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2009 J. Phys.: Conf. Ser. 194 032006

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Ionization of atomic Hydrogen by an intense resonant laser pulse

M G Bustamante† [1] **and V D Rodríguez**† [2]

†Departamento de Física, FCEyN, Universidad de Buenos Aires, 1428 Buenos Aires, Argentina

Synopsis The ionization of atomic Hydrogen by an intense laser field resonant with the transition *1s-2p*$_0$ is studied. The intensity of the field is strong enough to make the Rabi oscillations important. The theoretical treatment of this work is based on a modified form of the Coulomb-Volkov approximation. The decay to the continuum is accounted by coupling the initial and the excited resonant states to the continuum part of the atomic spectrum. A system of integro-differential equations numerically solved is obtained. The results obtained in this work have been tested against the numerical solution of the time-dependent Schrödinger equation. Good agreement has been obtained. ATI peaks splitting related to the Autler-Townes effect is discussed.

The above threshold ionization (ATI) of atomic hydrogen by ultrashort laser pulses with laser frequency in resonance with the transition *1s-2p*$_0$ is studied. The theoretical frame used in this work is based on a variational principle for the transition amplitude [1]. The trial wave function for the final state is the Coulomb-Volkov state. The initial state is approximated by a linear combination of the two resonant states:

$$\chi_i^+(\vec{r},t) = a_{1s}^{2SC}\varphi_{1s}(\vec{r})\exp(-i\epsilon_{1s}t) + a_{2p_0}^{2SC}\varphi_{2p_0}(\vec{r})\exp(-i\epsilon_{2p}t). \quad (1)$$

The coefficients are obtained from the solution of the integro-differential system of equations that results by coupling both resonant states altogether with the continuum spectrum in the first Born approximation. This theory is a refinement of the Coulomb-Volkov Two-States (CV-2S) model [2]. The decays of the initial and resonant states are incorporated.

The figure shows the ionization spectra computed exactly with the Qprop code [3] compared with the results obtained by the two states (CV-2S) and two states plus continuum (CV-2SC) approximations. The global agreement is good and both models show splitting of the ATI peaks. This feature may be related to the Autler-Townes effect [4]. The model that involves the decay to the continuum provides a better approximation near the maxima. The large value of ionization probabilities for these intensities (of the order of unity) demands the introduction of the resonant states decay into the model . Rabi oscillations are observed although the sum of initial and resonant state probabilities decay in time. There is a small structure in the spectra that remains unexplained by this model. It may be traced back to excitation to intermediate states followed by multiphoton absorbtion.

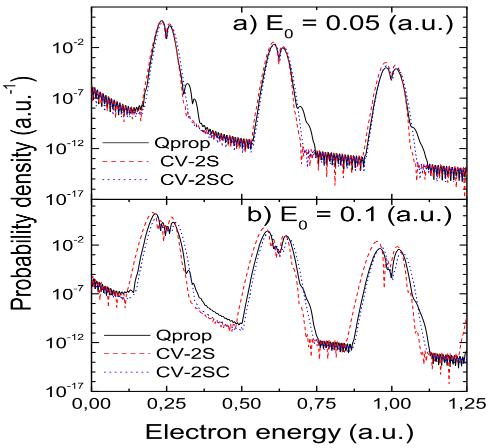

Fig. 1. Hydrogen ionization spectrum by a 40 cycles laser pulse (τ = 670 u.a. = 16.25 fs): a) E_0 = 0.05 a.u. ($I = 8.8 \times 10^{13}$ W/cm^2) and b) E_0 = 0.1 a.u. ($I = 3.5 \times 10^{14}$ W/cm^2).

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[1] E-mail: 6bustamante@gmail.com
[2] E-mail: vladimir@df.uba.ar

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