Inception of electronic damage of matter by photon-driven post-ionization mechanisms

W. Błachucki, J. Szlachetko

Institute of Nuclear Physics, Polish Academy of Sciences, ulica Radzikowskiego 152, 31-342 Kraków, Poland
E-mail: *wojciech.blachucki@ifj.edu.pl, jakub.szlachetko@ifj.edu.pl*

Studying the structure of complex systems by means of the 3rd and 4th generation radiation sources have been always associated with concern about the harmful influence of the probe beam on the target sample. The so called *probe-before-destroy* approach permits diffraction and imaging measurements of intact specimens using ultra-bright but highly destructive X-ray free-electron laser (XFEL) pulses [1]. In this approach the destructive nature of the X-rays is outrun by means of X-ray pulses shortened to tens of femtoseconds. The radiation damage considered in terms of structural changes occurs after time of more than 50 fs [2]. In this contribution I will report the electronic structure damage of a $Fe(CN)_6$ molecule in H_2O solution with 30 fs-short X-ray pulses under preservation of the atoms' positions [3]. A detailed investigation of the X-ray induced processes revealed that X-ray absorption events in the H_2O solvent produce a significant number of solvated electrons within attosecond and femtosecond timescales that are capable of coulombic interactions with the $Fe(CN)_6$ molecules. The presented findings show a strong influence on the experimental spectra coming from ionization of the probed atoms' surroundings leading to electronic structure modification much faster than direct absorption of photons.

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[1] H. N. Chapman *et al.*, *Nature* **470**, 73–77 (2011).
[2] J. Kern *et al.*, *Proceedings of the National Academy of Sciences* **109**(25), 9721–9726 (2012).
[3] W. Błachucki, J. Szlachetko *et al.*, *Structural Dynamics* **6**, 024901 (2019).