Stochastic Enhancement of High-order Harmonic Generation

To cite this article: I Yavuz *et al* 2012 *J. Phys.: Conf. Ser.* **388** 032023

Journal of Physics: Conference Series **388** (2012) 032023 doi:10.1088/1742-6596/388/3/032023

Stochastic Enhancement of High-order Harmonic Generation

I. Yavuz*[1], E. Bleda†, and Z. Altun*

* Department of Physics, University of Marmara, 34722, Ziverbey, Istanbul, TURKEY
†Depertment of Mathematic and Computer Science, AREL University, Tepekent, Istanbul, TURKEY

Synopsis Here we demonstrate that from the combination of fundamental laser and noise it is possible to enhance harmonic intensities by 5 orders of magnitude with a modest noise-to-laser amplitude ratio.

Due to its rather low conversion efficiency, optimal enhancement of high harmonic generation has attracted much attention over the last two decades. Different methods, based on multicolor driving fields or mixed gas targets, etc., have been introduced to improve the efficiency of high-harmonic generation for shorter-wavelengths.

We demonstrate the constructive role of noise addition for the generation high order harmonics from He^+ ion. Ti:sapphire laser with a peak intensity of $10^{15} W/cm^2$, a full-width half-maximum pulse duration of 10 cycles, a central laser wavelength of 800nm with a commonly used sine squared pulse shape is used as the fundamental driving field. The simulation of one-dimensional time dependent Schrodinger equation has been performed for He^+ ion interacting with the fundamental driving laser field with and without the addition of noise.

The form of the effective potential (Coulomb potential + laser potential) in the Hamiltonian is set to be $V(x,t) = -2/(|x|^\alpha + \beta)^{1/\alpha} + xE_0 \sin^2(\pi t/\tau)\sin(\omega_0 t)$ [1]. One of the purposes of this study has been the investigation of the stochastic effects as function of model potential. The simulations have been repeated for three different values of α. The β values are chosen so that the initial state state of the system corresponds to the ground state of the He^+ ion in each case.

As it can be seen from Fig 1, regardless of the type of effective potential used in the simulations, the overall profile of the power spectra with and without the stochastic effects in all cases look very similar. Small local differences in the power spectra obtained from laser field alone are completely wiped out by the addition of noise. In all cases the HHG yield is found to be 5 orders of magnitude larger than that of laser field alone. The 23rd harmonic for $\alpha = 1.0$ shifted its harmonic order to lower values as a function of model Coulomb potential for simulations with the laser field alone. Same feature persisted in the simultaneous presence of the laser and the noise. We think the shifted harmonic corresponds to the ionization with the 1s→2p pre-excitation.

A net enhancement by a factor 50 in the power spectrum by an optimal combination of laser field and noise is achieved from our simulations with the model potential of $\alpha = 2$. Such a net enhancement in the HHG yield may be attributed to the stochastic resonance induced by the noise.

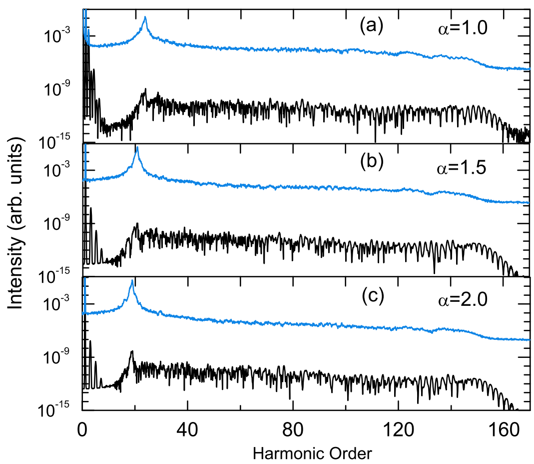

Figure 1. High-order harmonic spectrum for He^+ ion interacting with laser field (black lines) and combined laser and stochastic field (blue lines) for three different model potentials. (a) solid core (α= 1.0) (b) super-solid core (α= 1.5) and (c) soft core (α= 2.0). The noise-to-laser amplitude ratio is 0.097. The back-ground featureless curves are the averages over 50 different realizations for fixed noise-to-laser ratio.

References

[1] A. A. Silev, M. Yu. Ryabikin, and N. V. Vvdenskii *Phys. Rev. A* 82, 033416 (2010)

[1]E-mail: ilhanyav@marmara.edu.tr