Thermal Response of a Fluid Near its Critical Point: ^{3}He at T > T_c

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The local density response is studied in a simple fluid near the liquid-vapor critical point, subjected to temperature oscillations of its container. This investigation provides a new approach in the study of the adiabatic energy transfer ("piston effect") in the fluid. The density response function $Z_F(\omega, \epsilon, z)$ is calculated for ^{3}He in the absence of stratification, where ω is the angular frequency, $\epsilon = (T - T_c)/T_c$ the reduced temperature, T_c = 3.316 K the critical temperature, and z the vertical position in the container. Experiments are described where the density is measured by two superposed capacitive sensors in a cell of 3.5 mm height, and where the temperature oscillation frequency $f = \omega/2\pi$ is varied between 10^{-4} and 2 Hz. The results from predictions and experiments over the experimental range $5 \times 10^{-4} < \epsilon < 5 \times 10^{-2}$ are compared and discussed. Over the frequency and reduced temperature ranges, the damping effect from the critical bulk viscosity is predicted to be too small to be detectable. The observed effect of the stratification and its frequency dependence in Z_F are briefly discussed.