

## Calculations of electron and positron scattering from vibrationally excited $\text{H}_2^+$ and $\text{H}_2$

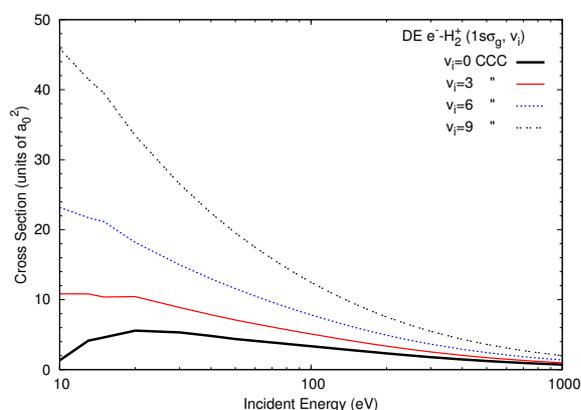
Mark C. Zammit <sup>1</sup>, Jeremy S. Savage, Dmitry V. Fursa, and Igor Bray

Department of Physics, Astronomy and Medical Radiation Sciences, Curtin University, GPO Box U1987, Perth, WA 6845, Australia

**Synopsis** Electron and positron scattering from the vibrationally excited  $\text{H}_2^+$  and  $\text{H}_2$  molecules were investigated using the adiabatic-nuclei convergent close-coupling method. Converged results are presented for a range of vibrationally excited states.

Collision data of electron and positron scattering from vibrationally excited molecules is particularly important in the modelling of fusion plasmas and in the calculation of gas and soft-condensed (biological) matter transport properties. Recent scattering studies indicate a large dependence on the initial vibrational state of the molecule [1, 2]. Utilising the *ab initio* adiabatic-nuclei convergent close-coupling (CCC) method, formulated in both the spherical [1] and spheroidal coordinate systems, we investigate electron scattering from vibrationally excited  $\text{H}_2^+$  and positron scattering from vibrationally excited  $\text{H}_2$ . Converged results in both the multichannel and partial-wave expansions are presented over a broad energy range for elastic, vibrational excitation, electronic excitation, grand total and total ionisation cross sections.

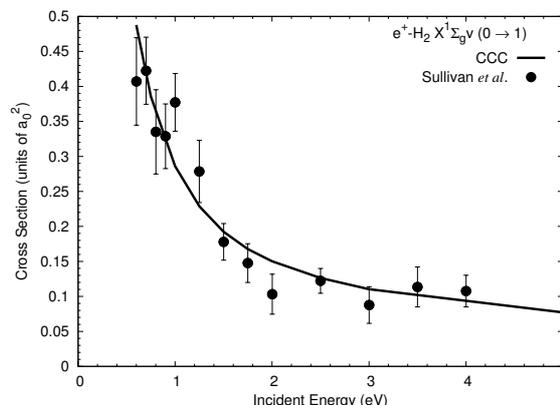
In Fig. 1 we present dissociative excitation (DE) cross sections for electron scattering from  $\text{H}_2^+$  in the initial vibrational state  $v_i$ . The DE cross sections have a major dependence on  $v_i$ . For example, at 20 eV the  $v_i = 9$  DE cross section is 500% larger than the  $v_i = 0$  state. As  $v_i$  increases the DE cross sections monotonically increase and the cross section peak shifts to lower energies.



**Figure 1.** Dissociative excitation (DE) cross sections for electron scattering from  $\text{H}_2^+$  in the vibrational state  $v_i$ .

The  $0 \rightarrow 1$  vibrational excitation cross section for positron scattering from  $\text{H}_2$  is presented in Fig. 2. Results are calculated directly from the adiabatic-nuclei approximation and are in excellent agreement with the measurements of Sullivan *et al.* [3].

Our preliminary results of positron scattering from  $\text{H}_2$  in the initial vibrational state  $v_i = 1$  indicate a major dependence on  $v_i$  in the low-energy region. At 3 eV the  $v_i = 1$  grand total cross section is approximately 25% larger than the  $v_i = 0$  cross section.



**Figure 2.** Vibrational  $0 \rightarrow 1$  excitation cross section for positron scattering from  $\text{H}_2$ . Adiabatic-nuclei convergent close-coupling (CCC) results are compared with the measurements of Sullivan *et al.* [3].

### References

- [1] M. C. Zammit *et al.* 2014 *Phys. Rev. A* **90** 022711
- [2] M. C. Zammit *et al.* 2013 *Phys. Rev. A* **88** 062709
- [3] J. P. Sullivan *et al.* 2002 *Nucl. Instr. Meth. B* **192** 3

<sup>1</sup>E-mail: [mark.zammit@postgrad.curtin.edu.au](mailto:mark.zammit@postgrad.curtin.edu.au)

