

The Critical Region - Critical Exponents and Equations of State

Wolfgang Wagner ^{C, S} and Norbert Kurzeja

Lehrstuhl für Thermodynamik, Ruhr-Universität Bochum, Bochum, Germany

In the critical region, the thermodynamic properties of a pure fluid change drastically, which in turn effects a strong curvature of the surface around the critical point; directly at the critical point some properties are even considered to take on the extreme values “infinite” and “zero”, respectively. In contrast to the technical importance, from the physical point of view, the immediate vicinity of the critical point is of outstanding interest. The thermodynamic properties in the near-critical region of pure fluids can be described by so-called power laws. The critical exponents α , β , γ , and δ are defined via such power laws of the corresponding property. The meanfield theory and analytical equations of state yield the so-called classical values, namely $\alpha = 0$, $\beta = 0.5$, $\gamma = 1$, and $\delta = 3$. The physically founded renormalization group theory yields the following values: $\alpha = 0.11$, $\beta = 0.326$, $\gamma = 1.24$, and $\delta = 4.82$. The renormalization group theory was developed by Wilson in 1971 on the example of magnets. It can be seen that there is a significant difference between the classical and the renormalization group values for the critical exponents. In order to try to clarify this discrepancy in the values of the critical exponents of pure fluid substances we designed a very special $p\rho T$ multi-cell apparatus that yields $p\rho T$ measuring points with an extremely high internal consistency with regard to temperature and pressure. Using this apparatus, we measured about 3500 $p\rho T$ data in the critical regions of SF_6 and CO_2 , where both substances were extremely pure. Very surprisingly, from these data we obtained values for the critical exponents that are, for pure fluids under gravity influence and within the experimental uncertainties, in agreement with the classical values. The talk presents details about these findings. In the last part of the talk, features of several kinds of equations of state in representing thermodynamic properties in the critical region of pure fluids are briefly presented.