

Dual-Capillary Apparatus for Accurate Density Measurements of Supercooled Water

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The properties of supercooled water are interesting from the point of view of fundamental physics underlying the strong anomalies in the supercooled region. At the same time, they are important in many applications (e.g. meteorology, aerospace engineering, cryobiology). Recently, an equation of state has been developed for the region of supercooled water [1] which represents the existing data to within their uncertainties. Further progress in this field depends on the availability of experiments either extending deeper into the supercooled region [2] or providing a significantly better accuracy than the present data [3]. An apparatus designed for high accuracy density measurements of supercooled water up to pressures of 200 MPa has been recently constructed at the Institute of Thermomechanics of the Czech Academy of Sciences. We report about its design and show examples of measured data. The principle of the measurement is based on volume changes of liquid enclosed in custom-treated fused silica capillaries associated with temperature change between a supercooled state and a reference state at the same pressure and a reference temperature (e.g. 298.15 K). Measurements are performed in two capillaries of different length to eliminate the effect of temperature transition. Positions of menisci are measured optically through sapphire windows using a high-resolution camera equipped with a telecentric lens and a glass scale attached to the capillaries. Very high accuracy (uncertainty at the level of 0.01% in density) is enabled by the fact that fused silica has a very small (and well known) coefficient of thermal expansion and the capillary is pressurized from both sides, so that the very small pressure coefficient is only given by the bulk modulus of fused silica.

References:

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