Measurements and Analysis of the Thermal Conductivity Close to the Vapor-Liquid Critical Line of Binary Fluid Mixtures

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It has been well established theoretically and experimentally that the thermal conductivity of one-component fluids shows a strong enhancement close to the vapor-liquid critical point and ultimately becomes infinite [1,2]. In case of binary fluid mixtures, already since 1971, several theories predict that asymptotically close to the line of vapor-liquid critical points, also referred to as plait points, the critical enhancement of the thermal conductivity remains finite [3]. However, the available thermal-conductivity data on binary fluid mixtures did not offer any experimental evidence for the predicted asymptotic behavior [4]. The most recent measurements were made on carbon dioxide-ethane mixtures with the guarded parallel-plate apparatus [5]. But also these measurements showed a behavior comparable to that found for one-component fluids and, therefore, failed to demonstrate the occurrence of the finite thermal conductivity near the plait point.

We present now new experimental thermal-conductivity data of an equimolar methane-ethane mixture very close to the plait point. For these measurements the upgraded version of our parallel-plate apparatus [6] was used. Since these new data on the equimolar mixture showed a small uncertainty, even in the near vicinity of the plait point, they allowed us to confirm for the first time experimentally that the thermal conductivity of a mixture does not diverge but crosses over to a finite asymptotic behavior at the plait point. These data were analyzed in terms of a new extension of the mode coupling theory for the transport properties, which includes the non-asymptotic critical behavior [7]. As result of this analysis, excellent agreement was found between measured and calculated thermal-conductivity values. A separate analysis was made on earlier measurements for methane-ethane mixtures, obtained with a different method [4], for various compositions and relatively far from the plait point. This analysis revealed the same qualitative behavior for the thermal conductivity, however, quantitatively large differences were found.

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