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Amplification of a train of attosecond pulses in a plasma-based X-ray laser driven by an IR field

V A Antonov[1,2,*], K C Han[3], I R Khairulin[1] and O Kocharovskaya[3,†]

[1]Institute of Applied Physics of the Russian Academy of Sciences, Nizhny Novgorod, 603950, Russia
[2]Prokhorov General Physics Institute of the Russian Academy of Sciences, Moscow, 119991, Russia
[3]Department of Physics and Astronomy, Texas A&M University, College Station, TX 77843-4242, USA

Synopsis We suggest a technique to amplify a train of attosecond pulses, produced via high-harmonic generation of an infrared laser field, in active medium of a plasma-based X-ray laser driven by a replica of the same IR field as used to produce high harmonics forming a train of attosecond pulses.

In this contribution, we suggest a technique to amplify a train of attosecond pulses produced via high-harmonic generation (HHG) of an infrared (IR) laser field in the active medium of a plasma-based X-ray laser driven by a replica of the same IR field. We consider the X-ray lasers generating at the transition from the first excited to the ground-state energy levels of hydrogen-like ions [1]. Under the action of the IR field the frequencies of inverted transitions of the active medium vary in space and time along with variation of the IR field strength due to the linear Stark effect [2, 3]. As a result, the gain for the X-ray field appears not only at the frequency of the resonance, but also at the frequencies of the sidebands, separated from the resonance by an even multiple of the frequency of the driving IR field. If the last one coincides with the frequency of the field used for HHG, and the intensity of the driving field is high enough, then all the high-order harmonics incident to the medium can be amplified simultaneously. If the scattering of the harmonics into each other is suppresed due to the strong plasma dispersion of the active medium at the frequency of the IR field, while the intensity of the IR field is chosen in such a way, that the harmonics of different orders experience approximately the same gain, then there is a possibility for nearly uniform independent amplification of the harmonics, preserving their initial phase relations, and a temporal shape of the attosecond pulse train. We propose an experimental implementation of the suggested technique in active medium of C^{5+} ions dressed by an IR laser field at either 2.1 μm or 0.8 μm wavelength, and show the possibility to amplify by two orders of magnitude a train of attosecond pulses at a carrier wavelength 3.4 nm in the "water window" range with duration down to 100 as, see Fig. 1. We show also a possibility to isolate a single attosecond pulse from the incident attosecond pulse train during its amplification in modulated optically deep medium.

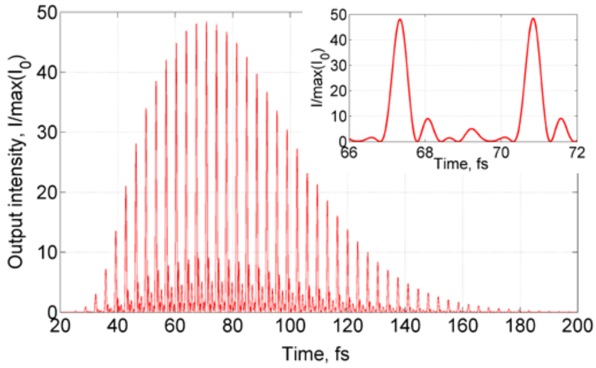

Figure 1. A train of amplified attosecond pulses. Output intensity is normalized to peak intensity of the incident attosecond pulse train. An insert shows two pulses from the train.

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* E-mail: antonov@appl.sci-nnov.ru
† E-mail: kochar@physics.tamu.edu