Effects due to the induced potential in ultrashort laser interactions with Al(100) and Al(111) surfaces

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Synopsis Photoelectron emission (PE) from the valence band of a metal surface due to the grazing incidence of ultrashort laser pulses on two faces of aluminum- Al(100) and Al(111) - is investigated in the framework of a distorted-wave formulation. We use the band-structure-based-Volkov (BSB-V) approach [1], including also induced-potential effects originated from the electron response of the surface to the external field. For both crystallographic orientations we found that the induced surface (IS) potential contributes to the emergence of band-structure signatures in the near-threshold region of photoelectron spectra.

When an ultrashort laser pulse interacts with a metal surface, the external electromagnetic field induces not only direct PE from the metal but also collective oscillations of valence electrons, i.e., an IS potential.

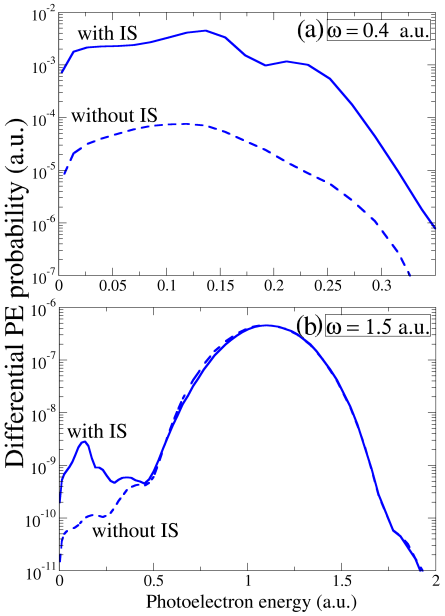

Figure 1. PE distribution from Al(100) for normal emission. The pulse carrier frequency is (a) $\omega = 0.4$ a.u. (b) $\omega = 1.5$ a.u. Solid (dashed) blue lines, BSB-V results with (without) the inclusion of the IS contribution.

In this work we study the role played by the IS field to reveal signatures of the surface-band structure in PE distributions from Al(100) and Al(111), produced by ultrashort laser pulses linear polarized perpendicular to the surface. Calculations were made within an improved version of the BSB-V approach, which includes an accurate description of the electron-surface interaction [2] as well as the contribution of the IS field [3].

Since the IS field depends strongly on the carrier frequency of the laser pulse ω, its contribution is expected to be essential for frequencies close to the surface plasmon frequency ω_s ($= 0.4$ a.u. for aluminum surfaces). However, we find that also for low and high ω values the IS potential produces an enhancement of band-structure effects in the low-energy region of photoelectron spectra (see Fig. 1).

Partial contributions from surface electronic states (SESs) and states at the top of the occupied states (TOSs) are analyzed, finding that they are more noticeable for the Al(100) face, in contrast to the Al(111) case (see Fig. 2).

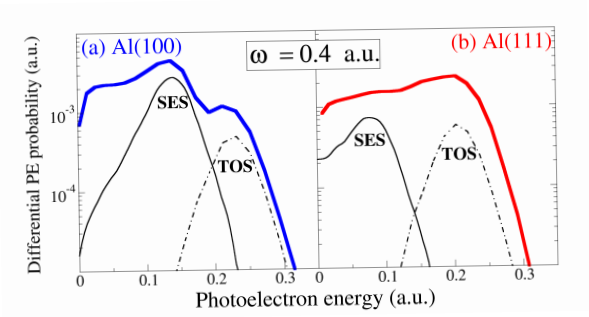

Figure 2. Similar to Fig. 1. In both panels, BSB-V results, including the IS contribution, are displayed with thick solid lines; partial contributions from SESs and TOSs are plotted with thin solid and dot-dashed black lines, respectively.

References

[1] C. Rios Rubiano *et al.* 2012 *Phys. Rev. A* **85** 043422

[2] E.V. Chulkov *et al.* 1999 *Surface Science* **437** 330

[3] C. Rios Rubiano *et al.* 2017 *Phys. Rev. A*. In press.

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