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Picosecond X-ray absorption spectroscopy of light-induced processes in liquids

MAJED CHERGUI, Ecole Polytechnique Fédérale de Lausanne

The importance of capturing the dynamics of molecular motion in real-time is crucial for our understanding of physical, chemical and biological phenomena. In addition, structural changes in molecular systems stem from ultrafast electronic structure changes, which change the field of forces within a molecule, and between a molecule and its environment. Therefore, observing both electronic and structural changes in a given system provides deeper insight into its dynamics. Ultrafast optical spectroscopy does not deliver molecular structure. Ideal structural tools in this respect are X-rays, via methods such as diffraction or spectroscopy. Here, we will present our recent results on the probing of structural changes in electronically excited solvated species, using picosecond X-ray absorption spectroscopy, in a laser pump/X-ray probe configuration. We will demonstrate the power of this new approach on three different types of processes: intramolecular electron transfer, ultrafast molecular magnetism and solvation dynamics around an atomic ion, and discuss future extensions to biological systems. We will also discuss future experiments with femtosecond time resolution at synchrotrons and 4^{th} generation light sources.