Réunions scientifiques

Séminaires

Séminaire SOLEIL

Table-top ultrafast X-ray science at the Advanced Laser Light Source

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Invité par la Nicolas JAOUEN

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Femtosecond laser technology has been extensively used to study how chemical bonds are broken and formed during reactions. Femtosecond laser sources provide the temporal resolution to probe in real time molecular vibrational dynamics as chemical reactions evolved and emerging X-ray sources at Free Electron Lasers will enable to make molecular movies. While there are different approaches to probe and image molecular vibrational dynamics, there is a growing interest to develop approaches for probing electronic dynamics. Since the electron orbit time around the hydrogen nucleus in the first Bohr electronic level is ~150 attoseconds, it is clear that attosecond pulses are required to probe electronic dynamics.

Within the last decade, attosecond metrology has been developed using carrier envelope phase stabilized few-cycle laser pulses obtained from Titanium-Sapphire laser system [1]. Currently, the world record for the shortest optical pulse is 80 attoseconds using high harmonic generation (HHG) in the spectral range of 15 nm (~80 eV) [2]. To obtain shorter attosecond pulses, more spectral bandwidth is required which can be obtained via the generation of X-rays at higher photon energies such as the soft X-ray spectral range. With HHG, the maximum photon energy scales linearly with the laser intensity and with the square of the driving laser wavelength [3]. Since the maximum intensity is limited by the ionization potential of the atom, the best approach for increasing the photon energies is to increase the driving laser wavelength. Despite this problem looks simple to solve, laser sources delivering intense few-cycle pulses at longer wavelength are not widely available and neither commercial which limits attosecond science to the VUV spectral range.

At the Canadian Advanced Laser Light Source (ALLS, located at INRS-EMT), my research team has developed a novel laser technology delivering almost single optical cycle pulses at 1800 nm wavelength [4-6]. This laser source is ideal to develop a table-top soft X-ray beam line delivering isolated attosecond pulses with spectra extending to the keV photon energy using the HHG process. HHG spectra for various gases will be presented and discussed. In particular, I will present the work related to our recent publication in Nature physics which discusses the observation of the Xenon giant resonance through the HHG spectra [7]. In addition, I will show how the infrared laser source allows us to obtain an X-ray supercontinuum that extends in water window spectral range (284 eV to 543 eV) and we are close to reach the keV. There are a large number of scientific applications for such an ultrafast X-ray source, with potential for major scientific breakthroughs in AMO physics, biological and material sciences. Among them, bringing attosecond science to the keV spectral range will provide a tool for studying multielectron dynamics [3], spectroscopic and imaging applications of biological structures in solution using X-rays in the water-window spectral range (284 eV to 543 eV) [8], and for time-resolved L-edge absorption spectroscopy (~700 eV for iron; magnetic materials, myoglobin) [9].

*[1] A. L. Cavalieri et al. New J. Phys. 9, 242 (2007). [2] E. Goulielmakis et al. Science 320, 1614 (2008). [3] P. B. Corkum and F. Krausz, Nat. Phys. 3, 381 (2007).[4] B. Schmidt et al. App. Phys. Lett. **96**, 121109 (2010). [5] P. Béjot et al. Phys. Rev. A 81, 063828 (2010). [6] B. E. Schmidt et al. Opt. Express 19, 6858 (2011). [7] A. D. Shiner et al. Nature Physics 7, 464 (2011). [8] J-F. Adam et al. Rev. Sci. Instrum. **76**, 091301 (2005). [9] H. Wang et al. JACS 119, 4921 (1997).*

Ce séminaire sera suivi d'une pause-café

***Formalités d'entrée** : accès libre dans l'amphi du Pavillon d'Accueil. Si la manifestation a lieu dans le Grand Amphi Soleil du Bâtiment Central, merci de vous munir d'une pièce d'identité (à échanger à l'accueil contre un badge d'accès).*

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