Which "anomalies" of aqueous systems can not be explained by the general laws of the statistical physics of fluids?

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Various properties of water and aqueous systems seem to be "anomalous" in comparison with the propeties of other fluid systems. To understand specfic behavior of aqueous systems, it is necessary to distunguish those properties, which are universal for all fluid systems. This can be done by application of the laws of the statistical physics of fluids, which describe how fluid properties are affected by the phase transitions and respective percolation transitions. Our simulation studies of the phase diagram and properties of various aqueous and non-aqueous systems (bulk fluids, confined fluids, fluid mixtures) evidence high universality in the behavior of fluids, including water. When the universal features in the behavior of aqueous systems are known, we can distinguish specific properties of aqueous systems and to consider their origins. Below, some examples are presented.

a) The specific properties of **bulk water** originate mainly from the proximity of the liquid-liquid phase transitions, which are located in supercooled region. These transitions are caused by the variety of the local ordering in water. The specificity of water is the location of the liquid-liquid transitions not very far from the freezing temperature; thus, their distant effect on the properties of liquid water is noticeable in a wide temperature-pressure range. **b)** Behavior of liquid water near **hydrophobic surfaces** is essentially the same as behavior of other fluids near weakly-attractive surfaces. In both cases, disordering effect of a surface causes density depletion near a surface. Solvent-mediated attraction between extended weakly-attractive surface ("**hydrophobic attraction**" in water) is a phenomenon universal for all fluids. The specificity of water is in abundance of hydrohpobic surfaces on the Earth. **c)** Near **hydrophilic surfaces**, liquid water forms two highly orientationally ordered layers, whose properties noticeably differ from water properties in third and subsequent layers. This specific water behavior is due to the rearrangement of H-bonds near a hydrophilic surface. **d) Clustering** of water and solute molecules in aqueous solutions and its changes upon varying thermodynamic conditions follow the laws general for lattices and fluids. **e)** Many solutes have an extremely **low solubility** limit in liquid water (for example, it is about 10^{-12} for amyloidogenic peptides). In oversaturated solution of such solutes, a lag time of aggregation (precipitation) may take years. **f)** The crucial **role of hydration water in biofunctions** is the most intriguing problem, which should be solved. Our simulation studies of hydration water evidences, that there is an area in the temperature-pressure diagram, where a surface is covered by a spanning network of normal (fragile) hydration water. This area is bounded by liquid-liquid transition to strongly tetrahedral water at low temperatures, by transition to weakly tetrahedral water at high pressures and by thermal break of a spanning water network via a percolation transition at high temperatures. Interestingly, this area approximately maps the thermodynamic range, where biomolecules exhibit activity and living organisms may function.

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