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2015 J. Phys.: Conf. Ser. 635 122005

(http://iopscience.iop.org/1742-6596/635/12/122005)

XXIX International Conference on Photonic, Electronic, and Atomic Collisions (ICPEAC2015) IOP Publishing
Journal of Physics: Conference Series **635** (2015) 122005 doi:10.1088/1742-6596/635/12/122005

Harmonic-emission from Rydberg states in the vicinity of metallic nanostructures

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Synopsis We theoretically demonstrate that harmonic emission could be achieved from Rydberg atoms without deteriorating the nanostructures.

The localized fields enhanced by surface plasmons often degrade the metallic nanostructure itself, since high field-intensities are in turn needed to achieve harmonic emission from ground-state atoms. [1]

We theoretically investigate harmonic emission from bound states of target atoms exposed to locally inhomogeneous electric fields. We numerically solve three-dimensional time-dependent Schrödinger equation for hydrogen atom in the vicinity of metallic nanostructure. The interaction between the nanostructure-enhance incident field and the target atom is taken as $z(1+\beta z)E(t)$ [2]. As we go up in Rydberg states of the hydrogen atom, we n-scale the input parameters for harmonic emission. Classical assessments have shown that incident field intensity and frequency and the field-free ionization potential (I_p) of hydrogen-like atoms scales as n^{-8}, n^{-4} and n^{-2}, respectively. Thus, for higher Rydberg states the incident field intensity becomes so weak that the nanostructure would not be damaged [3].

For field intensities on the order of $100TW/cm^2$, the tunnel ionization distance I_p/E_0 plus the excursion amplidute of the continuum electron E_0/ω_0^2 becomes $\sim 20-30a.u.$ and scales as n^2. Thus, due to electron confinement in the nano element, within a dimension of $\sim 200a.u.$ and the chances of absorbtions from metallic surfaces, one cannot speak of the likelyhood of recombination above a certain n-state. Therefore, tweaking the input parameters for an efficient HHG process in the vicinity of metallic nanostructure is essential.

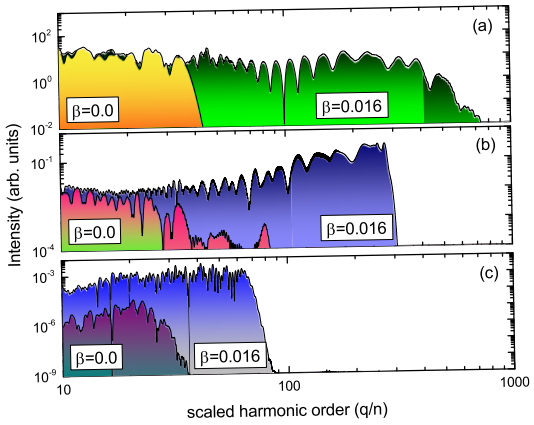

Figure 1. (a) n=1, (b) n=2, (c) n=4. $I_0 = 200TW/cm^2$

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