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The Dynamics of Supercooled Water
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We present an overview of recent experiments performed on transport properties of water in the deeply supercooled region, a temperature region of fundamental importance in the science of water. We report data of nuclear magnetic resonance, quasi-elastic neutron scattering, Fourier-transform infrared spectroscopy, and Raman spectroscopy, studying water confined in nano-meter-scale environments (nano-tubes and the protein hydration water) and in bulk solutions. When contained within small pores, water does not crystallise, and can be supercooled well below its homogeneous nucleation temperature $T_h$. On this basis it is possible to carry out a careful analysis of the well known thermodynamical anomalies of water. Studying the temperature and pressure dependencies of water dynamics, we show that the liquid-liquid phase transition (LLPT) hypothesis represents a reliable model for describing liquid water. In this model, water in the liquid state is a mixture of two different local structures, characterised by different densities, namely the low density liquid (LDL) and the high-density liquid (HDL). The LLPT line should terminate at a special transition point: a low-T liquid-liquid critical point. In particular We discuss the following experimental findings on liquid water: (i) a crossover from non-Arrhenius behaviour at high $T$ to Arrhenius behaviour at low $T$ in transport parameters; (ii) a breakdown of the Stokes-Einstein relation; (iii) the existence of a Widom line, which is the locus of points corresponding to maximum correlation length in the $p$-$T$ phase diagram and which ends in the liquid-liquid critical point; (iv) the direct observation of the LDL phase; (v) a minimum in the density at approximately 70K below the temperature of the density maximum. In our opinion these results represent the experimental proofs of the validity of the LLPT hypothesis.