Bulk Viscosity of Stirred Xenon near the Critical Point

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We deduce the thermophysical properties of near-critical xenon from measurements of the frequencies and half-widths of the acoustic resonances of xenon in centimeter-sized cavities. The xenon, maintained at its critical density, was stirred to reduce density stratification in Earth's gravity. In the reduced temperature range $7 \times 10^{-6} < (T-T_c)/T_c < 1 \times 10^{-3}$, we measured the resonance frequency and quality factor (Q) for each of six modes spanning a factor of 27 in frequency. As T_c was approached, the frequencies decreased by a factor of 2.2 and the Q's decreased by as much as a factor of 140. Remarkably, these results [1] are predicted (within 2% of the frequency and within a factor of 1.4 of Q) by a model for the resonator and a model for the frequency-dependent bulk viscosity $\zeta(\omega)$ that uses no empirically-determined parameters. The resonator model is based on a theory of acoustics in near-critical fluids developed by Gillis, Shinder, and Moldover [2]. In addition to describing the present low-frequency data (120 Hz to 7.5 kHz), the model for $\zeta(\omega)$ is consistent with ultrasonic (0.4 MHz to 7 MHz) velocity and attenuation data from the literature [3]. However, the model predicts a peak in the temperature-dependence of the dissipation in the boundary layer that we did not detect. We also present an empirical analysis of the acoustic data, motivated by dynamic scaling theory, from which we deduce the frequency-dependent bulk viscosity. The stirring technique is described in another presentation at this conference.

[1] K.A. Gillis, I.I. Shinder, and M.R. Moldover, *Phys. Rev. E,* **72**, 051201 (2005).
[2] K.A. Gillis, I.I. Shinder, and M.R. Moldover, *Phys. Rev. E,* **70**, 021201 (2004).
[3] P. E. Mueller, D. Eden, C.W. Garland, and R.C. Williamson, *Phys. Rev. A,* **6**, 2272 (1972); Jan Thoen and Carl W. Garland, *Phys. Rev. A*, **10**, 1311 (1974).