Amplification of Attosecond Pulse Trains with Arbitrary Polarization by IR-Field-Dressed Plasma-Based X-Ray Lasers

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The attosecond pulses of extreme-ultraviolet and soft X-ray radiation, produced via high-order harmonic generation (HHG) of optical and infrared (IR) laser fields in gases, have opened up qualitatively new opportunities in the study and control of the electronic processes in atoms, molecules and solids at their intrinsic time scales. However, the energy of high-order harmonics (HHs) is quite limited, especially in the X-ray range and for the harmonics with high ellipticity.

Recently, we suggested a technique to amplify a train of attosecond pulses, produced by HHG of an IR laser field, in a hydrogen-like active medium of a plasma-based X-ray laser. This technique is based on modulation of the frequency of the inverted transition of the X-ray laser by the same IR field, as used to generate the harmonics, via linear Stark effect, which results in redistribution of the gain to the combination frequencies coinciding with the frequencies of harmonics. An experimental implementation of the suggested technique in an active medium of C^{5+} ions at wavelength 3.4 nm in the "water window" range was proposed, and the possibility to amplify by two orders of magnitude a train of attosecond pulses with pulse duration down to 100 as was shown [1].

In the present contribution, we generalize this technique to Ne-like collisional X-ray lasers [2,3]. We show the possibility to amplify a set of HHs constituting sub-fs pulse trains with arbitrary polarization from linear to circular, with either preservation or increase of the harmonic ellipticity during their amplification in the Ne-like active medium of an X-ray laser, dressed by the IR field of the fundamental frequency with linear polarization. We discuss the possibility of an experimental implementation of the proposed technique in the wavelength range 20-30 nm in the active medium of Ne-like Ti^{12+} ions, additionally irradiated by a mid- or near-IR laser field.

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References

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