Electron emission from metal surfaces by ultra-short pulses

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Synopsis: We study electron emission spectra produced by the grazing incidence of ultra-short laser pulses on metal surfaces. To describe this process we introduce a distorted-wave approach, based on a simple description of the solid, which includes the main features of the process, taking into account the contribution of the induced potential. The method is applied to evaluate photoemission from the valence band of Al(111), considering different frequencies and durations of the pulse. The results so obtained are contrasted with the numerical solution to the time-dependent Schrödinger equation (TDSE), finding a very good agreement through the whole energetic range.

In the last few years developments in the time domain of laser pulses have made it possible to reduce the durations of them up to sub-femtosecond scale. This fact opens up the study of electron dynamics at surfaces to a new dimension [1,2]. Here, we investigate photoelectron emission produced when an ultra-short laser pulse impinges grazingly on a metal surface.

The problem is described by means of a one active electron model developed in the framework of the time-dependent distorted wave formalism [3]. The proposed theory, called *Surface Jellium Volkov* (SJV) approximation makes use of the Volkov phase to represent the interaction of the active electron with the external and induced fields, while the surface potential is described within the jellium model. The induced surface potential is produced by the rearrangement of the valence-band electrons due to the presence of the external electromagnetic field and it is evaluated with a linear response theory.

To verify our approximation we test the SJV results with the numerical solution to the time-dependent Schrödinger equation (TDSE). In Fig. 1 we show, for both method, photoelectron emission spectra originated from the valence band of a typical metal surface, as Al(111). To complete the study, in Fig. 2 we plot the SJV momentum distribution for the same laser parameters of Fig. 1.

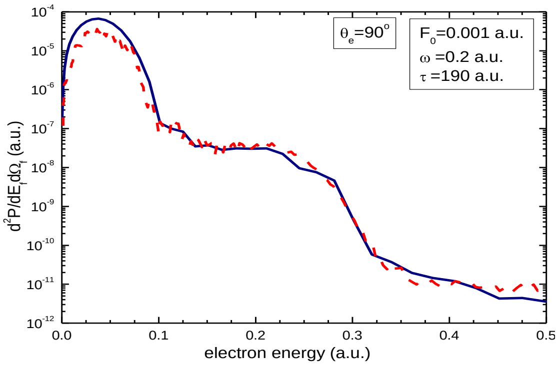

Fig. 1: Electron emission probability, as a function of the electron energy, for the ejection angle θ_e=90°. Solid (blue) line: SJV model; dash (red) line: TDSE results. Laser parameters: F_0=0.001 a.u., ω=0.2 a.u. and duration τ=190 a.u.

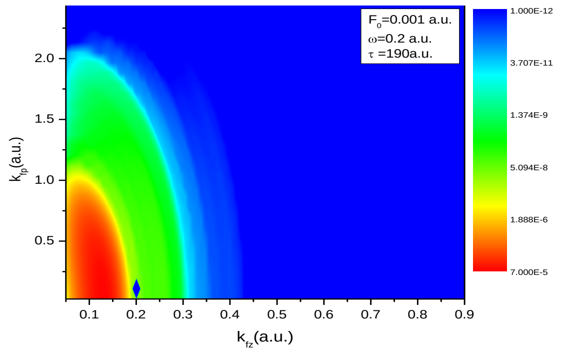

Fig. 2: Electron momentum distribution derived from SJV model.

References

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