A New Electrostriction Method for Measuring the Isothermal Susceptibility and Chemical Potential Change Near the ^{3}He Liquid-Gas Critical Point

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A flight definite experiment, called MISTE, is proposed to measure the isothermal susceptibility, $\chi_T = (\partial\rho/\partial\mu)_T$, near the liquid-gas critical point of ^{3}He in a microgravity environment. A new electrostrictive technique has been developed to measure χ_T near the liquid-gas critical point. This technique takes advantage of the fact that an electric field gradient can produce a pressure gradient ($\delta P \propto E^2$) within a dielectric fluid. By applying an electric field across the same parallel plate capacitor used for the local density measurement, the density change, $\delta\rho$, can be measured as a function of the electric field squared, E^2. The ratio of $\delta\rho/E^2$ in the limit of $E \rightarrow 0$ is proportional to χ_T. Electrostriction measurements were performed over the reduced temperature range $1\times10^{-6} < T/T_c - 1 < 1\times10^{-3}$. Although the new technique has a limited range around the critical point, it eliminates the requirement for a high resolution pressure sensor ($\delta P/P \approx 10^{-9}$). Data obtained with the new technique agree with the susceptibility measurements using a conventional PVT technique along the isotherms over the range where the two overlap. The data from the electrostriction measurements can also be used to derive the chemical potential change in the critical region. Experimental results for the susceptibility and chemical potential change will be presented and compared to theoretical predictions.