New high-magnetic-field thermometers for sub-millikelvin temperatures

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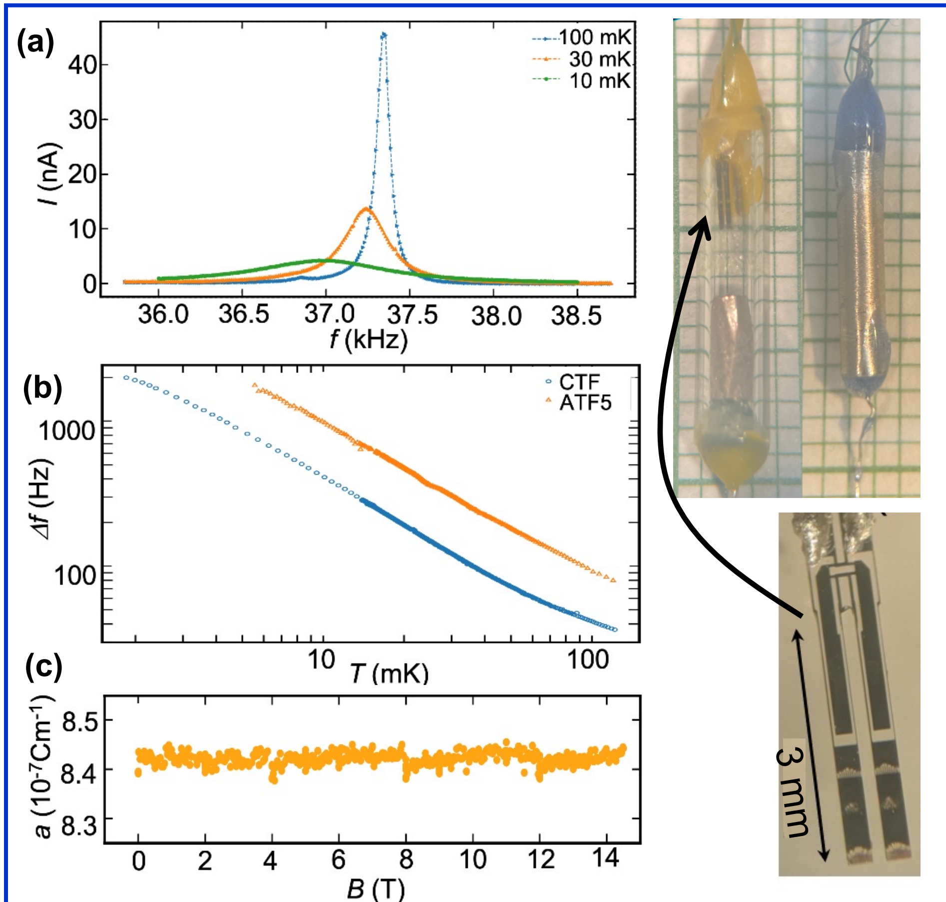
The MagLab's High B/T facility at the University of Florida combines high magnetic fields with the extreme environment of ultra-low temperatures of order 1 mK. Most measurement techniques require adaptations to be successfully performed under these conditions, but specific heat and thermal transport are particularly challenging due to a lack of suitable thermometry. Here, MagLab scientists report progress on developing new thermometers, based on quartz tuning forks in liquid ^{3}He, that will help realize these heavily-demanded user experiments.

The measurement principle relies on the temperature-dependent viscosity of liquid ^{3}He, which leads to a temperature-dependent broadening of the Lorentzian vibration resonance curves. Despite being a measurement in liquid, *tuning fork thermometers are one of the most promising candidates to realize miniature thermal probes for small solid crystals, since they are scalable to microscopic dimensions and compatible with both high magnetic fields and ultralow temperatures*.

The newly developed thermometers will make the high B/T regime accessible to calorimetric and thermal transport measurements, enabling users to study superconductors, quantum critical behavior, quantum spin liquid states, and topological materials under these extreme conditions.



(a) Resonance of a tuning fork in liquid ^{3}He at three temperatures.
(b) Temperature-dependent resonance widths of two tuning forks.
(c) Calibration constant independence of magnetic field up to 14.5 Tesla.
Photos (by L. Steinke): Prototype thermometers photographed on mm paper.

Facilities and instrumentation used: MagLab High B/T facility, Bay 3, University of Florida, Gainesville, FL.
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