Light-Scattering Study of a Ternary Fluid Mixture Near the Liquid-Vapor Critical Point

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The critical behavior of a ternary hydrocarbon mixture, methane-propane-pentane, with mole fractions of the components 0.5, 0.35, and 0.15 respectfully, has been investigated. A number of densities, including the critical density, have been studied. A precision instrument for static and dynamic light scattering with a specially designed high pressure optical cell is used for this study. An original fast logarithmic correlator and an original cross-correlation photon counting system enable us to measure a wide range of decay rates of light-scattering intensity fluctuations. Temperature dependences of the light scattering intensity, the mutual diffusion coefficient, and the turbidity have been measured. Phase diagrams of the ternary mixture and the critical locus have also been determined using the same instrument.

In order to analyze and theoretically interpret the obtained results, we have modified the application of the principle of critical-point universality to fluid mixtures (also known as the "isomorphism") to specifically address critical phenomena in ternary systems. After implementation of the isomorphism approach, the critical exponents obtained from our experiment are found to be in agreement with predictions of the renormalization-group theory. Far away from the critical point only a single diffusion mode is observed. In the critical region two diffusivities, the "critical" diffusion mode and the non-critical diffusion mode emerge. The behavior of the critical diffusion mode is in agreement with the predictions of the dynamic-scaling theory.