Two-photon detachment cross sections and dynamic polarizability of H^- using a variationally stable, coupled-channel hyperspherical approach

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The hydrogen negative ion has long served as a testing ground for new theoretical methods aimed at the accurate treatment of electron correlation effects. This is true also for the case of multiphoton detachment processes, for which the number of theoretical calculations including at least some electron correlation effects has grown substantially since the mid-1980's. However, significant disparities exist even among the results of only these more accurate calculations. Thus, for the most fundamental three-body Coulomb system, there does not exist either a consensus among the theoretical predictions or an experimental measurement of the two-photon detachment cross section in the energy region between the two-photon and one-photon thresholds.

We present here benchmark results for the two-photon detachment cross section of H^- for photon energies up to the one photon threshold. For this purpose we have combined the variationally stable method of Gao and Starace [1] with a coupled-channel, adiabatic hyperspherical approach [2-6] The variationally stable method allows one to control errors in calculating perturbation matrix elements of second and higher order by ensuring that the error in the matrix element is of second order in any errors that occur in representing the generally infinite summations over intermediate states. The adiabatic hyperspherical representation is known on the other hand to provide an excellent basis for describing correlations in two-electron states as well as for describing single- and multiphoton processes in two-electron systems. Our results show the effects of including one to four coupled adiabatic hyperspherical channels. A key finding is that our four-coupled-channel results for the two-photon cross section have qualitatively the same shape as results of Refs. [7, 8], but are modestly lower in magnitude than those results, thereby agreeing with results of Refs. [9-11] above photon energies of 0.3 eV and with the B-spline results of van der Hart [11] for all energies. Our present results and those of Ref. [11] are also in close agreement with results of a phase-shifted, short-range potential model result [7], thereby indicating that the electron correlations important in this energy region are of short range. The close agreement of these three independent results brings a measure of consensus to this problem. Our results and those of others are shown in Fig. 1.

We have calculated also the dynamic polarizability of the ground state of H^- and the single-photon detachment cross section of H^-as a means to judge the reliability of our approach. These results compare well with prior results.

Acknowledgments. This work is supported in part by the DOE, Office of Science, Division of Chemical Sciences, under Grant No. DE-FG03-96ER14646. Mauro Masili is supported by Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP)-Brazil, under Process No. 98/03044-7.

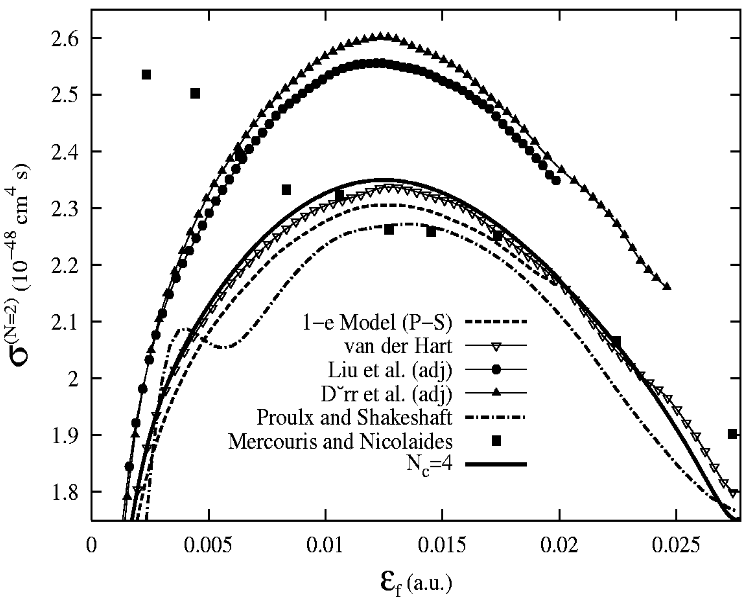

Figure 1: Generalized two-photon detachment cross section of H^- for the case of linearly polarized light as a function of the photoelectron kinetic energy, ϵ_f. *Solid curve*: present ($N_c = 4$) coupled-channel, variationally stable result; *solid squares*: MEMPT result of Mercouris and Nicolaides [9]; *dash-dot line*: complex Sturmian result of Proulx and Shakeshaft [10]; *solid circles*: variationally stable, uncoupled channel result of Liu *et al.* [7] with adjusted electron affinity; *dashed line*: phase-shifted (P-S) single-electron, short-range potential model result of Liu *et al.* [7]; *open triangles*: B-spline result of van der Hart [11]; *solid triangles*: R-matrix Floquet result of Dörr *et al.* [8] with adjusted electron affinity.

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