Crossover Between Singular Critical Behavior and Classical Behavior in a van der Waals Fluid*

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The behavior of fluids away from the critical point is described by a variety of classical equations of state. The simplest example is the van der Waals equation. All classical equations, however, fail near the critical point where density fluctuations become important. The behavior of fluids asymptotically close to the critical point is strongly affected by these fluctuations and can be described in terms of universal scaling laws. Here we present a crossover procedure which enables one to incorporate the universal critical scaling behavior into a classical equation of state. As an example we demonstrate how the crossover procedure works for a van der Waals fluid. In this particular instance the crossover equation of state is universal, i.e. it does not contain any system-dependent coefficients except the critical parameters. Specifically, the van der Waals fluid exhibits a universal shift between the classical and the actual critical points. We elucidate the microscopic meaning of the crossover parameters and discuss different versions of the crossover functions. We demonstrate how the critical point shift, although system-independent, depends on which particular version of crossover function is used.

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