Fr-11.

Attosecond pulse generation in noble gases in the presence of extreme high intensity THz pulses

E. Balogh[1], J. A. Fülöp[2], J. Hebling[2], P. Dombi[3], G. Farkas[3], K. Varjú[4]
[1]*Department of Optics and Quantum Electronics, University of Szeged, 6720 Szeged ,Dóm tér 9. Hungary*
[2]*Department of Experimental Physics, University of Pécs, 7624 Pécs, Ifjúság u. 6. Hungary*
[3]*Research Institute for Solid-State Physics and Optics, 1121 Budapest, Konkoly-Thege M. út 29-33, Hungary*
[4]*HAS Research Group on Laser Physics, University of Szeged, 6720 Szeged, Dóm tér 9. Hungary*

The shortest – attosecond – light pulses available today are produced by high harmonic generation (HHG) of near-infrared (NIR) laser pulses in noble gas jets [1,2], providing a broad spectral plateau of XUV radiation ending in a cutoff. The minimum pulse duration is determined by the achievable bandwidth (i.e. the position of the cutoff), and the chirp of the produced pulses. The extension of the cutoff by increasing the laser intensity is limited by the depletion and phase matching problems of the medium. An alternative method demonstrated to produce higher harmonic orders is by using longer pump pulse wavelength, with the disadvantage of decreased efficiency [2]. Recently it was shown that application of a quasi-DC high strength electric field results in an increase of more than a factor of two in the order of efficiently generated high harmonics [3]. However, the possibility to implement the method proposed in [3] of using a CO_2 laser to create a quasi-DC field for assisting HHG of the NIR laser is questionable, because it's technically very challenging to synchronize pulses from different laser sources. Alternatively, synchronous production of THz pulses with the NIR laser pulse offers a more promising route. The first numerical test of this idea has been reported in [4].
In this contribution we further investigate the method for realistic THz field strengths and short driving pulses, exploring the effect of longer pump laser wavelength on the process. We assume the presence of high intensity THz pulses for supplying the high-strength quasi-DC electric field. The spectrum as well as the chirp of the produced radiation is calculated. We use the non-adiabatic saddle point method to determine the generated radiation described in [6]. We simulate harmonic generation in noble gas atoms, with few cycle NIR pulses of peak intensity at and above 2×10^{14} W/cm^2 (388 MV/cm) and wavelengths 800 nm and 1560 nm. The THz field strength is varied from 0 to 100 MV/cm (the highest field strength currently available [5]). The generated spectra is calculated for each half-cycle, and coherently summed.
As a result of the presence of the THz field, the half-cycle periodicity of the HHG process is broken, leading to the appearance of both odd and even harmonics and a radiation with a spectrum split to two plateaus. The two cutoffs are set by the radiation produced in the consecutive half-cycles. The higher cutoff increases, whereas the lower cutoff decreases with increasing THz field strength. In cases when THz field is added to a few cycle laser pulse a broad super-continuum part in the spectra can be obtained. The broad spectrum of the produced radiation would support the synthesis of single attosecond pulses in the absence of a strong chirp. The method presented here allows for the production of a broader spectral range of harmonics, leading to the synthesis of even shorter attosecond pulses.

References

[1] Gy. Farkas and Cs. Toth, Phys. Lett. A 168, 447 (1992).
[2] F. Krausz and M. Yu. Ivanov, Rev. Mod. Phys. 81, 163 (2009).
[3] Y. Xiang, Y. Niu, S. Gong, Physical Review A 79, 053419 (2009).
[4] W. Hong, P. Lu, P. Lan, Q. Zhang, X. Wang, Optics Express 17, 5139 (2009)
[5] A. Sell, A. Leitenstorfer, and R. Huber, Optics Letters 33, 2767 (2008).
[6] G. Sansone, C. Vozzi, S. Stagira, and M. Nisoli, Phys. Rev. A 70, 013411 (2004)