Attosecond Science Using Free-Electron Lasers

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The last years has witnessed two important milestones in attosecond metrology in the ex-treme ultra-violet and soft X-ray spectral range with the temporal characterization of trains and isolated attosecond pulses at free-electron lasers (FELs) [1,2]. The succesfull implementation of attosecond techniques using these large scale facilities required to overcome the intrinsic shot-to-shot instabilities for FELs working on the self-amplified spontaneous emission process [3] and the femtosecond timing jitter between the atto-second waveform and the infrared pulse in the case of seeded FELs [4,5].

In my talk, I will discuss how the well-established techniques of attosecond streaking [6-8] and re-construction of attosecond beating by interference of two-photon transitions (RAB-BIT) [9] have been adapted to FELs, delivering a reliable temporal characterization of tunable and controllable attosecond waveforms. In particular, I will show how correlation-based methods [10] can be used for the character-ization and control of the temporal shape of attosecond pulse trains. The experimental approach also delivers a meth-od for determining a posteriori the relative phase between the attosecond waveform and an infra-red pulse [11]. This correlation-based, attosec-ond timing tool could open important perspec-tives for the realization of time-resolsed experi-ment at FELs.

As first application, I will present results on the coherent control of attosecond electronic wave packets emitted in a two-color photoioni-zation process, exploiting transitions character-ized by the absorption of several infrared pho-tons (four and five photons). The experimental observations are in good qualitative agreement with the predictions of a model based on the strong-field approximation [11].

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