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Thermoacoustic waves near the liquid-vapor critical point

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The thermal relaxation in a fixed-volume cell filled with a near-critical fluid is governed by the rapid expansion of thermal boundary layers, which drive a series of thermo-acoustic waves in the bulk fluid. The long-term cumulative effect of these waves is to increase the pressure in the cell, which in turn leads to a global temperature increase (a process named the Piston Effect). Recently and for the first time, the thermo- acoustic waves produced by the Piston Effect have been measured experimentally using interferometric methods [Y. Miura et al., to appear in Phys. Rev. E (2006)]. In the present work, we use asymptotic methods in order to derive a complete theoretical model of the Piston-Effect-driven acoustic waves, applicable to real fluid equations of state and to arbitrary reduced temperatures. The predictions of this model are compared to the above-mentioned experimental data, and an excellent agreement is observed without any fitting parameter. This result confirms the high precision of the data in question, and shows that asymptotic models such as ours can be a powerful tool for analyzing the results of such experiments.