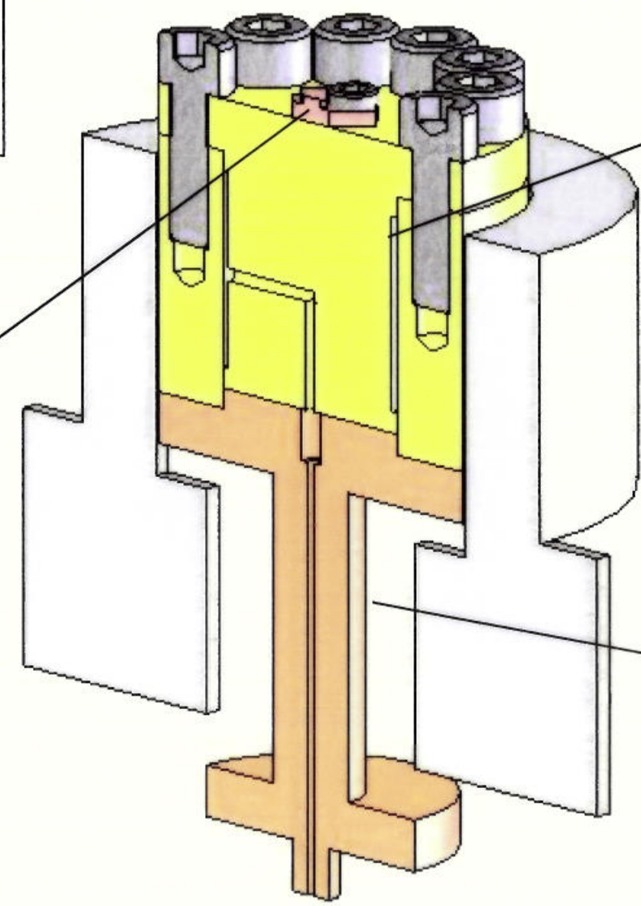


Thin annular oscillator

$f_{4K} = 920$ Hz

$Q_{4K} = 5 \times 10^5$

Heater for quench cooling



Torsion bob

$I_{est} = 90.61$ g*cm^2

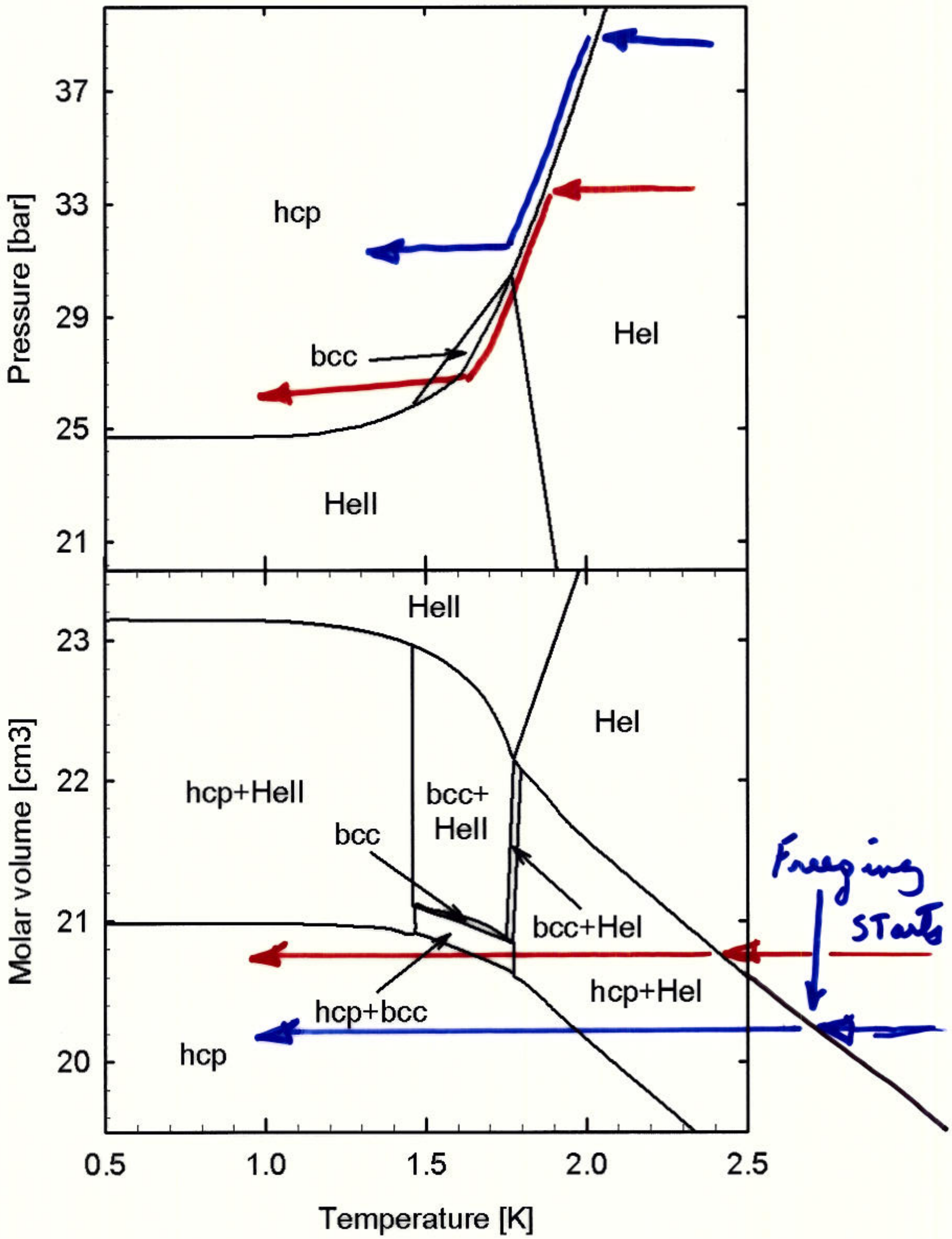
$\Delta P_{freeze} = 40.5$ns

gap = 101 μm

Torsion rod with fill line

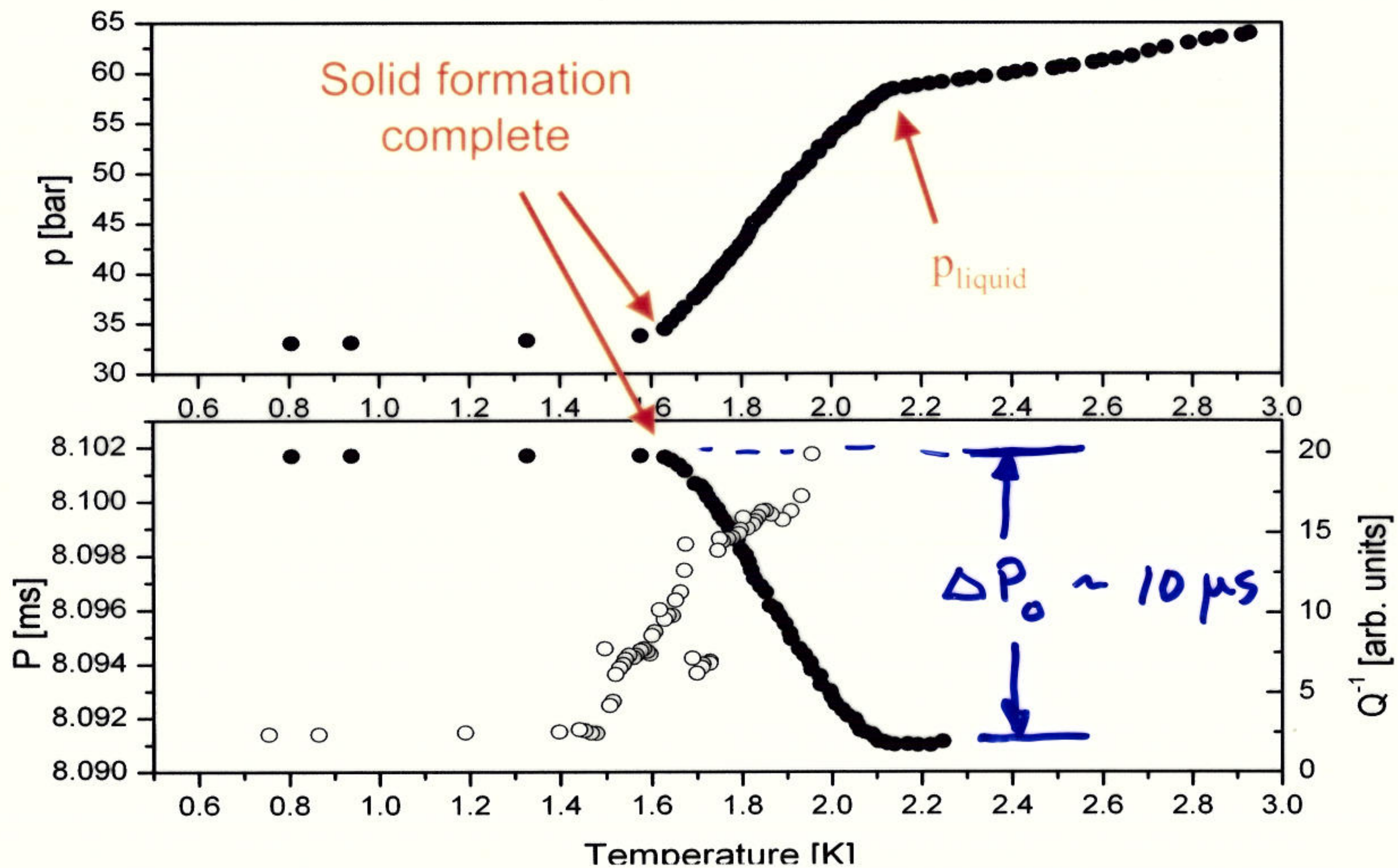
OD = 0.63 cm

ID = 0.7 mm

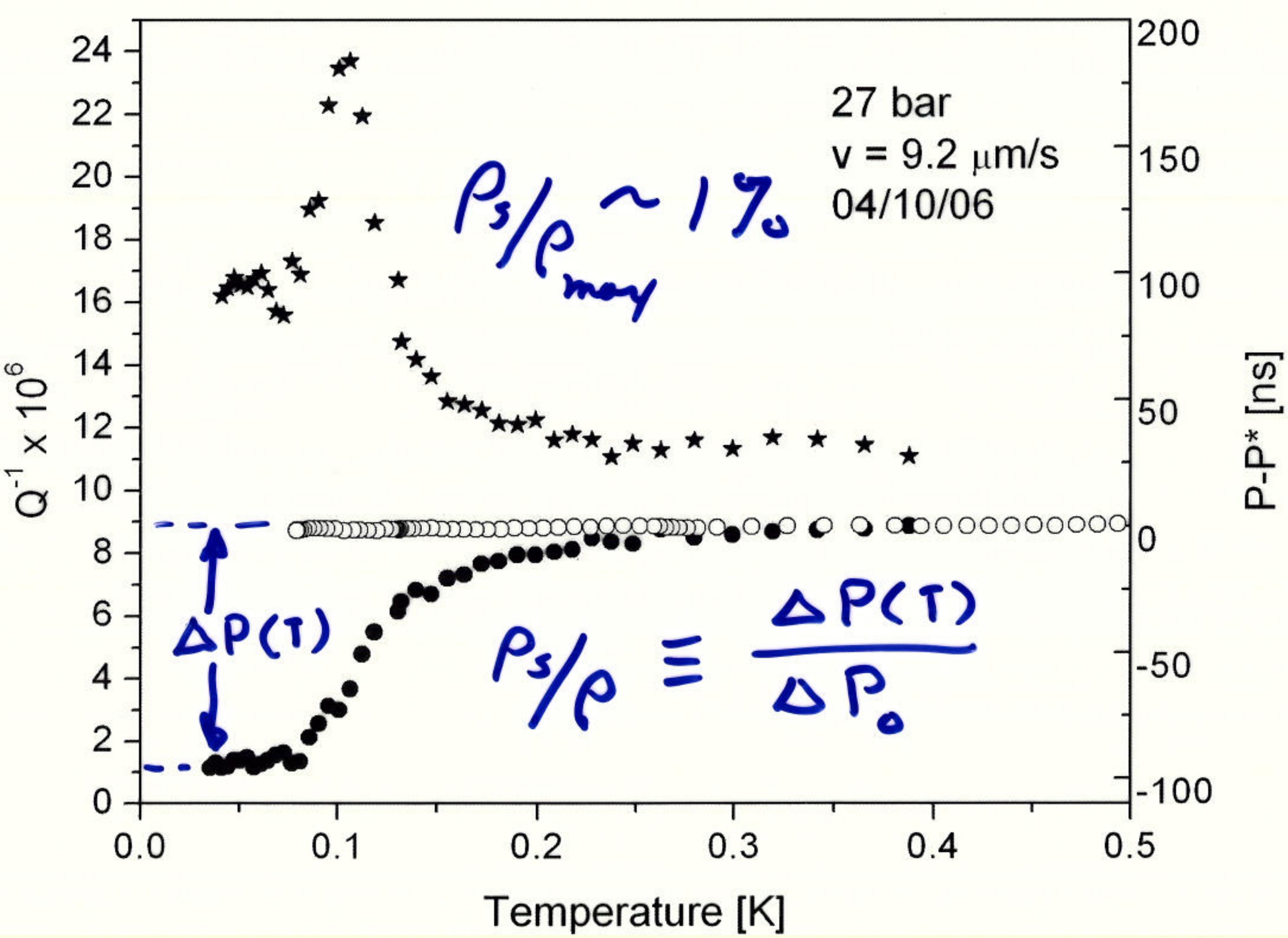


hcp
bcc
HeI
HeII
Pressure [bar]
37
33
29
25
21
HeII
HeI
hcp+HeII
bcc+
HeII
bcc
bcc+HeI
hcp+bcc
hcp+HeI
hcp
Molar volume [cm3]
23
22
21
20
0.5
1.0
1.5
2.0
2.5
Temperature [K]
Freezing
starts

Solidification of Sample

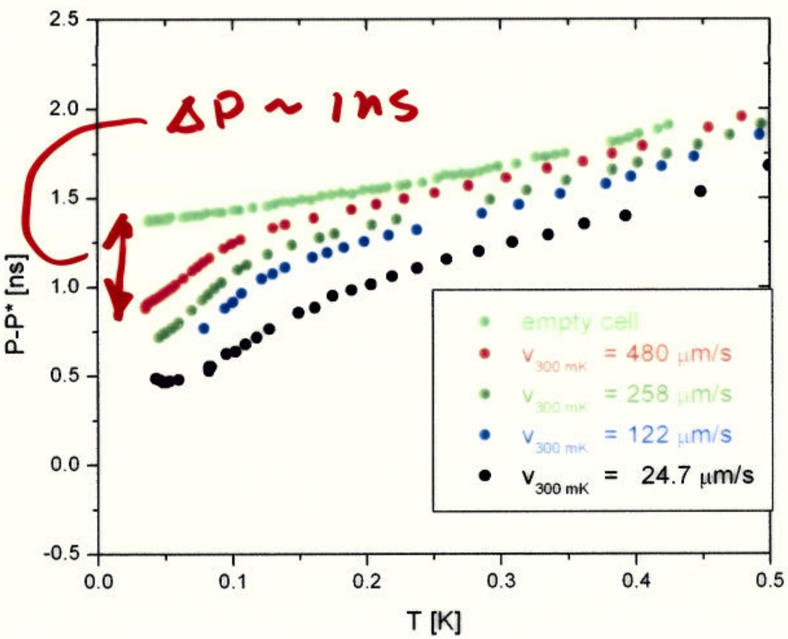


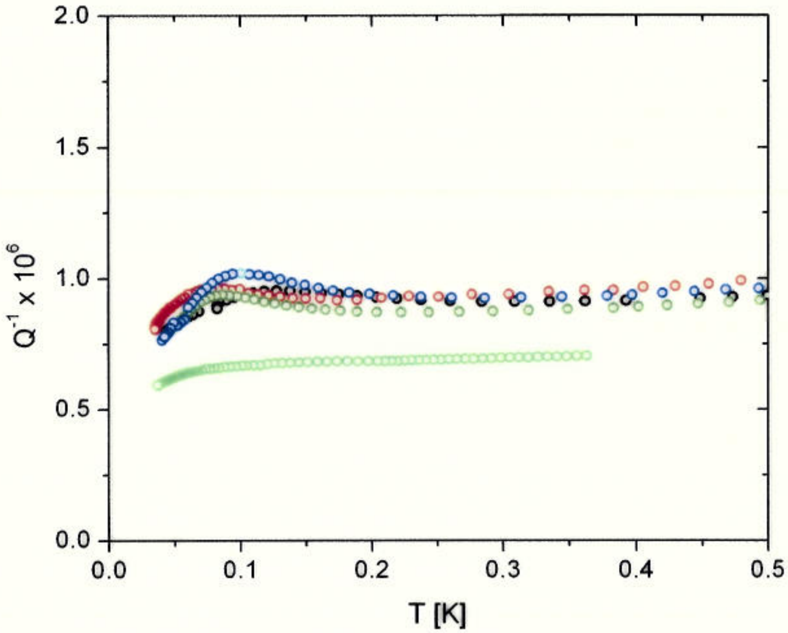
Square cell 27 bar



Cylindrical cell, S/V = 5.8 cm^{-1}

$\rho_s/\rho_{max} \sim \frac{1 ns}{1.9 \mu s} \sim \frac{1}{2} \times 10^{-3} = 5 \times 10^{-4} = 0.05\%$

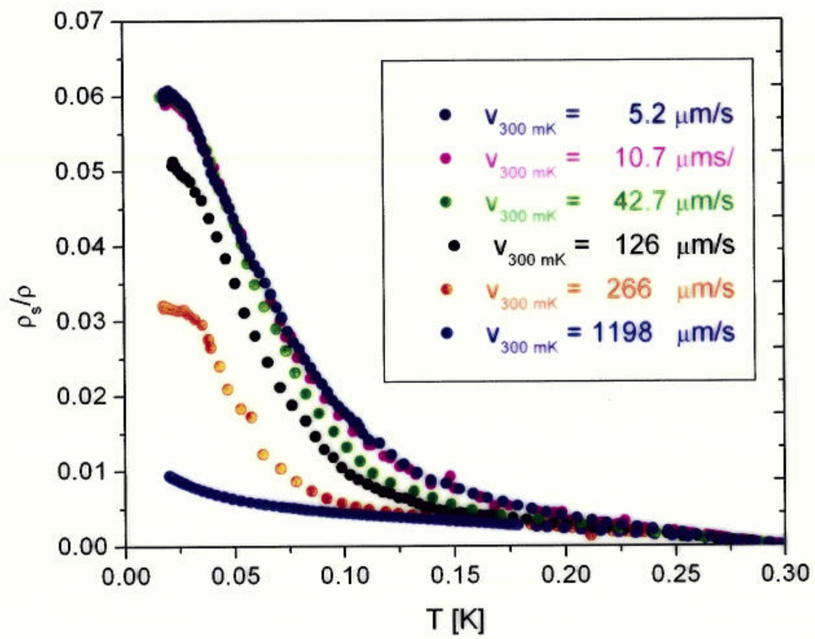




- f = 949 Hz , V = 1.8 cm^3, p = 30.5 bar
- ΔP_0 = 1.91 ms, ρ_s/ρ between 1.5×10^{-4} and 3.5×10^{-4}
- No suppression of NCRI up to 480 μm/s, T_c seems to drop

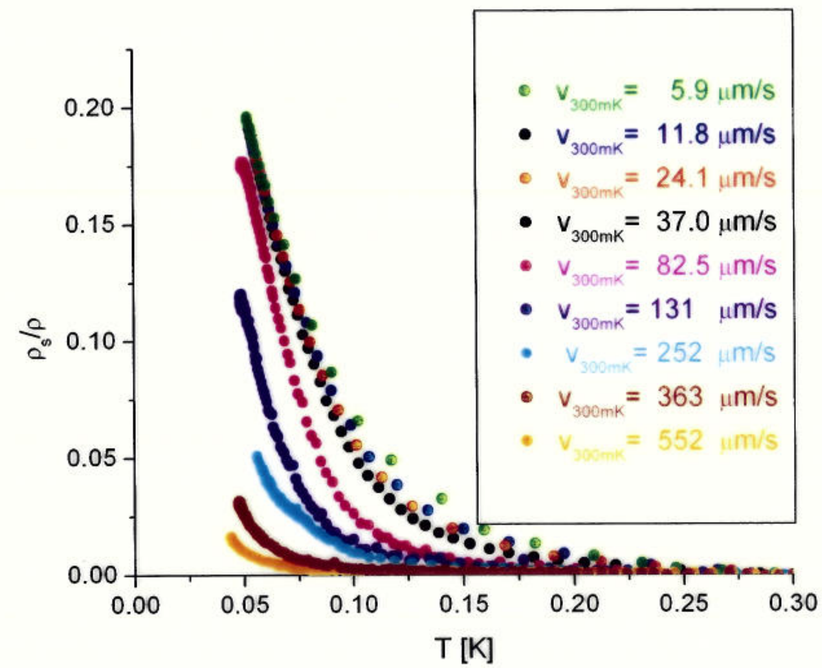
Thin annular geometries

S/V=65.6 cm^{-1}



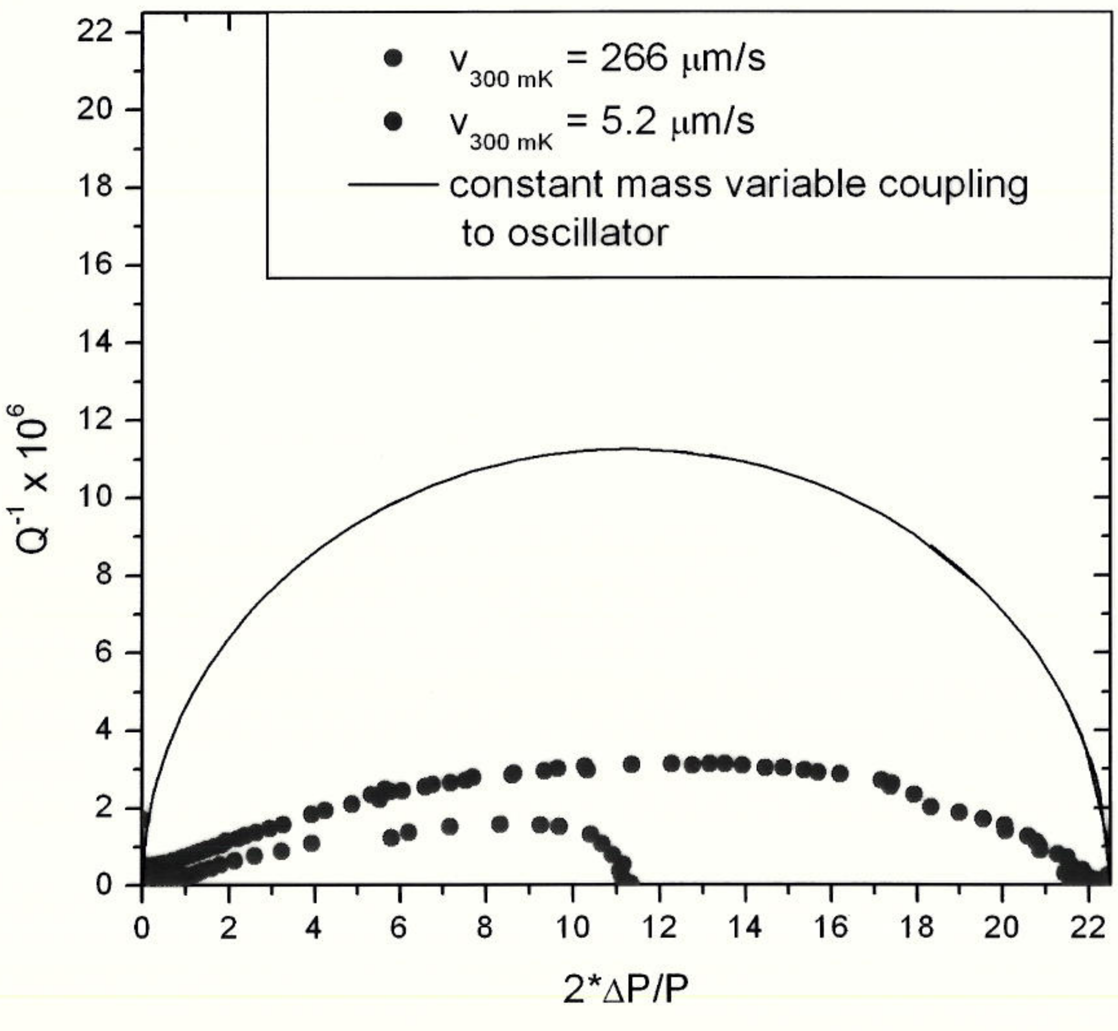
- gap 0.3 mm, half the spacing of Kim & Chan (ρ_s/ρ = 1.4 %) (Science)
- p = 31 bar
- maximum ρ_s/ρ = 6.0 %

S/V=131.2 cm^{-1}

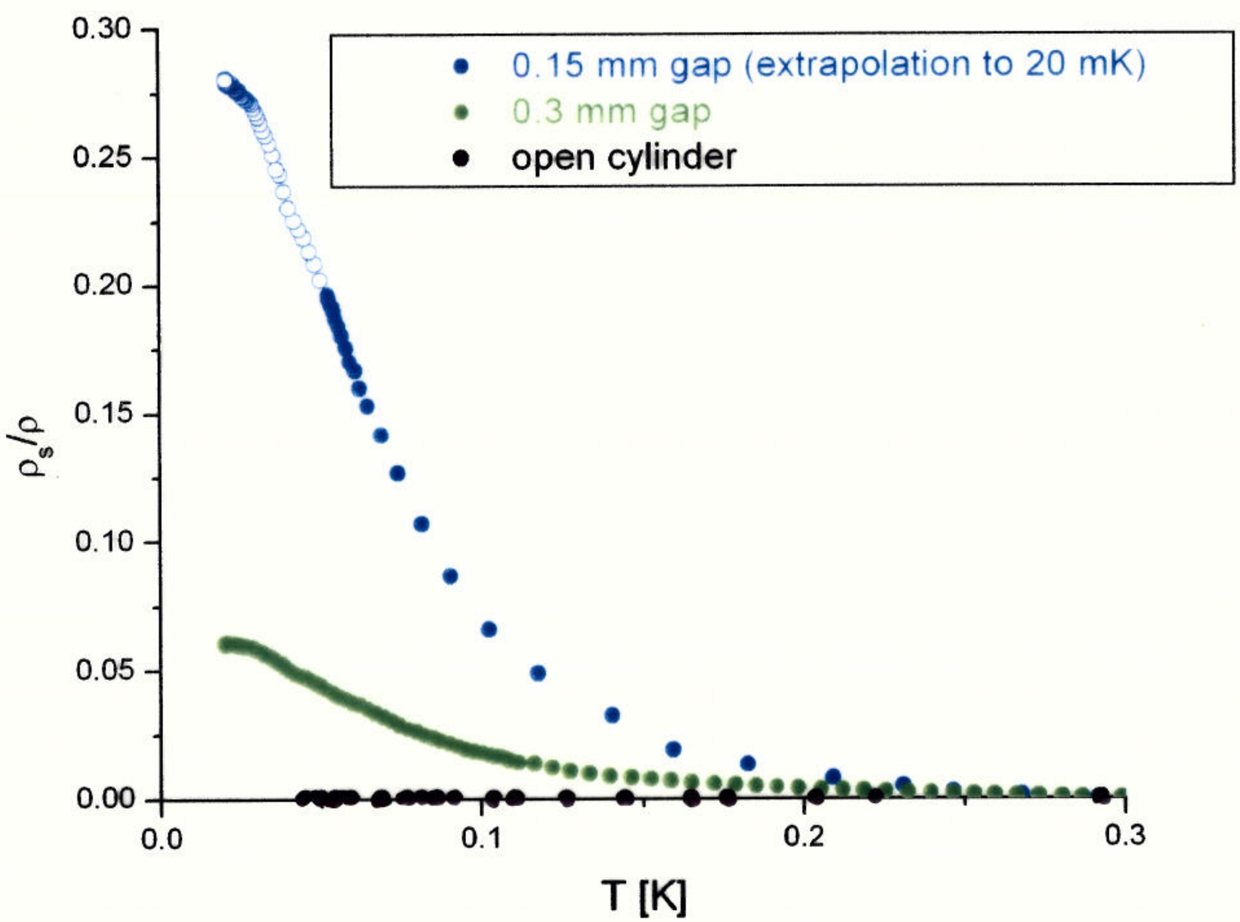


- gap 0.15 mm
- p = 51 bar
- maximum ρ_s/ρ (50 mK)= 20 %

Q^{-1} versus $2\Delta P/P$ 0.3 mm gap



Maximum ρ_s/ρ in different geometries



Conclusions and Questions

- Disorder is the Key to the Supersolid State.
- "High Quality" Samples show only trace signs of the Supersolid State.
- What is the Nature of the Disorder which supports the Supersolid?
- What is the upper limit to the Supersolid Fraction? 100% ??

Summary

- We have observed supersolid signals over three orders of magnitude depending on S/V.
- Increase of signal could be explained by stabilization of disorder by confinement or more rapid freezing.
- Puzzle: Results of Kim and Chan in vycor and porous gold