Brilliant FEL Light: New Frontiers in AMO Research

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Upcoming 4th generation lights sources, Free Electron Lasers (FEL), will provide, for the first time, intensities, coherence properties, short-time and pump-probe options in the VUV to X-ray regimes comparable to those presently realized by intense, ultra-short laser pulses in the visible. At least three completely new fields of research are expected to open up in atomic and molecular physics. First, the huge integrated radiation flux enables to investigate in unprecedented detail dilute samples, as for example positive ions up to the highest charge states, negative atomic ions, negative or positive state-prepared molecular and size-selected cluster ions. Second, the tremendous peak intensities allow investigating, for the first time, fundamental non-linear processes where few photons interact with few electrons in atoms, molecules, clusters or ions. Third, the short-time properties will enable unique time dependent experiments with any of these targets and first femtosecond VUV-VUV pump-probe measurements have been demonstrated recently. In the talk, these novel fields will be highlighted and first results of pioneer experiments at the **F**ree Electron **Las**er at **H**amburg (FLASH) [1-6] as well as at the **S**pring8 **C**ompact **S**ASE **S**ource (SCSS) in Japan will be discussed. Future possibilities opened e.g. by the integration of large area imaging photon CCD detectors into reaction microscopes (REMI) [7] or by providing ultra-cold targets via a magneto-optical trap (MOT) in a REMI, the streaking of electrons and ions by overlapping phase stabilized THz radiation etc. will be envisioned.

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