NEWS | NOVEMBER 08 2019

Quartz tuning forks can be used as sub-kelvin thermometers in high magnetic fields

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Scilight 2019, 451104 (2019)
https://doi.org/10.1063/10.0000260

Scilight

5 November 2019

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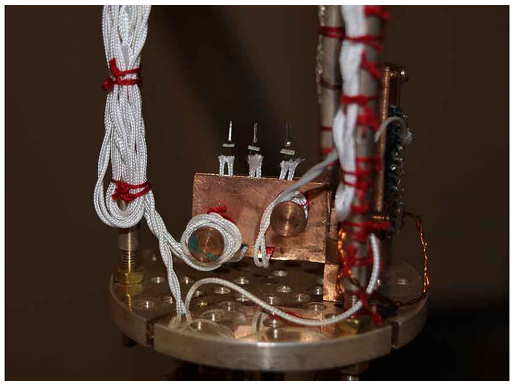
The determination of low temperatures in high fields is a difficult task. The resonances of quartz tuning forks are a promising solution.



Experimental measurements of low temperatures in high magnetic fields are challenging, as many thermometric parameters are sensitive to high fields, and calibrations to account for such effects are non-trivial. To address this limitation, Marcel Človečko and Peter Skyba sought to find a temperature-dependent physical parameter unaffected by large magnetic fields.

The authors determined the resonance frequency of a quartz tuning fork has a temperature dependence in the millikelvin temperature regime. This is due to the relationship between the oscillation restoring force and temperature, which is governed by temperature-dependent interactions of electric dipoles induced in the quartz tuning forks. Though the resonance frequency also increases slightly with increasing magnetic field, a normalization procedure can eliminate this dependence, allowing for the determination of a single oscillation frequency associated with a given temperature.

“Any experimenter has to measure temperature indirectly,” said Skyba. “One has to always use a thermometer -- a sensor having some physical parameter that is temperature dependent. In our case, as we found, this temperature-dependent parameter is the resonance frequency of the tuning fork.”

To observe this relationship, the researchers used a pulse-demodulation technique and measured the resonance frequency of the tuning fork decay signal. By using an external measurement of the temperature of the mixing chamber used to test the tuning fork behavior, they were able to calibrate the resonance to its corresponding temperature.

The one-to-one correspondence between temperature and resonance frequency makes quartz tuning forks promising as sub-kelvin thermometers in high magnetic fields and potentially useful in a wide variety of physics experiments.

Source: “Quartz tuning fork – A potential low temperature thermometer in high magnetic fields,” by M. Človečko and P. Skyba, *Applied Physics Letters* (2019). The article can be accessed at https://doi.org/10.1063/1.5124736.