### **PAPER • OPEN ACCESS**

# High-Order Harmonic Generation from the Cu(111) surface

To cite this article: Néstor F. Aguirre et al 2015 J. Phys.: Conf. Ser. 635 102010

View the article online for updates and enhancements.

### Related content

- High-Order Harmonic Generation from a <u>Model of Ar<sup>+</sup> Ionized Clusters</u>
  Li Na-Na, Zhai Zhen and Liu Xue-Shen
- High-Order Harmonic Generation of hydrogen molecule ions in a large
- internuclear distance Ling-Ling Du, Peng-Cheng Li, Hong-Shan Chen et al.
- High-Order Harmonic Generation by Two Non-CollinearFemtosecond Laser Pulses in CO

Wang Run-Hai, Jiang Hong-Bing, Yang Hong et al.



## IOP ebooks™

Bringing together innovative digital publishing with leading authors from the global scientific community.

Start exploring the collection-download the first chapter of every title for free.

### High-Order Harmonic Generation from the Cu(111) surface

### Néstor F. Aguirre<sup>\* 1</sup>, Sergio Díaz-Tendero<sup>\*</sup>, Fernando Martín<sup>\*†‡</sup>

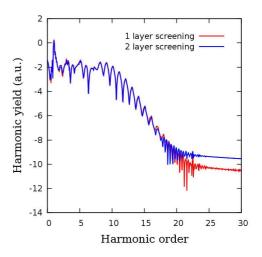
 $^{\ast}$  Departamento de Química, Módulo 13, Universidad Autónoma de Madrid, 28049, Madrid, Spain  $^{\dagger}$  Instituto Madrileo de Estudios Avanzados en Nanociencias (IMDEA-Nanociencia), 28049 Madrid, Spain  $^{\ddagger}$  Condensed Matter Physics Center (IFIMAC), Universidad Autónoma de Madrid, 28049 Madrid, Spain.

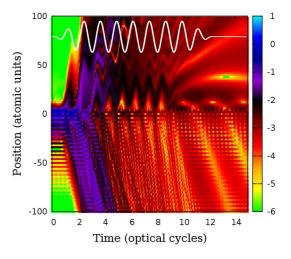
**Synopsis** We investigate theoretically the origin behind the formation of the plateau and cutoff structures in the high-harmonic spectra produced after the interaction of a near-infrared laser pulse with a metal surface. We use a wave packet propagation scheme and a one dimensional description of the Cu(111) surface.

It has been demostrated that solid-state samples can be used as generators of high-order-harmonic (HHG) radiation. The interest of this phenomenon resides in the fact that HHG represents one of the most reliable way to generate coherent ultraviolet to extreme ultraviolet light, with the possibility to observe strong-field physics with modest laser-fields strengths, in contrast with atoms (see for example [1]).

Image-potential states are quantized electronic states that appear near the vacuum level and are present in metal surfaces containing a band gap. The coupling of these states with bulk electronic states is the key point to understand a variety of dynamical processes, as for example the desorption of adsorbates induced by electronic excitations [2]. We are interested in the theoretical description of high-order harmonic generation when electrons are trapped in such image states.

In this work we present a theoretical study of HHG from a Cu(111) surface, by using a quantum-mechanical model within the singleactive-electron (SAE) approximation. For the description of this surface, we use a model potential reported by Chulkov et. al. in ref. [3]. The time-dependent Schrödinger equation is solved numerically on a one-dimensional grid of equidistant points in the position coordinate, where the time evolution of the electronic wave function is described with a modified version of the splitoperator technique [4]. We investigate the formation of the plateau and cutoff as a function of the field intensity and the screening length. For example, Fig. 1 shows some results for a given intensity and two values of the screening length, corresponding to the penetration of laser field inside the material in one and two atomic layers.





**Figure 1.** Top panel: harmonic spectra for a 1D Cu(111) surface irradiated by a 26.7 fs laser pulse  $(I_0 = 50 \text{ TW/cm}^2, \lambda = 800 \text{ nm})$ . Lower panel: time-dependent change in density on a log. scale.

#### References

- [1] G. Wachter et al 2012 Phys. Rev. B 86 035402
- [2] J. Güdde et al 2006 Chem. Rev. 106 4261
- [3] E.V. Chulkov et al 1999. Surf. Sci. 437 330
- [4] C. M. Dion et al 2014. Comput. Phys. Comm. 185 407

<sup>&</sup>lt;sup>1</sup>E-mail: nestor.aguirre@uam.es

Content from this work may be used under the terms of the Creative Commons Attribution 3.0 licence. Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.