Two types of liquid water – diffusive dynamics during the transition from high- to low-density amorphous ice

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Water is undoubtedly the most important liquid on earth and plays an important role throughout various scientific disciplines ranging from physics and chemistry to biology and geoscience. It is well known that water shows many anomalous properties, such as density maxima and diverging thermodynamic properties at supercooled conditions. Despite its importance, most of those anomalies are not understood. It is believed that their origin lies in the complex hydrogen bond network of water. For instance, it allows water to form a large number of crystalline ice phases (17 are known so far) as well as three forms of amorphous ices [1]. In order to obtain a detailed understanding of water’s anomalous properties, knowledge about the instantaneous structure and dynamics of water is needed.

One popular model for liquid water is the two-liquids-hypothesis [2,3]. It describes water as a mixture of two liquids of high (high-density liquid, HDL) and low density (low-density liquid, LDL). These phases are believed to correspond to the two glassy water phases low- and high-density amorphous ice (LDA and HDA) [4]. While at ambient conditions access to these phases is difficult, they are proposed to become distinguishable at deeply supercooled conditions in the vicinity of the hypothesized liquid-liquid critical point. However, as studies of liquid water and amorphous ice at temperatures below ~230 K and above the glass transition temperatures of LDA and HDA around ~150 K can hardly be performed due to the high crystallization rate [1], this regime is denoted as “No man’s land”.

In this contribution I will discuss recent routes to access the structure and dynamics of amorphous ice and liquid water in the “No man’s land”. XPCS studies on amorphous ice suggest the appearance of ultraviscous water in low- and high-density phases upon heating [5]. Afterwards, I will focus on dynamics studies in the ultrafast regime studying water dynamics in the range of fs to ps at FEL facilities. This can be achieved using different pulse lengths or double pulses from split-and-delay devices [6]. Finally, I will discuss potentials of obtaining structural information by X-ray Cross Correlation Analysis (XCCA) [7,8] from supercooled water droplets.

References