Water: The most anomalous liquid

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Water is unique in its number of unusual, often called anomalous, properties. When hot it is a normal simple liquid, but close to ambient temperatures properties, such as the compressibility, begins to deviate and do so increasingly upon further cooling. Clearly, these emerging properties are connected to its ability to form unique hydrogen bonding structures. A wealth of new data from various experiments and simulations has recently become available. The lectures will cover how in particular x-rays that together with theoretical simulations can provide deeper insights into the structural origins of the unique properties of water.

Lecture 1: Fundamental properties of water (Nilsson)
Topics to be covered are a comparison between the thermodynamic properties of normal simple liquids and water, the water phase diagram, various glassy forms of water and finally different hypothesis to explain the structural origin of waters anomalous properties.

Lecture 2: X-ray spectroscopy and x-ray scattering of water (Nilsson)
Topics to be covered for spectroscopy are basic principles of electron spectroscopy, x-ray absorption spectroscopy, x-ray emission spectroscopy and resonant inelastic scattering, theoretical simulations of the spectroscopic process and finally spectroscopic signatures of various structural motifs in water and ice. Topics to be covered for scattering are measurements of x-ray scattering and the derivation of O-O pair correlation functions, test of various structural models, long range correlations based on small angle x-ray scattering, comparison to molecular dynamic simulations.

Lecture 3: X-ray lasers (Perakis)
Topics to be covered are basic principle of x-ray laser generation, unique properties in terms of ultrashort pulses and coherence, probing water at extreme conditions such as in the deep supercooled regime, evaluation of various hypothesis to explain supercooled water behavior based on experimental data and finally future utilization of x-ray correlation spectroscopy to derive dynamical information of water.

Prerequisites for attending the lecture: General condensed-matter physics, atomic and molecular physics, thermodynamics for physics and physical chemistry including spectroscopy for chemists.