6-11-2020

Opto-optical modulator (OOM) for extreme ultraviolet pulses

A. Olofsson
Lunds Universitet

E. R. Simpson
Lunds Universitet

M. Labeye
Louisiana State University

S. Camp
Louisiana State University

N. Ibrakovic
Lunds Universitet

See next page for additional authors

Recommended Citation

Olofsson, A., Simpson, E., Labeye, M., Camp, S., Ibrakovic, N., Bengtsson, S., Schafer, K., Gaarde, M., & Mauritsson, J. (2020). Opto-optical modulator (OOM) for extreme ultraviolet pulses. *Journal of Physics: Conference Series, 1412* (7) https://doi.org/10.1088/1742-6596/1412/7/072006

Authors

A. Olofsson, E. R. Simpson, M. Labeye, S. Camp, N. Ibrakovic, S. Bengtsson, K. J. Schafer, M. B. Gaarde, and J. Mauritsson

Journal of Physics: Conference Series

PAPER • **OPEN ACCESS**

Opto-optical modulator (OOM) for extreme ultraviolet pulses

To cite this article: A Olofsson *et al* 2020 *J. Phys.: Conf. Ser.* **1412** 072006

Opto-optical modulator (OOM) for extreme ultraviolet pulses

A Olofsson[1], E R Simpson[1], M Labeye[2], S Camp[2], N Ibrakovic[1], S Bengtsson[1], K J Schafer[2], M B Gaarde[2] and J Mauritsson[1*]

[1]Department of Physics, Lund University, P.O. Box 118, SE-221 00 Lund, Sweden
[2]Department of Physics and Astronomy, Louisiana State University, Baton Rouge, Louisiana, 70808, USA

Synopsis There is a profound, almost symbiotic relation between electrons and photons. When light interacts with matter the electrons in the material will start to move and oscillate. When a charged particle, such as an electron, oscillates it will act as a dipole and emit light. We utilize this symbiotic relation and extend the control of light to the extreme ultraviolet (XUV) region using the newly developed XUV opto-optical modulator.

To control light with short wavelengths is challenging since the tools available for visible light cannot easily be extended to shorter wavelength regions. We present a technique to control the phase of light in the extreme ultraviolet XUV wavelength region. We do this using the recently demonstrated opto-optical modulator (OOM), a technique for controlling the direction, duration and timing of XUV pulses using infrared (IR) control pulses [1,2].

In the OOM, coherent XUV light is used to promote an ensemble of atoms to a superposition of the ground state and a series of excited states. As the excited states decay [4,5], emission of the same XUV frequency light is reradiated, destructively interfering with the incident radiation to produce a normal absorption spectrum on-axis in the far-field. In this time, a second laser pulse can be used to control the target atoms, directly affecting the wavefronts, and consequently the direction, of any subsequent XUV emission. This is achieved through the application of a state-specific, spatial phase gradient across the radiating target focus, arising from the intensity-dependent, AC Stark-induced energy shifts that occur upon interaction of the target atoms with the control laser pulse. By offsetting the foci of the excitation and probe pulses, simple control over the spatial gradient of intensities applied to the target atoms can be achieved, allowing manipulation over the redirection angle of subsequent XUV emission.

Since the spatial profile of the IR probe in the interaction regioncan be easily controlled the method can be further extended to steer or split XUV pulses. We demonstrate this control through a which-way interference experiment where different parts of the XUV beam are made to overlap in the far-field producing interference. Control over the IR probe pulse may be further improved, for example, by using spatial light modulators to shape the IR beam and enable phase gratings and beam splitters for XUV pulses.

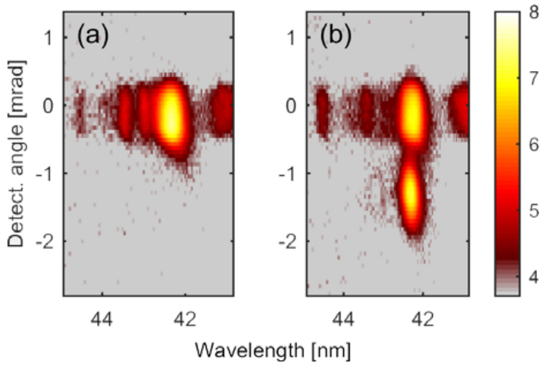

Fig. 1. a) The XUV spectrum transmitted through argon and b) the same spectrum partially re-directed by an IR control pulse. The IR pulse modulates the spatial phase of the excited dipoles, thus modifying the directionality of the emitted light.

References

[1] Bengtsson S *et al.* 2017 *Nature Photonics* **11** 252
[2] Bengtsson S and Mauritsson J 2019 *J. Phys. B* **52** 063002
[3] Ott C *et al* 2014 *Nature* **516** 374
[4] Brewer R G and Shoemaker R L 1972 *Phys. Rev. A* **6** 2001
[5] Hopf F A *et al* 1973 *Phys. Rev. A* **7** 2105

* E-mail: johan.mauritsson@fysik.lth.se