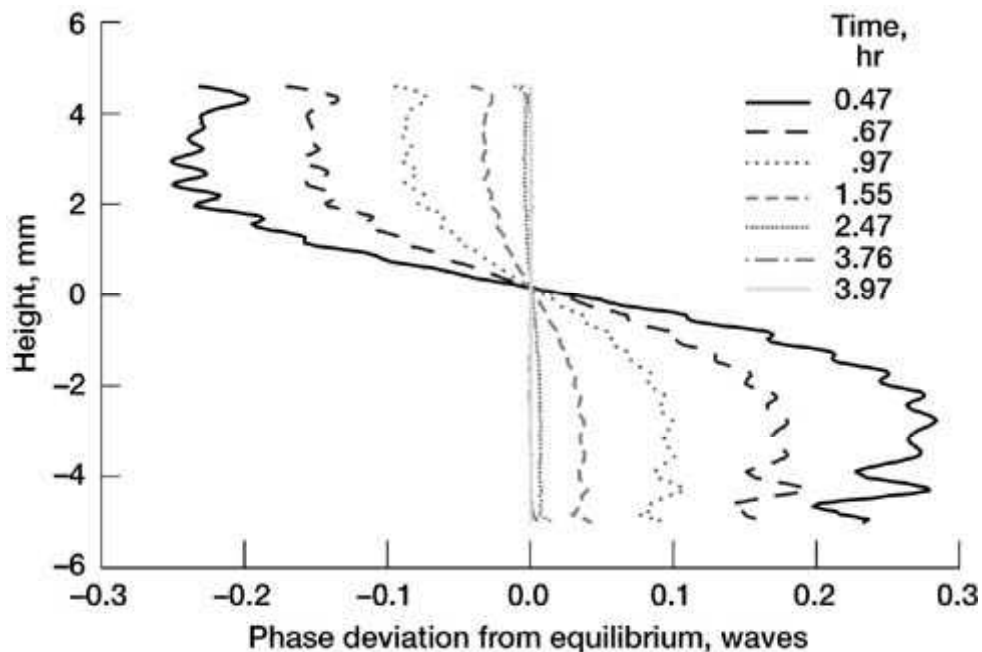


Density Relaxation of Liquid-Vapor Critical Fluids Examined in Earth's Gravity

This work shows quantitatively the pronounced differences between the density equilibration of very compressible dense fluids in Earth's gravity and those in microgravity. The work was performed onsite at the NASA Glenn Research Center at Lewis Field and is complete. Full details are given in references 1 and 2.

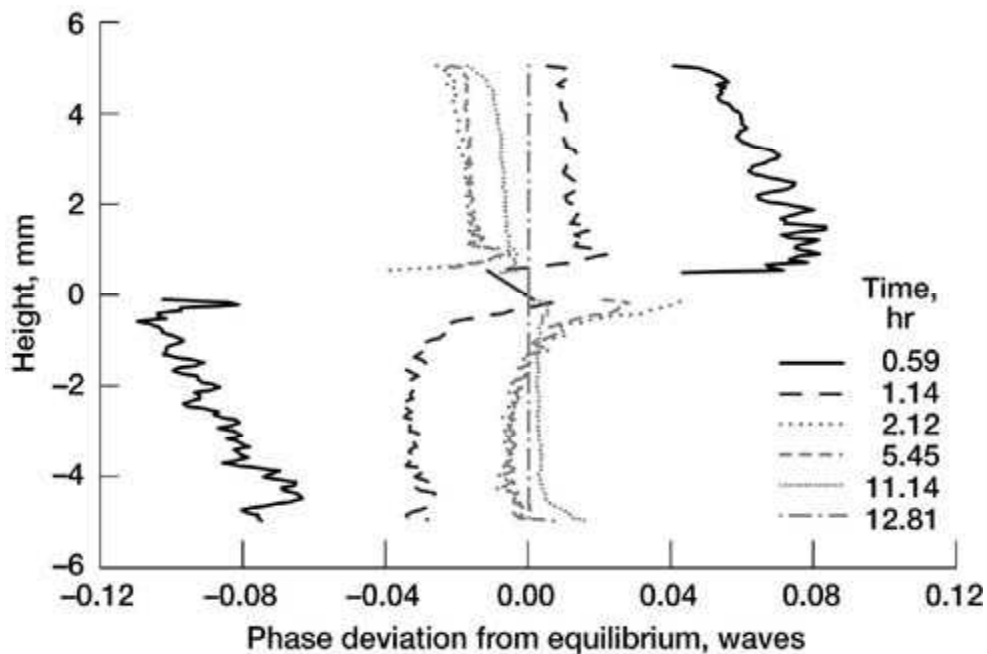
Liquid-vapor critical fluids (e.g., water) at their critical temperature and pressure, are very compressible. They collapse under their own weight in Earth's gravity, allowing only a thin meniscus-like layer with the critical pressure to survive. This critical layer, however, greatly slows down the equilibration process of the entire sample. A complicating feature is the buoyancy-driven slow flows of layers of heavier and lighter fluid. This work highlights the incomplete understanding of the hydrodynamics involved in these fluids.

In low gravity, critical fluids equilibrate to a homogeneous density state by diffusion only. Density disturbances are very easy to induce in low gravity and are very very slow to relax away.

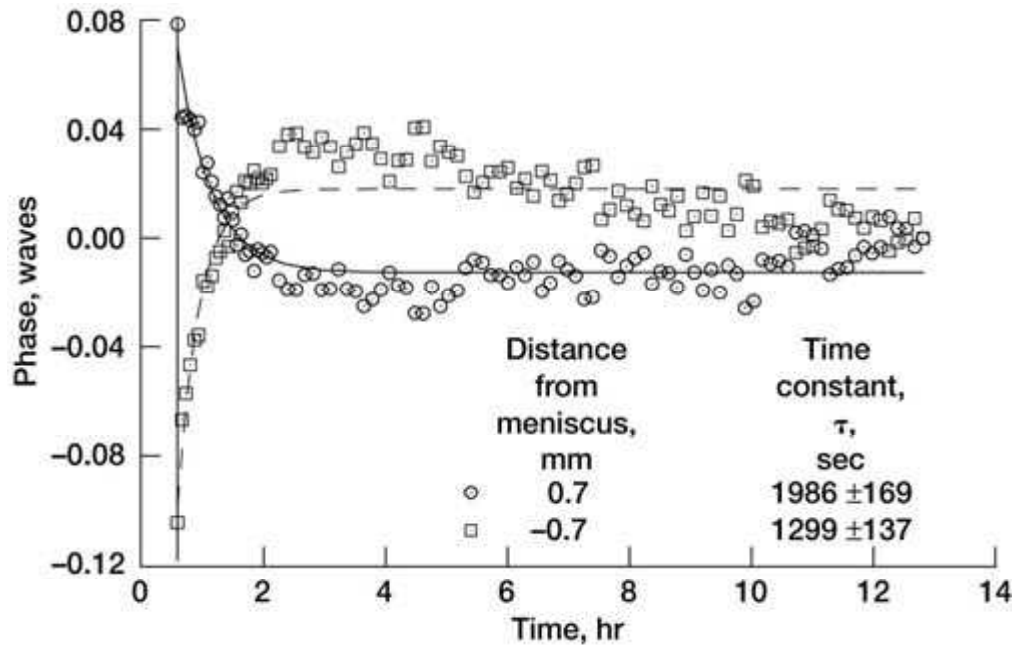


Height profiles of deviation from equilibrium with time for a run with an initial state of $T_c - 50$ mK and a final state of $T_c + 29.6$ mK. The earliest and latest times plotted reflect the time window when the thermostat was stable to ± 50 mK. One wave (fringe) of phase deviation corresponds to a 0.35-percent density deviation.

These experiments studied the density relaxation of a liquid-vapor critical fluid in Earth's gravity over a temperature regime of severe density stratification. A 10-mm-diameter, 1-mm-thick, disk-shaped sample of SF₆ was placed in a Twyman-Green phase-shifting interferometer with a phase uncertainty of only 1/65 of a wavelength during a test period of over 60 hours. Relaxations to an equilibrium stratification were observed for a temperature range from 1.0 to 29.6 mK above the critical temperature T_c . The interferometry provided a density distribution history over the full extent of the sample cell. Two types of initial density states were established before stepping to the final temperature (density) states for relaxation: (1) the two-phase state at $T_c - 50$ mK and (2) the equilibrium state at $T_c + 100$ mK. Upper and lower portions of the cell relaxed differently for these two initial states. For the $T_c + 100$ mK initial state, relaxation to $T < T_c + 3$ mK showed an early density overshoot, followed by an additional long-time relaxation not seen in the other relaxation sequences. Otherwise, relaxations were faster and increasingly nondiffusive (without a unique exponential description) as the final state drew closer to the critical temperature.



Height profiles for a run with an initial state of $T_c + 100$ mK and a final state of $T_c + 2.8$ mK. Note the geometric time sequence of the plots. Ignore the traces in the height region ± 0.5 about 0 because the fringes were too closely packed for reliable analysis.



Relaxation at 0.7-mm above and below the meniscus for a run with an initial state at $T_c + 100$ mK and a final state of $T_c + 2.8$ mK. In low gravity, the time constant was 5546 ± 62 sec at $T_c + 3.4$ mK. The legend notes the fit exponential time constants and their fit uncertainties.

Reference

1. Wilkinson, R.A., et al.: Equilibration Near the Liquid-Vapor Critical Point in Microgravity. Phys. Rev. E, vol. 57, no. 1, 1998, p. 436.
2. Wilkinson, R.A.: Int. J. Thermophysics, vol. 19, no. 4, 1998.

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