Convergence properties of the separable potential model applied to strong field Hydrogen ionization

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Synopsis Convergence properties of a recently proposed separable potential model with the number of supported bound states are examined. Calculation of excitation and ionization probabilities of a Hydrogen separable potential model supporting up to 15 bound-states by strong polarized laser field are presented. Transition probabilities to $1s$, $2p_0$, and $3p_0$ states converge smoothly as a function of time with increasing bound states.

A separable potential model for atomic ionization by laser pulses has been recently introduced [1]. The local target potential is replaced by a non-local separable model supporting a few bound-states from the original one. Only three states to obtain excitation probabilities as well as ionization spectrahave been employed rather succesfully. The method has been tested by other authors [2] suggesting to increase the basis set supported by the potential model.

In this work results obtained by separable potential models corresponding to n_{max} ranging from 2 to 5 are presented. Therefore, the maximum number of supported states is 15 ($n_{max} = 5$). The same parameters as in Figure 3 of reference [1] are used, though the laser pulse has been reduced to 20 cycles (the half). In this way the atom is not fully ionized at the end of the pulse, and ionization probability can be used to test the model convergence properties.

In Table 1, total ionization probabilities at the end of the pulse are listed for different values of n_{max} in the separable potential model. When using lower three states ($1s$, $2s$ and $2p_0$) a clear overestimation of the ionization probability is observed. However, ionization probabilities with n_{max} 4 and 5 differ each other less than 5 percent.

Table 1. Ionization probability for different n_{max} values

n_{max}	number of states	ionization probability
2	3	0.91
3	6	0.72
4	10	0.67
5	15	0.64

In Figure 1, excitation probabilities for higher populated states, (a) $1s$, (b) $2p_0$ and (c) $3p_0$ as a function of time for different values of n_{max} are shown. Clearly, all of the n_{max} cases agree well up to 4 cycles. Beyond this time, $1s$ and $2p_0$ probabilities for $n_{max} = 2$ depart from higher n_{max} cases. The latter ones show a global convergence. The comparison between n_{max} 4 and 5 are fairly good even at the end of the pulse. It is concluded that the method exhibits good convergence properties once at least the first six states are represented by the separable potential model.

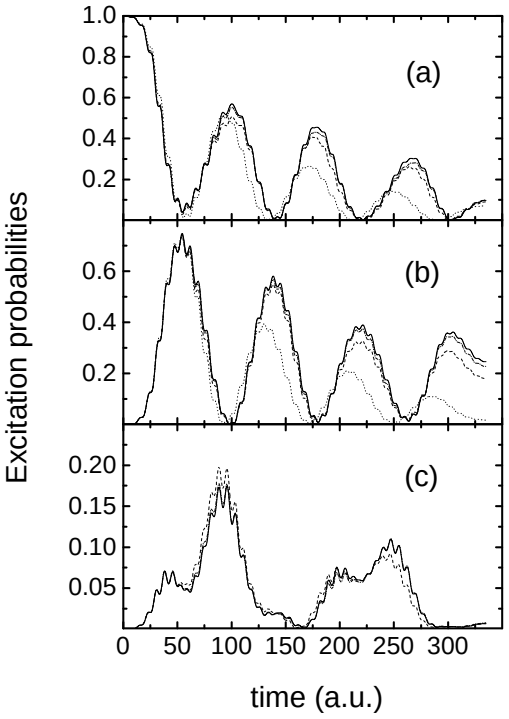

Figure 1. (a) $1s$, (b) $2p_0$ and (c) $3p_0$ excitation probabilities as a function of time for n_{max}: 2, dotted; 3, dashed; 4 dot-dashed and 5, solid lines.

References

[1] H. M. Tetchou Nganso *et al.* 2013 *Phys. Rev. A.* **87** 013420

[2] A. N. Grum-Grzhimailo, M.l N. Khaerdinov and K. Bartschat 2013 *Phys. Rev. A.* **88** 055401

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