

EDITORIAL

## Frontiers of free-electron laser science

To cite this article: Philip Bucksbaum *et al* 2013 *J. Phys. B: At. Mol. Opt. Phys.* **46** 160201

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# Frontiers of free-electron laser science

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The special issue '*Frontiers of free-electron laser (FEL) science*' will highlight the achievement in AMO physics enabled by fourth generation light sources, i.e., short wavelength FELs in Europe, Japan and the USA. AMO physics at these FELs now covers a broad energy range from a few tens of eV to a few tens of keV. The key questions in this new field concern the nature of the interactions of intense FEL pulses with matter and the description of strong-field short-wavelength ionization dynamics. What are the dominant mechanisms of light absorption and electron emission in this new regime? What contrast mechanisms can enhance imaging with superintense pulses? How are the concepts of nonlinear optics altered at short wavelengths? Time-resolved studies are ideal to address many of these issues. The basic techniques of ultrafast pump-probe spectroscopy have now been extended to FELs, both with multiple FEL pulses and with synchronized optical and FEL pulses. The methods for timing synchronization of FEL pulses to optical laser-induced phenomena, including streaking, cross correlations and other time tools are now enabling new studies of time-resolved phenomena. A broad interdisciplinary research field has been formed, which extends the borders of AMO science into biology, chemical dynamics and plasma physics.

Three review articles in this special issue summarize the performances of the fourth generation FEL light sources at FLASH, LCLS and SACLA/SCSS and the first years of research performed there. The contributing authors report on new experimental methods, instrumentations, including the endstation for AMO physics at a newly launched seeded FEL facility FERMI in Elettra, and theoretical tools. The present compilation of results is by no means complete. Examples of exciting research achieved at the new facilities in Europe, Japan and the USA are presented in separate sections. We expect that this collection will be a resource for the rapidly expanding scientific community interested in this new research field.