AMO Physics with Intense Extreme-UV (XUV) and X-ray Free Electron Lasers

The advent of short wavelength Free Electron Lasers (FELs) operating in the 0.1 to 100 nm wavelength range has opened up the study the interaction of matter with coherent X-ray radiation at intensities previously limited to optical and infrared fields. In particular the high photon energy means that inner-shell electrons mediate the fundamental laser-matter interaction [1,2]. In addition the high photon number (> 10^{12} per pulse) permits measurements on ultradilute targets and photo-processes of extremely low cross-section. Finally the short X-ray wavelength (from < 0.1 nm) and ultrashort pulse duration (few to few 10 femtoseconds) mean that measurements can be made at characteristic atomic space and timescales simultaneously for the very first time. Combining all of the above properties, the prospects for coherent imaging features with (sub-)nanometer scale such as viruses [3] becomes quite bright. Our work has focused on the study of electron emission from benchmark atoms and molecules which can complement the X-ray imaging. The talk will focus on recent measurements made by our collaboration at the FERMI VUV FEL in Trieste, the FLASH XUV FEL in Hamburg and the LCLS X-ray FEL in Stanford aimed at both characterizing and utilizing the radiation.

E.g., we have applied the so-called atomic streaking technique (Figure 1.) to measure few femtosecond pulses at FLASH [4]. Following an introduction to SASE-FELs, a couple of examples from one or more of two-photon [4] and above threshold [5] inner-shell ionization, EUV and X-ray/IR cross-correlation [6,7] and fs streaking electron spectroscopy [8] will be given.

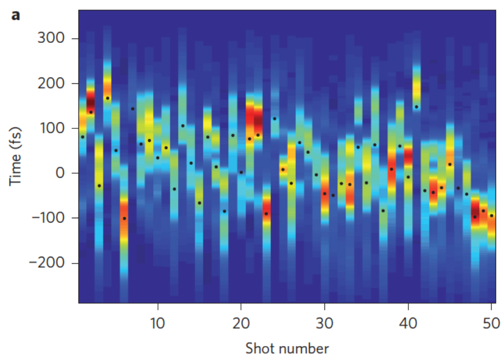

Figure 1. Arrival times (in femtoseconds) of XUV FEL pulses showing the inherent jitter due to the statistical nature of the radiation generation in SASE devices. The block dot represents the centre of gravity of each ‘streaked’ trace.

References

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