Measurement of Specific Heat Using a Gravity Cancellation Approach

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The specific heat at constant volume, C_V, of a simple fluid diverges near its liquid-vapor critical point. However, a gravity-induced density stratification due to the divergence of isothermal susceptibility hinders the direct comparison of the experimental data with the predictions of renormalization group theory. In the past, a microgravity environment has been considered essential to eliminate the density stratification.
We propose to perform specific heat measurements of 3He on the ground using a method to cancel the density stratification. A He-3 fluid layer will be heated from below, using the thermal expansion of the fluid to cancel the hydrostatic compression. A 6% density stratification at a reduced temperature of 1e-5 can be cancelled to better than 0.1% with a steady 1.7 micro Kelvin temperature difference across a 0.05 cm thick fluid layer. A conventional AC calorimetry technique will be used to determine the heat capacity. The minimized bulk density stratification with a relaxation time 6500 sec at a reduced temperature of 1e-5 will stay unchanged during 1 Hz AC heating. The smear of the specific heat divergence due to the temperature difference across the cell is about 0.1% at a reduced temperature of 1e-6. The combination of using High Resolution Thermometry with a 0.5 nK temperature resolution in the AC technique and the cancellation of the density stratification will enable C_V to be measured down to a reduced temperature of 1e-6 with less than a 1% systematic error.