HIGH-BRIGHTNESS HIGH-ORDER HARMONIC GENERATION IN THE SUB-10-FS REGIME

S. De Silvestri[1], M. Nisoli[1], S. Stagira[1], P. Villoresi[2]

[1]INFM, Dipartimento di Fisica, Politecnico di Milano (Italy)
[2]INFM, Università di Padova (Italy)

When an intense short light pulse is focused into an atomic gas medium, extremely high harmonics of the incident-laser frequency can be generated. This is a table-top source of coherent extreme ultraviolet (XUV) radiation, with pulse duration potentially in the sub-femtosecond regime. The unique properties of the harmonic emission can open the way to new applications in atomic and molecular spectroscopy, solid state and plasma physics. The optimization of the harmonic-generation conversion efficiency and of the spatial properties of the harmonic radiation are very important issues in such applications.

In this work, we report on a novel scheme for the generation of high-brightness harmonic radiation by employing sub-10-fs laser pulses, generated by the hollow fiber compression technique [1,2]. We show that the use of a fundamental beam with truncated-Bessel intensity profile, produced by propagation in the hollow fiber, allows to significantly improve the spatial properties of the high-order harmonic beam. Since the hollow-fiber compression technique allows to generate few-optical-cycle pulses, this result is of particular relevance for applications of the XUV radiation, where extreme temporal resolution and high brightness are required.

The measurements demonstrate novel spatial properties of the harmonic emission: regular harmonic spectral profiles, with small divergence, can be generated not only when the gas jet is located significantly after the laser focus, where conversion efficiency is not optimal, as previously observed, but in a considerably larger range of positions around the laser focus, including that corresponding to the maximum conversion efficiency. The experimental results were also predicted by a three-dimensional, nonadiabatic numerical simulation of the generation process.

By using neon gas and 7-fs driving pulses, a relevant conversion efficiency is observed in the soft X-ray part of the spectrum: 3×10^{-7} at 23 nm and 1×10^{-7} at 13 nm. The harmonic beam is very regular in the profile, with FWHM angle of about 3 mrad. The developed sub-10-fs-pulse-driven neon harmonic source emits $\sim10^{6}$ photons/pulse per harmonic (in the plateau region), within an estimated time interval of ~3 fs. The corresponding brightness is about 5×10^{13} W/srad cm^{2} [3]. The resultant high brightness is very interesting looking in the perspective of harmonics utilization.

References

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