Renormalization Group Correction to the Multi-Parameter Equation of State for Carbon Dioxide

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The Kiselev crossover method [1] based on the renormalization group (RG) theory reproduces the singularity and the scaling laws at the critical point, and reduces to the mean field theory far from the critical point. It is appealing to apply the rigid scheme of the RG theory while preserving the wide range and high precision of the multi-parameter equations of state (EoS). However, the traditional approach requires a refit of the mean-field EoS from scratch [2]. Near-critical behavior of carbon dioxide is of utmost importance because of the increasing interest in supercritical carbon dioxide Brayton cycle technology. The multi-parameter EoS for carbon dioxide developed by Span and Wagner (SW EoS) [3] is among the most well-established EoSs. In this work, we present a new crossover function for the Kiselev crossover method, tailored for the RG-corrected SW EoS. The resulting new EoS is Helmholtz energy explicit. The crossover procedure does not alter the SW EoS parameters. The introduced crossover parameters are fitted to reference data near the critical point, i.e., the saturation densities below the critical temperature (T_c), the energetic properties and the Widom line above T_c. The difference between the new and SW EoSs only appears in the region that is very close to the critical point. The new EoS reproduces the singularity and the scaling laws at the critical point. The same procedure can be easily altered and applied on other industrial fluids, such as water, nitrogen, and methane, as well as fluids for which the available multi-parameter EoSs do not account for the critical behavior.

References:

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