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Rarefaction Waves in Van Der Waals Fluids

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As the simplest description of material that exhibits a liquid- vapor two-phase state, the Van der Waals' fluid model can be used to obtain qualitative (and sometimes quantitative) information about the fluid dynamics of material in the two-phase regime. We apply the general one-dimensional self-similar solution of a rarefaction wave in an initially semi-infinite liquid, uniform in temperature and density, to the specific case of a Van der Waals' fluid. Using dimensionless variables, we obtain a set of profiles for the fluid density, temperature and velocity, that describes the fluid for a wide range of space, time, initial conditions, and Van der Waals' parameters. These dimensionless results may be used to interpret experiments in which a material is rapidly isochorically heated before expanding. In particular, "plateaus" in temperature, density and velocity as a function of position are observed characterizing entrance into the two-phase regime. We observe that these "plateaus"- as well as the maximum fluid velocities, the densities and the temperatures of the liquid before entering the two-phase regime - depend exclusively on the initial entropy.
Based on this set of universal dimensionless curves and the observed "plateaus", we propose a semi-analytical method to determine the Van Der Waals parameters, the initial temperature and pressure from a single density profile recorded during the expansion.

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