Relaxation dynamics of isolated atoms and molecules in the tender x-ray domain (1-12 keV)

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Understanding of the processes resulting from interaction between light and matter is of interest in many diverse fields such as photochemistry, astrophysics, as well as in biology and medicine. The lifetime of electronic states created by the absorption of a photon by an atom or a molecule determines the time scale within which these processes will occur, and the resulting reactions. When tender X-rays are absorbed, deep electron shells are excited. The significant time scale then becomes of the order of a few femtoseconds. Photoionization of deep atomic core shell is followed by a number of relaxation processes. The primary hole is unstable and the atom will relax mainly through the emission of Auger electrons: an electron from a shallower shell fills the hole and another electron is emitted carrying the excess energy. The atom is then ionized again by Auger decay. A cascade can develop when a series of electrons "tumble" to fill the core holes created subsequently in different electron shells and several Auger electrons are emitted one after the other. Thus, Auger relaxation is a dynamical process that leads to the formation of multiply charged ionic species and involves many intermediate electronic states.

I will describe two original experimental setup we use at the French synchrotron source SOLEIL : CELIMENE has been designed to provide the full momentum vectors of coincident particles emitted after deep core-level photoexcitation [1]. We have also developed a Photoemission setup, permanent endstation of SOLEIL, unique for gases [2].

Photoexcitation of deep inner shells produce instable species in the femtosecond or subfemtosecond time range. This provides useful internal clock to measure chemical bonds elongation dynamics [3]. Cascade Auger effect occur in the electronic relaxation process providing opportunities to study Post Collision Interaction close to the ionization threshold [4]. Multiply charged ions created after the cascade Auger effect were measured in coincidence with the photoelectron allowing to deduce the delocalization dynamics of the initial deep inner shell in the CS2 molecule [5]. Several keV above the ionization threshold, momentum conservation induces a strong recoil in the ion recently observed through Auger Doppler [6]. I will show how High resolution spectroscopy of Double Core Hole states have been characterized [7].

References

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