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Synopsis We present experimental mass stopping powers of electrons in gaseous H_2 obtained with a newly developed electron time-of-flight spectrometer, for the incident electron energy range of 10 eV to 25 eV. In our procedure the average energy loss is derived from our conversion of measured electron time-of-flight spectra into equivalent electron energy loss spectra so as to obtain the values of mass stopping power for electron scattering from H_2.

Considerable effort has been made in the past to investigate the electron collisions with molecular hydrogen. Before considering more complex molecular systems it is fundamentally important to investigate this simplest molecule, to provide insights into quantitative studies of electron-molecule collision processes.

The mass stopping power (MSP) - a useful parameter obtained from collision studies - is of fundamental importance in biomedical dosimetry, radiation physics, chemistry, medicine and biology involving neutrons, protons, X-rays and electrons [1]. The MSP is defined by the well-known formula:

$$\mathrm{MSP} = \frac{1}{\rho}\frac{dE}{dx} = \frac{N_a}{M}\langle E_L\rangle\,\sigma_{\mathrm{inel}}\ , \qquad (1)$$

where N_a is Avogadro's number, M is the molar mass of the molecule, in this case for H_2 = 2.016 g/mol. $\langle E_L\rangle$ is the mean inelastic energy loss, and σ_{inel} is the integral inelastic cross section in a.u. and ρ, is the density of gaseous H_2.

Although, MSPs are widely used in many fields they are not easy to obtain experimentally. This is because in these measurements the complete electron energy loss spectrum should be measured, and the spectrum should be corrected for instrumental transmission effects.

Our measurements were obtained from a recently constructed time-of-flight (TOF) spectrometer, consisting of an intense energy unselected pulsed electron gun and a TOF analyzer [2]. In our studies we collide low-energy electrons with target H_2 gas molecules in the crossed beam configuration, and we measure transmission-effects-free TOF electron scattering spectra and used them to provide experimental MSP of electrons in H_2 in the low electron energy range, as presented in Fig. 1.

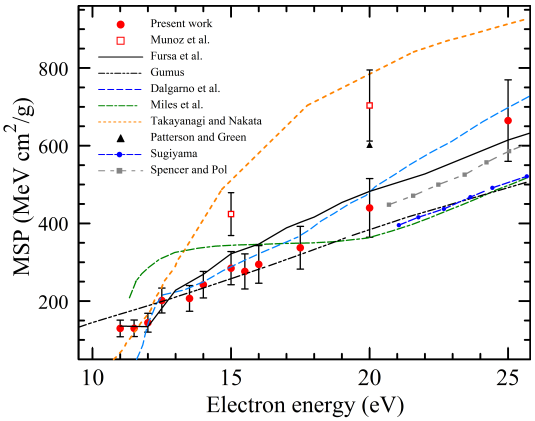

Figure 1. MSP for electron scattering from the ground state of H_2 compared with (many) available theoretical and (one other) experimental data.

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References

[1] Mayles P, Nahum A and Rosenwald J C 2007 *Handbook of Radiotherapy Physics: Theory and Practice* (CRC Press, Boca Raton)
[2] Zawadzki M *et al* 2018 *Phys. Rev. A* **98** 062704

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