Development of a Low Temperature Dilatometer for the User Community at the NHMFL

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Introduction

Cryogenic capacitive dilatometers [1] are usually designed to run in hard vacuum or in a low-pressure helium exchange gas, though immersing the dilatometer in any medium can lead to dielectric effects which can be significant [2]. Experimental challenges also include thermal contact between the sample, thermometer, and refrigerant. These challenges are exacerbated at the lowest temperatures, especially in the presence of high magnetic fields.

We are developing a new capacitive dilatometer to address these challenges. The new dilatometer is designed for operation when immersed in the liquid helium of an operating dilution or 3He refrigerator. The capacitor gap is sealed to prevent dielectric material (liquid helium) from entering. The sample and thermometer are in direct contact with the liquid helium to maximize thermal contact and minimize thermal gradient effects.

Results and Discussion

The new design has been tested in the top-loading dilution refrigerators of the Millikelvin facility. The capacitor gap is superfluid tight and the sensitivity is somewhat higher than expected. However the cell-effect, the response of the “empty” cell to varying temperatures and/or magnetic fields, is larger than expected. Variations in design and construction materials are being explored to reduce the cell-effect. Preliminary data suggests that reliable operation to temperatures below 20 mK, in the highest dc fields available at the NHMFL, is an achievable goal.

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References

[1] For example: Schmiedeshoff, G.M., *et al*., Rev. Sci. Instrum, **77**, 123907 (2006).
[2] Schmiedeshoff, G.M., *et al*., Phil. Mag., 89, 2071 (2009).