



Lancaster
University

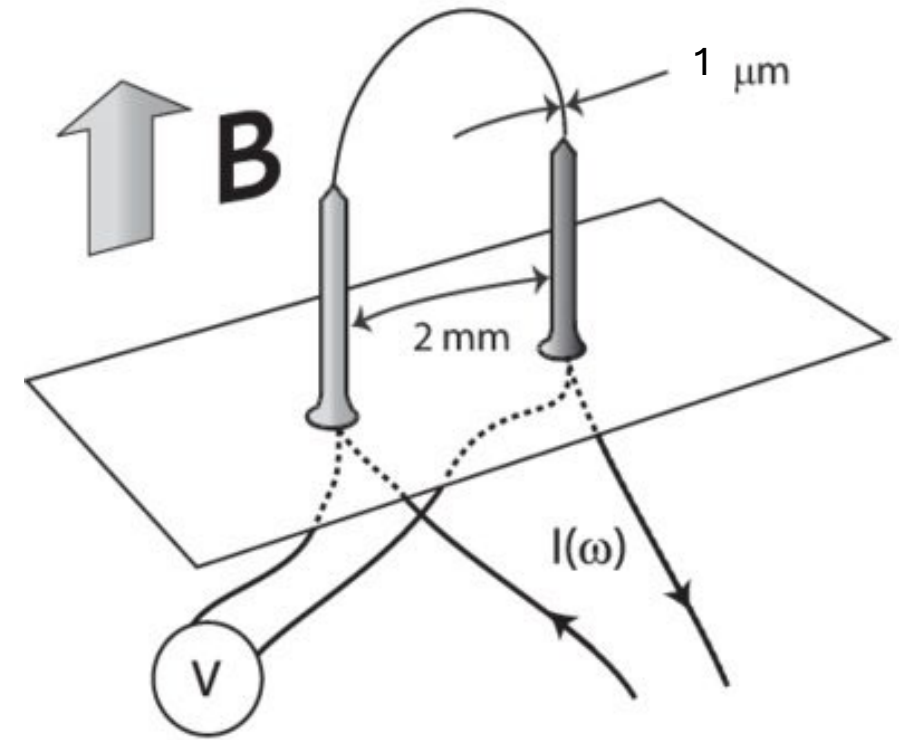
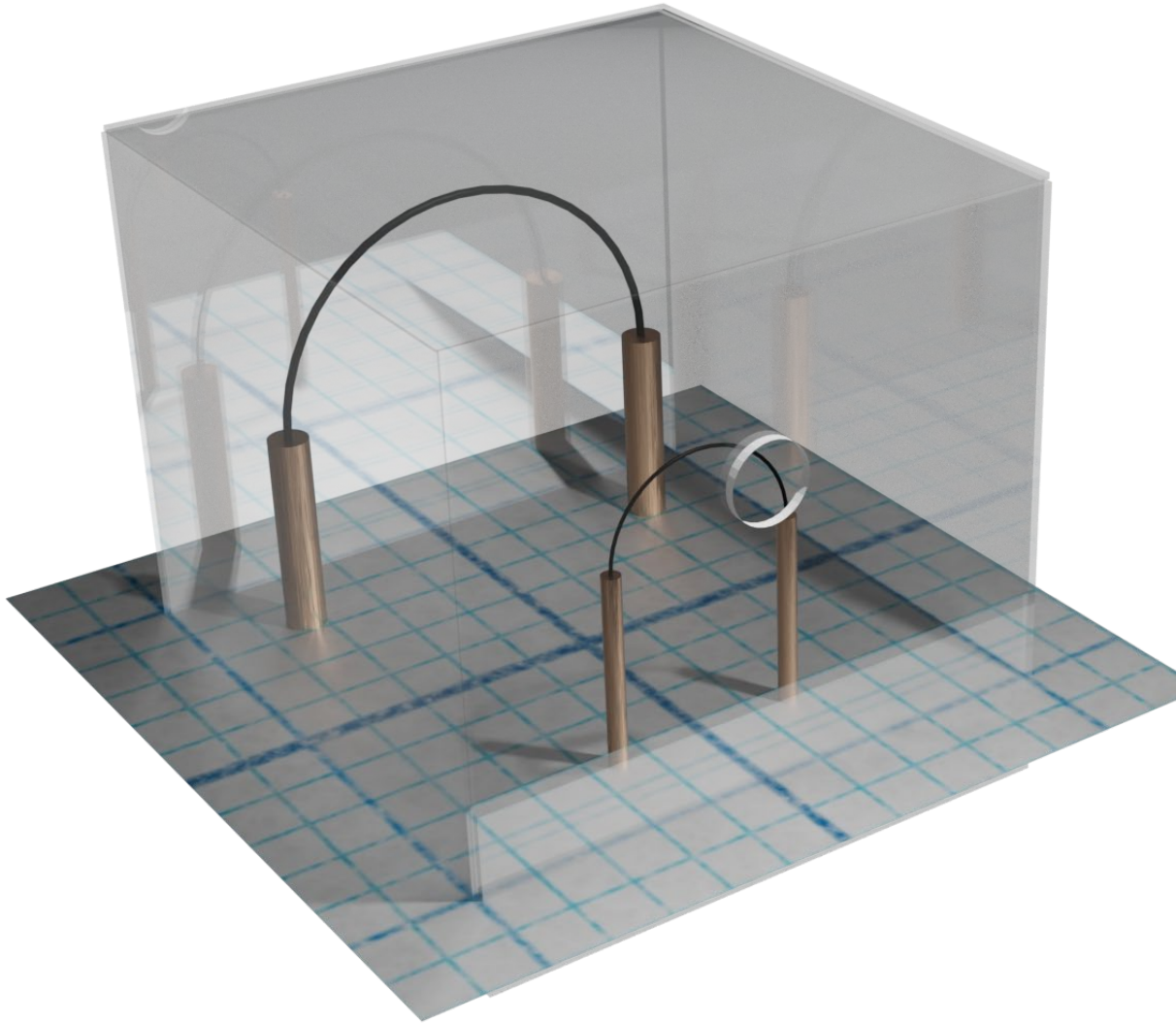


Ultra
Low
Temperature

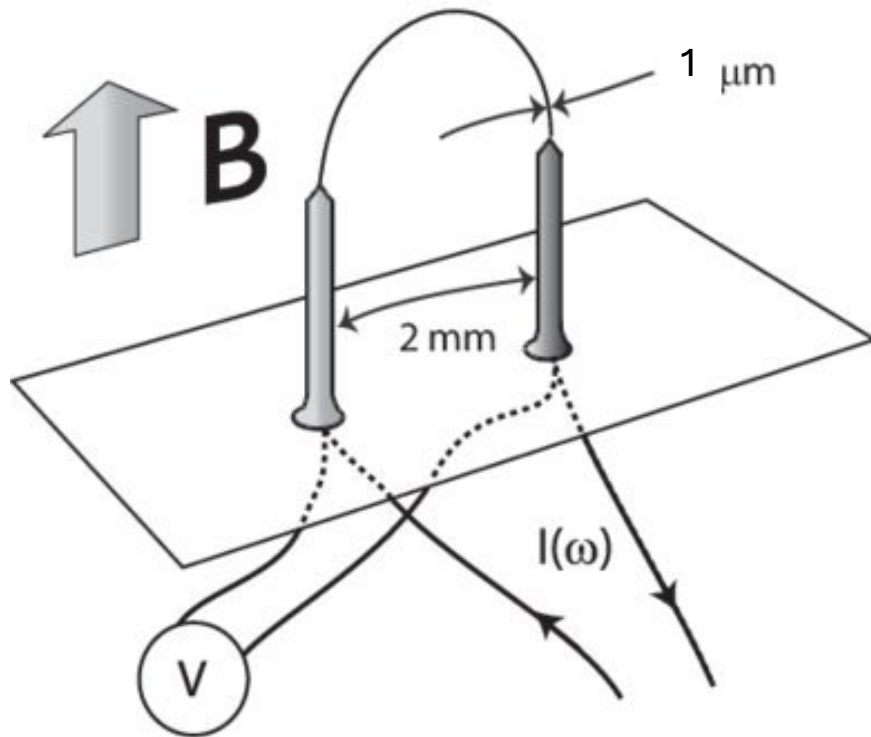
Bolometer designs for detection of heating events in superfluid ^3He

D. Zmeev, Lancaster University

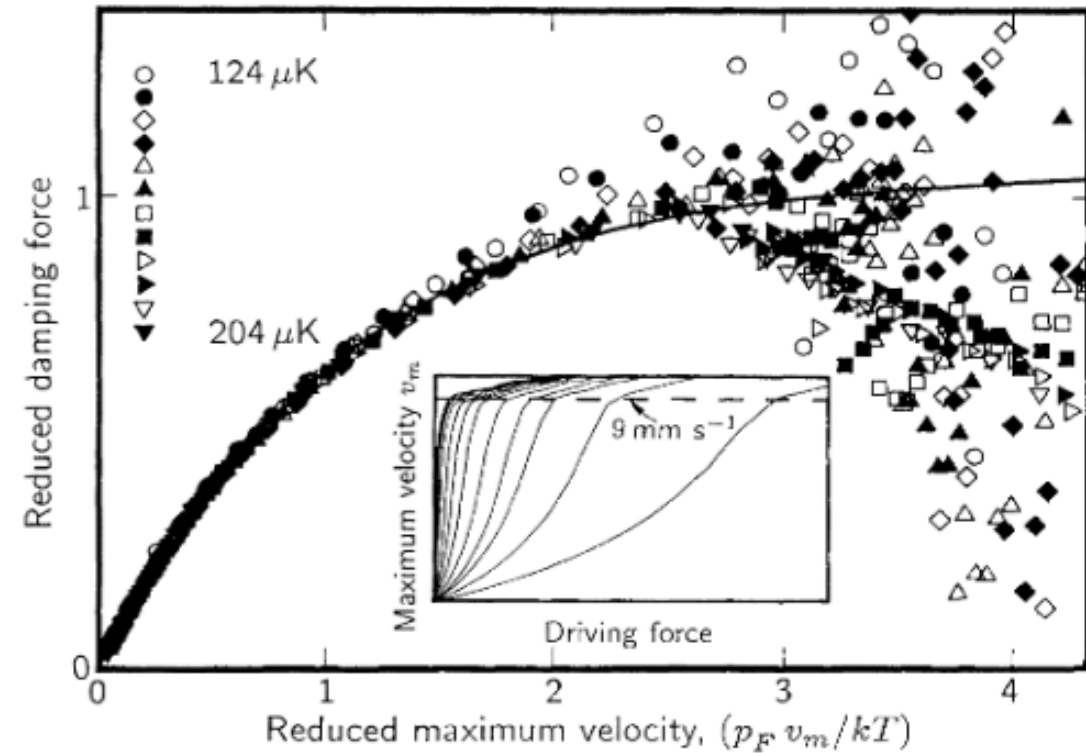
Bolometers as used by



Mechanical oscillator in $^3\text{He-B}$



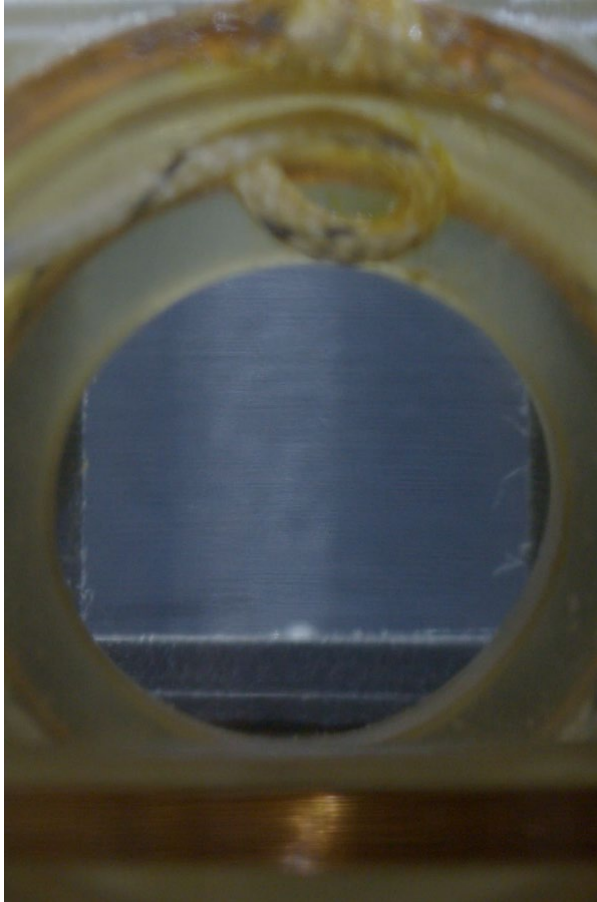
Damping due to interaction with QP:



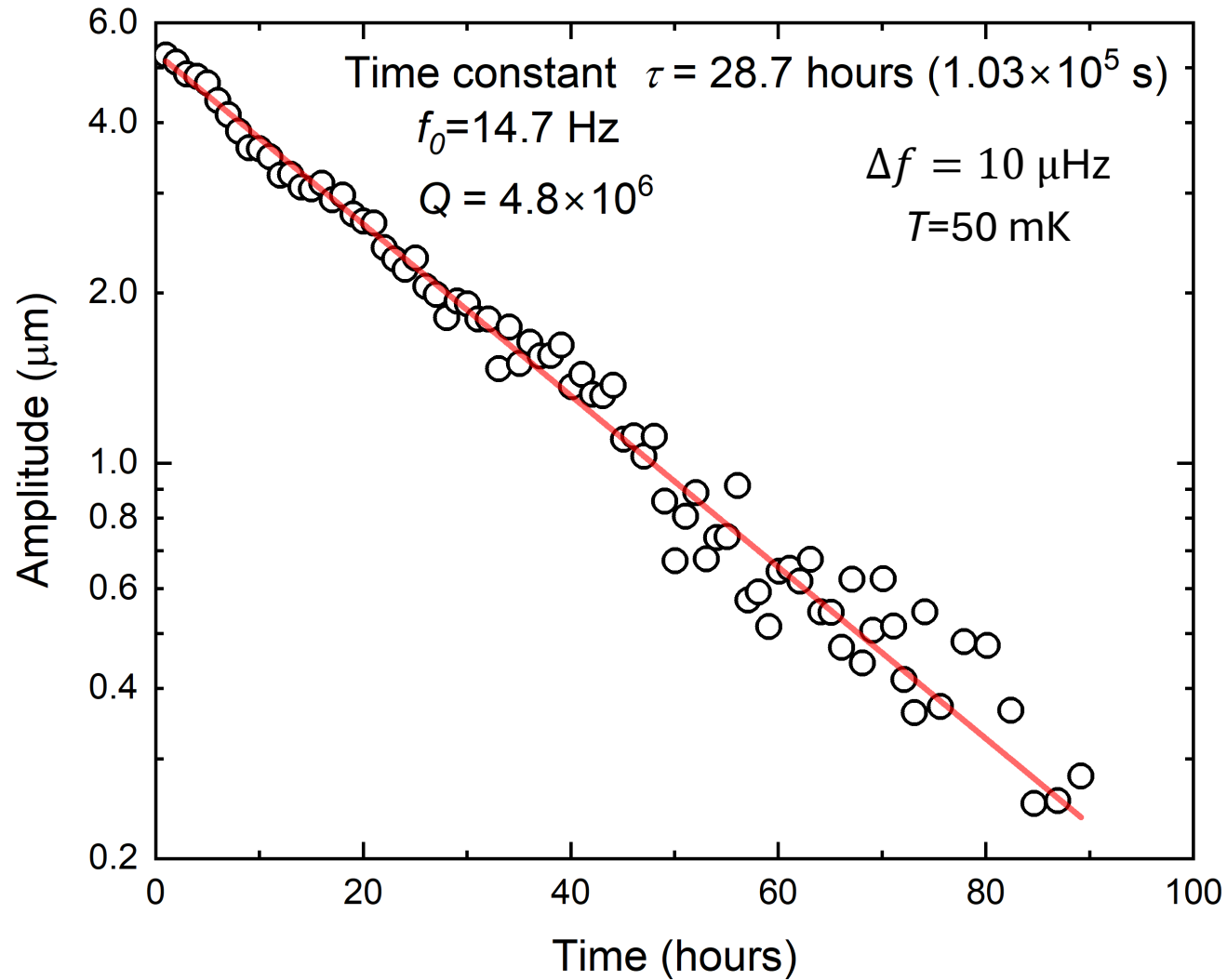
Intrinsic damping: $\Delta f_0 \sim 100\ \text{mHz}$

For a $\sim 1\ \mu\text{m}$ wire, Δf_0 corresponds to QP damping at $\sim 100\ \mu\text{K}$ ($3 \times 10^{18}\ \text{cm}^{-3}$)

Part I: Levitating probes

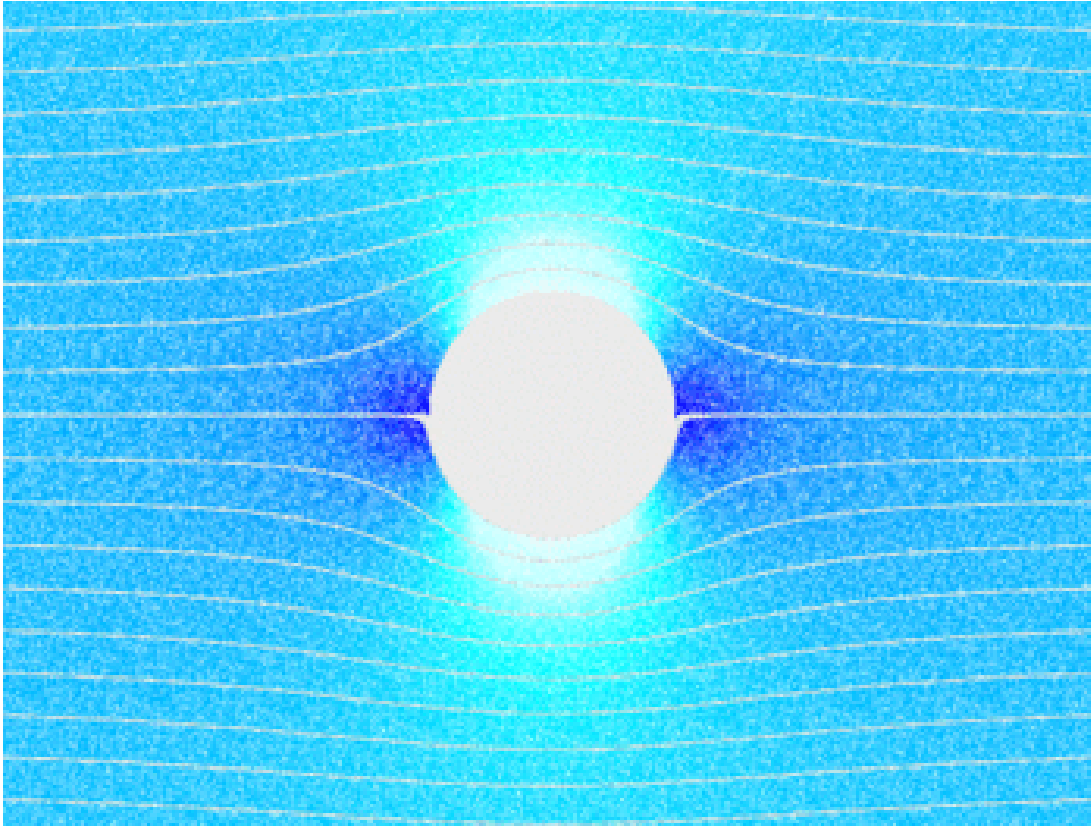


Part I: Levitating probes



For a ~ 1 μm wire, $\Delta f = 10$ μHz corresponds to QP damping at ~ 60 μK (3×10^{14} cm^{-3})

Flow enhancement factor



- $V_{\max} = \alpha v$

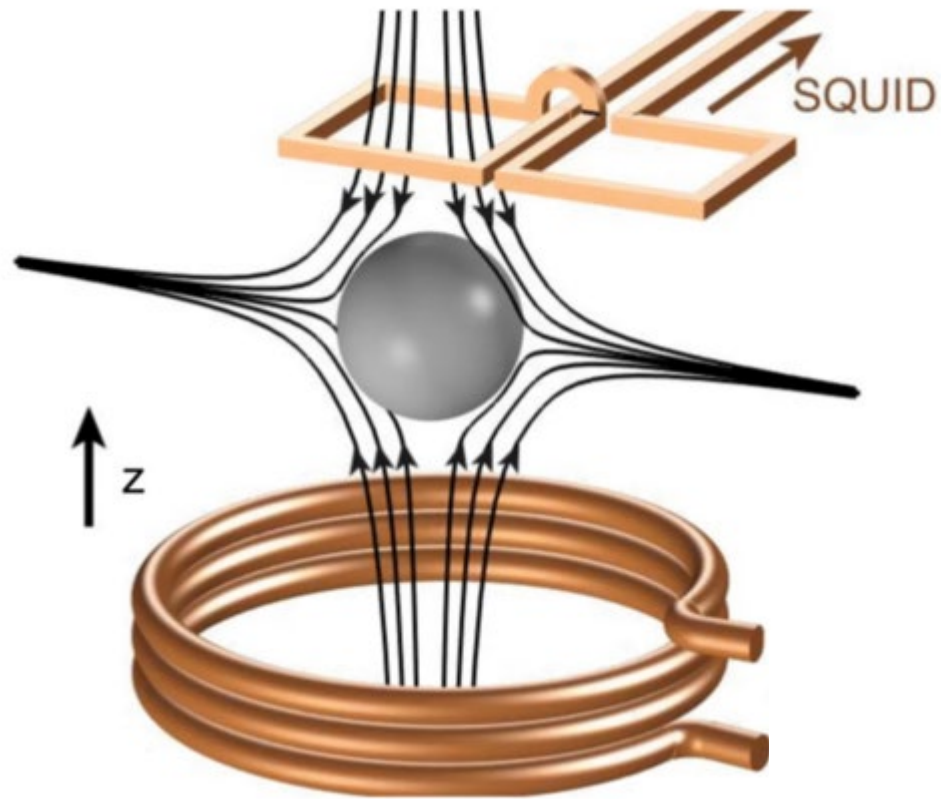
$\alpha = 2$ for a cylinder

$\alpha = 1.5$ for a sphere

$$V_{\text{critical}} = v_{\text{Landau}} / (1 + \alpha)$$

~20 % gain in max. velocity for a sphere

Control and position measurement



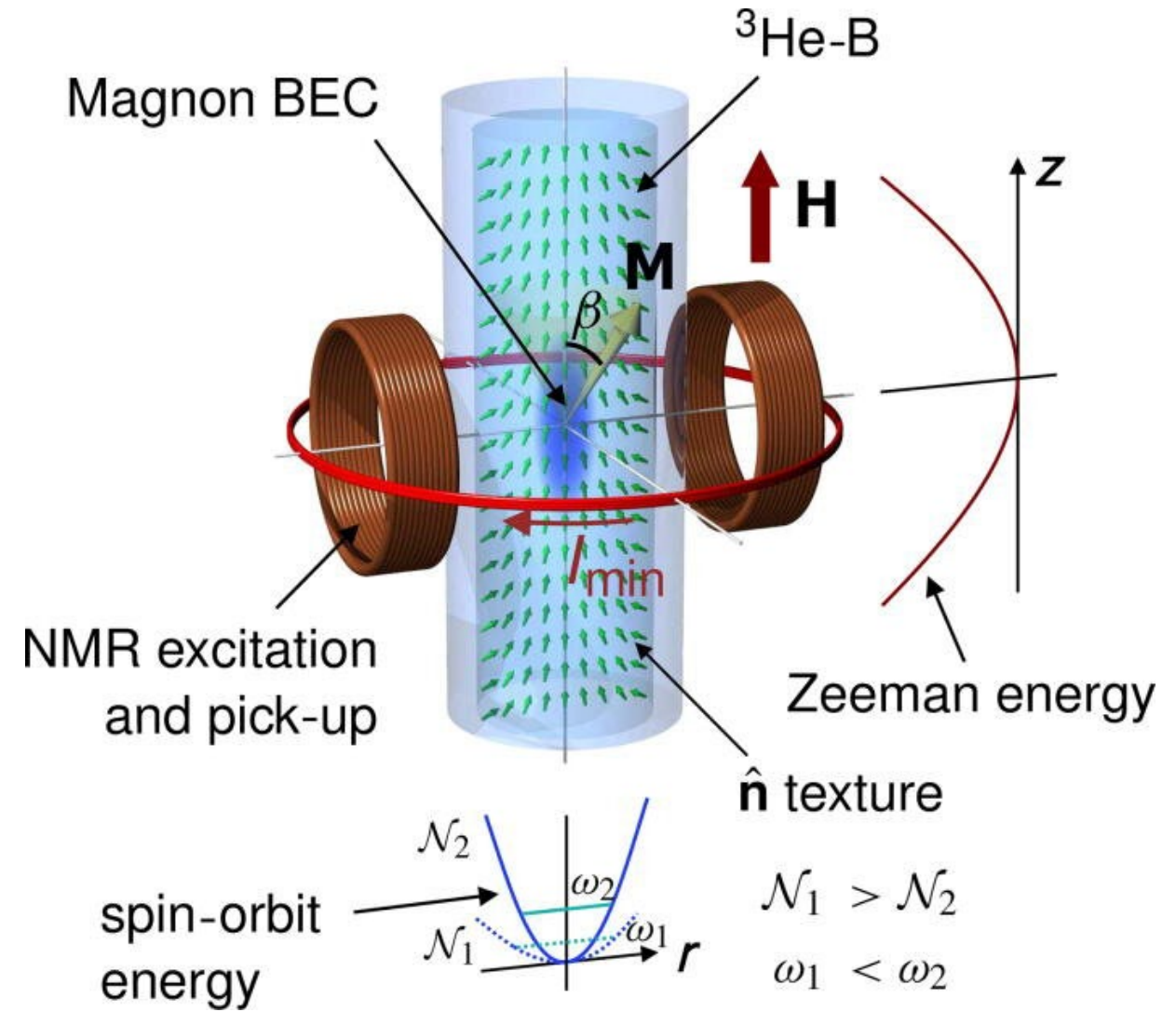
- Position and resonant frequency can be adjusted in situ
- Position resolution better than $1 \text{ nm}/\sqrt{\text{Hz}}$, can be improved by a factor 10^4

Wire vs Levitating Ball

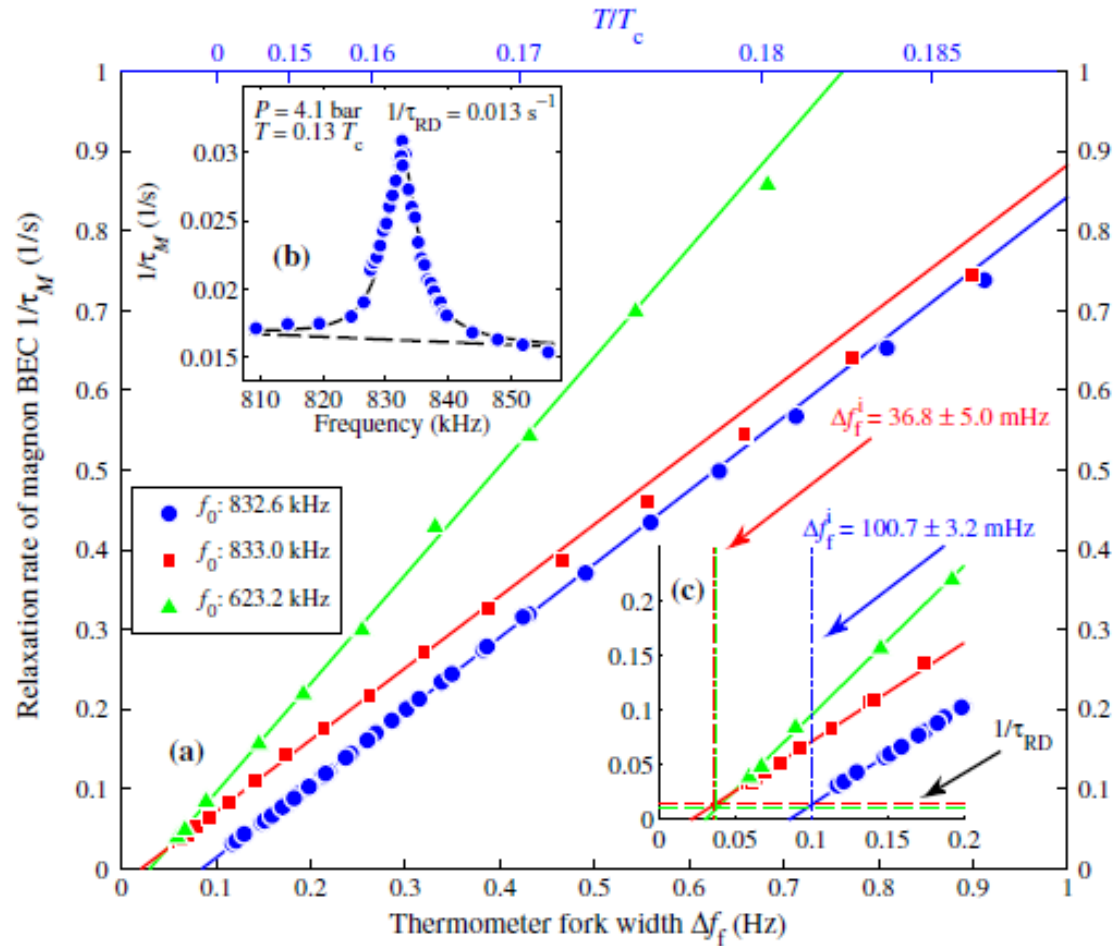
Property	Wire	Ball
Max. velocity [mm/s at 0 bar]	9	11
Δf_0 [mHz]	~100	<0.01
Frequency Adjustable in situ	No	Yes
Annealing defects (e.g. vortices)	Unlikely	Likely
Scalability	Yes	Yes
Resolution [nm/sqrt(Hz)]	TBD	<1

J Low Temp Phys (2014) 175:681–705
DOI 10.1007/s10909-014-1173-x

**P. J. Heikkinen · S. Autti · V. B. Eltsov ·
R. P. Haley · V. V. Zavjalov**



Magnon BEC: calibration vs mechanical probe



- Frequency ~ 1 MHz : adjustable in situ, many amplifier techniques, away from vibrational noise (compatible with dry fridges)
- Relaxation time > 100 s (depends on QP density)

Mechanical vs Magnetic QP probes

Property	Mechanical	BEC
Frequency	<100 kHz (due to sound emission)	~1 MHz
Affected by defects	Yes (possible to anneal for)	Yes
Scalability	Yes	Yes
Sensitivity	Depends on many factors, particularly geometry, lower frequency usually means	Potentially higher due to amplifier-friendly frequency