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Two-photon ionization using pseudostate summation technique

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Abstract : Accurate and powerful pseudostate summation technique has been used to study two-photon ionization of an atom. Results are obtained for the two-photon ionization of hydrogen from the ground state and the variation of ionization cross section on the frequency of incident radiation is shown for both linearly and circularly polarised light.

Keywords : Ionisation, pseudostate

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With the availability of well defined powerful laser sources and the recent progress in the photoelectron spectroscopy it has now become possible to observe experimentally multiphoton ionization processes during the interaction of strong electromagnetic fields with atoms. In general the transition probabilities are computed on the basis of N-th order time-dependent perturbation theory. The main difficulty encountered in the computation of transition amplitudes of order $N \geq 2$, comes from the presence of infinite sums extended to the whole atomic spectrum.

Different approaches were used in order to solve the problem. Bebb and Gold [1] introduced an average frequency $\bar{\omega}$ related to the real energy spectrum of the atom thereby replacing the infinite summation by an average term and using closure property of the wave functions to remove the intermediate-state transitions from the problem. Gontier and Trahin [2] related the infinite summations to the numerical solutions of a set of first order differential equations.

Over the last few years, there has been considerable interest to develop alternate approaches to those indicated here. In this paper, we shall present calculations for the multiphoton ionization of hydrogen which involves evaluation of summation over intermediate states. We have replaced the intermediate states by a finite set of pseudo-states which are expanded in terms of a basis which is discrete and complete. The main advantage of the method is that it replaces the infinite summation over the intennediate states by a finite sum over the pseudo states.

We investigate two-photon ionization of atomic hydrogen in the ground state. The pseudostate method begins with the choice of N basis functions which are of the simple form

$$\phi_j = e^{-ar} r^{l+1} Y_{l,m}(\theta,\varphi)$$

where a = basis parameter;
l = angular momentum;
N = size of basis.

We diagonalize the target Hamiltonian in this basis and obtain N pseudostates

$$|n\rangle = \Psi_n = \sum_{j=1}^{n} C_j \phi_j / r$$

The pseudostates have the normalization $\langle n|n'\rangle = \delta_{n,n'}$ and the corrosponding pseudostate energies are given by

$$\langle n|H_0|n'\rangle = E_n \delta_{n,n'}$$

These pseudostates are taken as the intermediate states for the evaluation of the transition amplitudes. Our results for

the two-photon ionization cross sections of $H(1S)$ are shown in Figure 1. Curves are shown for both linearly and circularly polarised light. As shown in the curves a resonance enhancement of several orders of magnitude is obtained when the frequency of incident photons corresponds to one of the intermediate states.

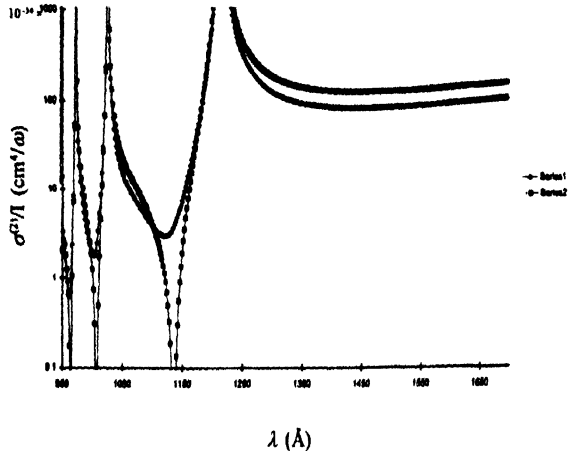

Figure 1. Two photon ionization rates from the hydrogenic ground state : Series 1 : liner polarisation; Series 2 · circular polarisation.

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