Thermophysical Property Research by Dynamic Light Scattering (DLS) - A Review over the Past Four Decades

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The present work summarizes and reviews the activities performed at the Department of Engineering Thermodynamics (LTT) of the University of Erlangen-Nuremberg, and continued in the meantime at SAOT-Erlangen, as well as by different research groups accepted worldwide during the past four decades in the field of thermophysical property research by dynamic light scattering (DLS). The continuous progress in this field is given in retrospect, covering the first steps since helium lasers became available in the 1960's and until today. The representation of the methodological principles of DLS and its experimental realization includes light scattering from the bulk of fluids and the application of the method to fluid surfaces, also called surface light scattering (SLS). Measurement examples are presented for the variety of thermophysical properties accessible both by DLS from the bulk of fluids and by SLS, i.e., thermal and/or mutual diffusivity, dynamic viscosity, speed of sound, and sound attenuation and dynamic or kinematic viscosity, surface tension, and interfacial tension, respectively. Here, limitations of this method regarding the thermodynamic state and the accuracy will also be discussed in detail. Finally, a compilation of thermophysical property data obtained until now at LTT- and SAOT-Erlangen by DLS for specific working fluids in chemical and energy engineering is given. The objects of investigation cover industrial standard reference fluids for thermal conductivity and viscosity, refrigerants including chlorofluorocarbons, hydrofluorocarbons and their mixtures, and hydrofluoroethers, working fluids for organic Rankine cycles, as well as pure ionic liquids and their mixtures with dissolved substances. While refrigerant mixtures of technical interest have been investigated at a given composition, special interest has also focused during the last years on the study of thermophysical properties of refrigerant mixtures in dependence on their composition as a means of developing and improving prediction models. Besides offering a significant contribution to a reliable database for different working fluids, DLS from bulk fluids and SLS also provide answers to fundamental questions regarding the critical behavior of pure fluids and fluid mixtures.