The Phenomenon of Superheat of Liquids: in Memory of V.P. Skripov

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The properties of fluids are usually investigated in stable states of a system. Such states are retained as long as one likes under constant external conditions and, therefore, are convenient for performing measurements. However, both in nature and in engineering practice (not to mention the effect of heat-pulse sources) a liquid frequently passes to metastable states. In particular, a superheated liquid is observed when the system crosses the line of liquid-vapor or liquid-liquid (for mixtures with LCST) equilibrium without undergoing a phase transition. For example, for water at atmospheric pressure the value of superheat that precedes the boiling-up may reach 210 K. The crucial feature of the superheated state is the finite time of its existence. In spite of the fact that the superheating is really “an everyday occurrence” [1], the region beyond the line of absolute stability of a fluid remains poorly known so far. This circumstance has given grounds to refer the metastable states of fluids as one of a number of “uncharted territories” in thermophysics [2]. A study of superheated liquids at the Ural Thermophysical School is reviewed in this work from the very beginning up to present. The essence of the techniques of a rising droplet and a small bubble chamber providing a breakthrough in the research of spontaneous boiling-up kinetics and the related phenomenon of attainable superheat in the sixties is discussed. Moreover, these techniques created a basis for performing measurements of fluid properties in superheated states. Step by step, the corresponding methods have been developed and the essential results for the properties of pure liquids have been obtained [3, 4]. The emphasis is made on the description of the method of controlled pulse heating of a thin wire probe. The method allows one to select the entrance trajectory (in time-temperature variables) into the region of superheated states in accordance with a number of thermal properties and with a set of relaxation times for the system, to detect the characteristic boiling-up signal on the heating curve, to determine the substance temperature as well as the heat-flux density from the probe at any chosen moment. Some useful applications of the method to “unconventional fluids”, such as oils, polymeric and gas-saturated liquids, nanofluids are presented. In conclusion, the prospects of our approach to estimating the thermophysical properties of locally superheated liquids are discussed.

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