



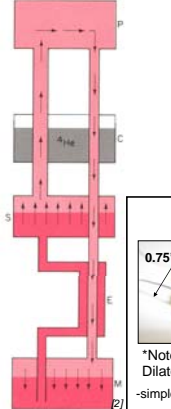
# Measuring Cell-Effect of Copper Dilatometer in <sup>3</sup>He-<sup>4</sup>He Dilution Refrigerator

Amanda Lounsbury  
Occidental College

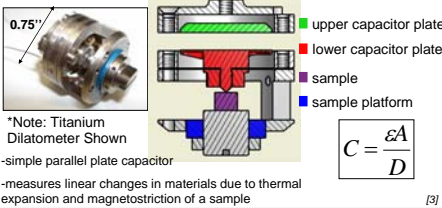
**ABSTRACT:** Using a jelly roll capacitive thermometer<sup>1</sup> we measured the cell-effect of a capacitive copper dilatometer in a <sup>3</sup>He-<sup>4</sup>He Dilution refrigerator. The jelly roll used, Oxy 5, has a capacitive minimum around 140 mK, and is calibrated with a 9 coefficient Chebyshev polynomial. Oxy 5 is useful when the measurements of interest are above or below 140 mK. We plan to build a thermometer such that the minimum is below the base temperature, ~13 mK of the dilution refrigerator. In fields greater than 4 T the dilatometer was found to have that noise grows with increasing field. We are still trying to determine the source of this noise. The data collected from Oxy 5 and similar jelly roll thermometers will also be used to calibrate a RuO resistive thermometer in high fields at low temperatures.

## I. Introduction: Dilution Refrigerator

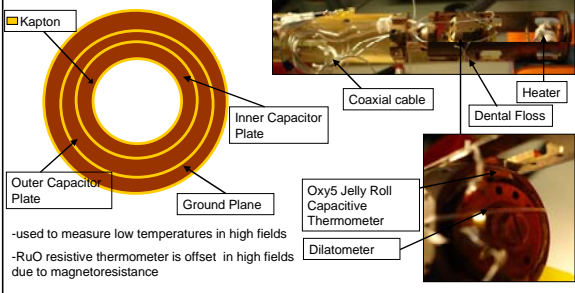
- <sup>3</sup>He rich phase
  - <sup>3</sup>He dilute phase
- P:** Pump circulating <sup>3</sup>He gas T ~ 300 K  
**C:** <sup>4</sup>He pot absorbs heat from condensing <sup>3</sup>He T = 1.5 K  
**E:** Heat exchanger absorbs heat from returning <sup>3</sup>He 10 mK < T < 850 mK  
**M:** Mixing chamber, where dilution cooling occurs (location of dilatometer). T ~10 mK  
**S:** Still, where <sup>3</sup>He is evaporated. T ~850 mK



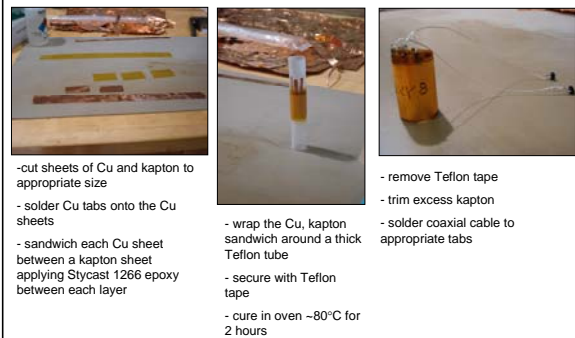
### Dilatometer



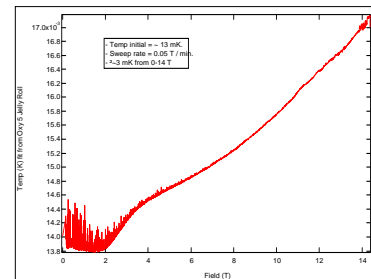
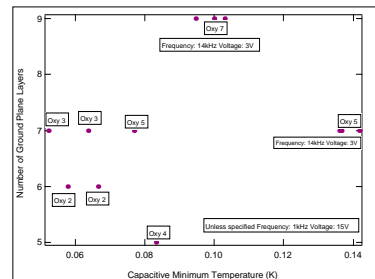
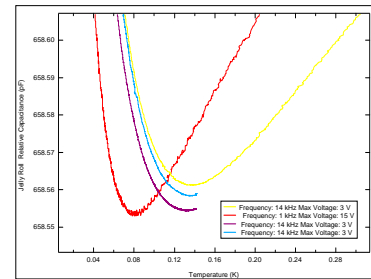
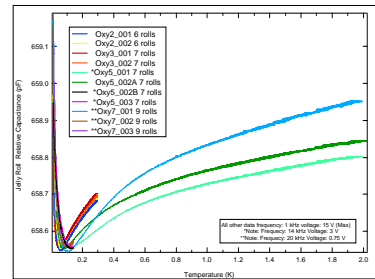
## Jelly Roll Capacitive Thermometer



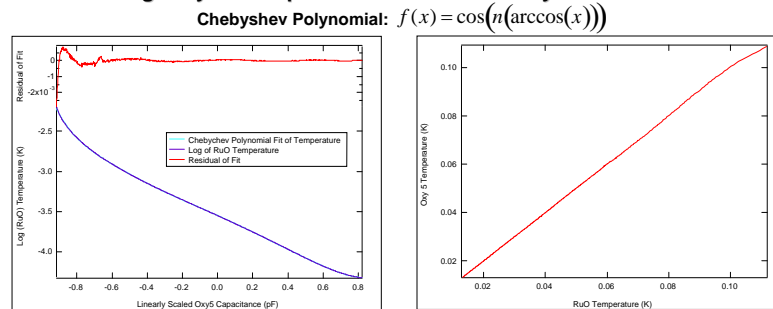
## II. Construction of a Jelly Roll Capacitive Thermometer:



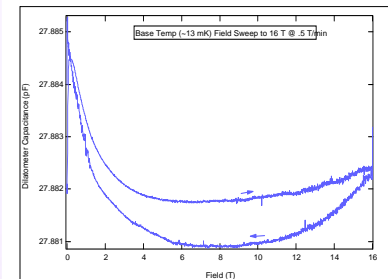
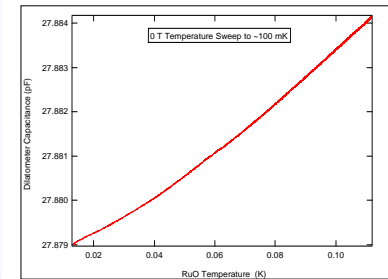
## III. Characterizing the Jelly Roll Capacitive Thermometers:



## IV. Calibrating Jelly Roll Capacitive Thermometer Oxy 5:



## V. Cell Effect in a <sup>3</sup>He-<sup>4</sup>He Dilution Refrigerator:



## VI. Conclusion:

We were able to determine that a copper-kapton, jelly roll capacitor can be used as a reliable thermometer at low temperatures and high fields. Using the Oxy 5 jelly roll capacitive thermometer, calibrated with a 9 coefficient Chebyshev polynomial, we determined the cell effect of a simple copper capacitive dilatometer in fields up to 14 T. At fields above 14 T the dilatometer displayed a large amount of noise which seemed to increase with increasing field. We are still researching the source of the noise. We plan to use the jelly roll data to calibrate the RuO resistive thermometers at low temperatures in high fields, as well as to build a jelly roll such that the minimum is below the base temperature of the <sup>3</sup>He-<sup>4</sup>He dilution refrigerator.

### Acknowledgements:

I would like to thank George Schmiedeshoff and the Extreme Condition Group at NHMFL for sharing their knowledge with me as well as for their help, advice and guidance. As well as for giving me the opportunity to do this research. I would also like to thank Jose Sanchez of the NHMFL REU program for the support to do research at NHMFL. Also I would like to thank Alice Hobbs whose endless supply of peanut M&M's kept me motivated throughout.

### Citations:

- [1] Murphy, T.P Palm, E. C. Peabody L. Tozer, S. W. Capacitance thermometer for use at low temperatures and high magnetic fields. Review of Scientific Instruments **72**, 8 (2001).
- [2] Mendelssohn, Kurt, *The quest for absolute zero, 2<sup>nd</sup> ed. S.I. units.* Halsted Press, New York, 1977.
- [3] Schmiedeshoff, G. M. Lounsbury, A. W. Luna, D. J. Tracy, S. J. Schramm, A. J. Tozer, S. W. Correa, V. F. Hannahs, S. T. Murphy, T. P. Palm, E. C. Lacerda A. H. Budko, S. L. Cantfield, P. C. Smith, J. L. Lashley, J. C. and Cooley J. C. Versatile and compact capacitive dilatometer. Review of Scientific Instruments **77**, 1 (2006).