

A statistical description of scattering at the quantum level

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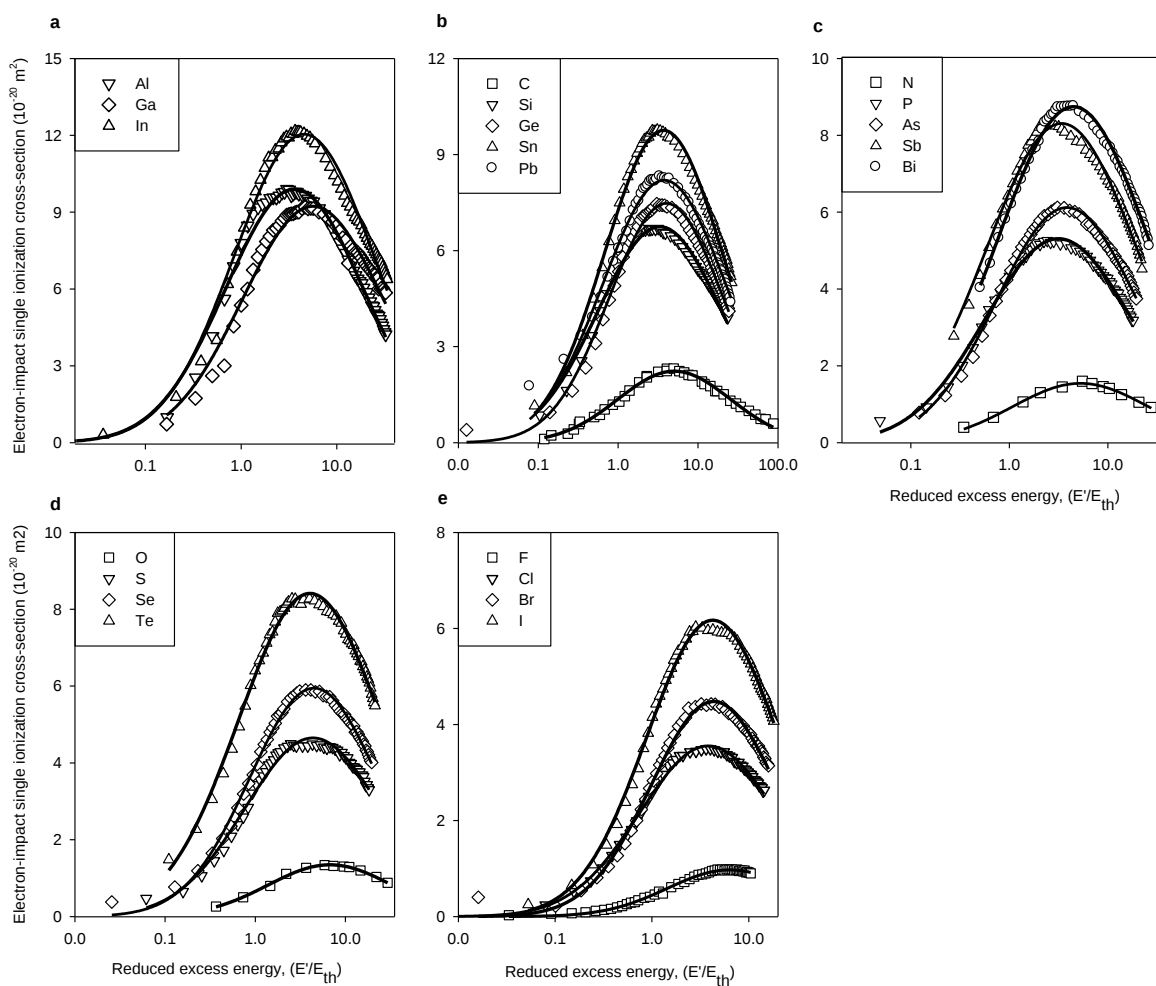


Fig. S1 Single ionization by electron impact on neutral atoms. **a**, Column III Al [1], Ga, In [2] ($R^2 > 0.964$). **b**, Column IV [1] except C [3] ($R^2 > 0.976$). **c**, Column V [1] except N [3] ($R^2 > 0.986$). **d**, Column VI [1] except O [3] ($R^2 > 0.984$). **e**, Halogens [5] ($R^2 > 0.993$).

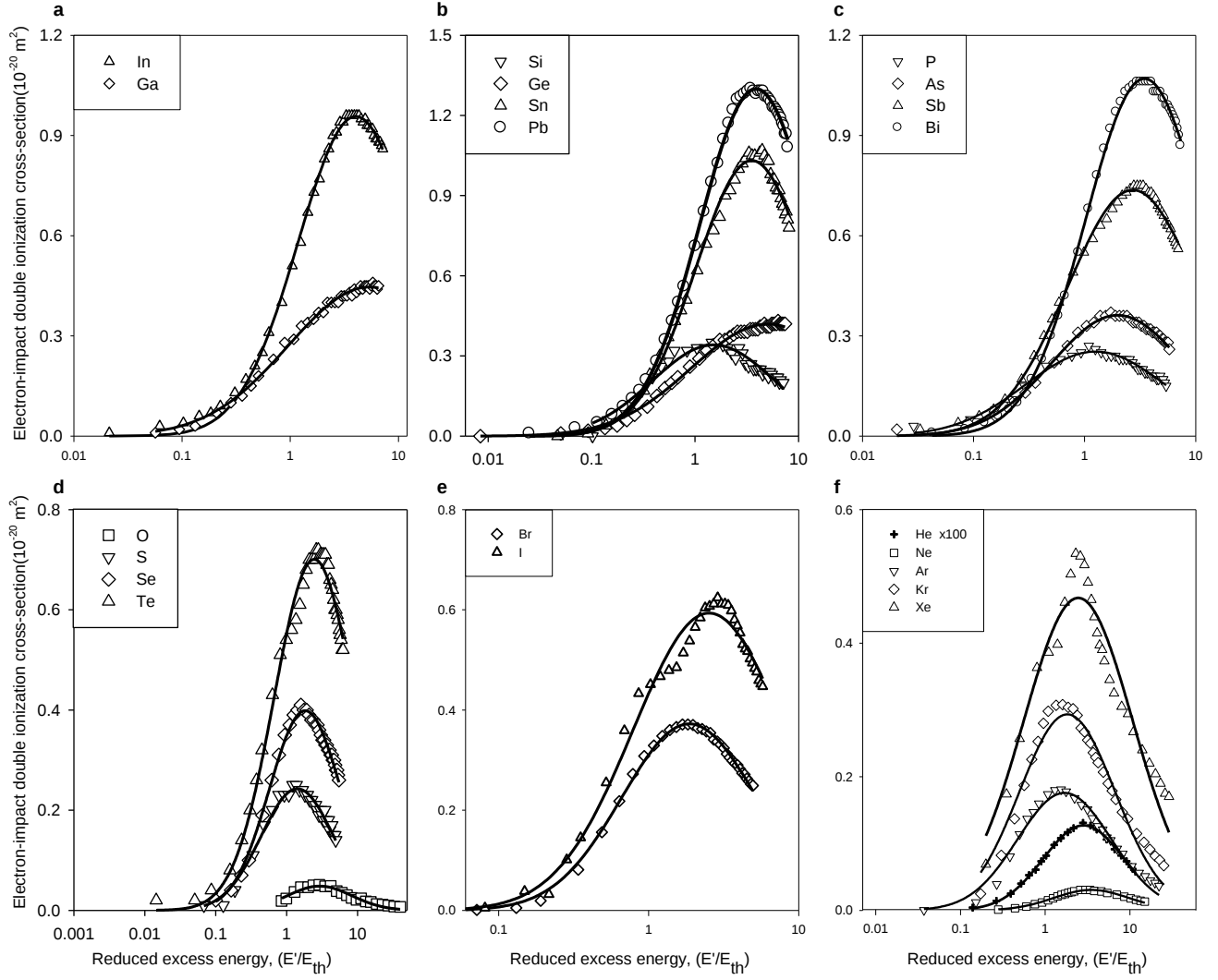


Fig. S2 Double ionization by electron impact on neutral atoms. **a**, Column III [2] ($R^2 > 0.995$). **b**, Column IV [1] ($R^2 > 0.937$). **c**, Column V [1] ($R^2 > 0.995$). **d**, Column VI [1] except O [4] ($R^2 > 0.943$). **e**, Halogen [5] ($R^2 > 0.964$). **f**, Noble gases [6] ($R^2 \geq 0.964$). Iodine, tellurium and xenon have structure (to some extent visible also in Extended Data Figures 1d and 1e) which reduces the goodness of the fits. The structure has been associated with 4d type resonance [1], [7].

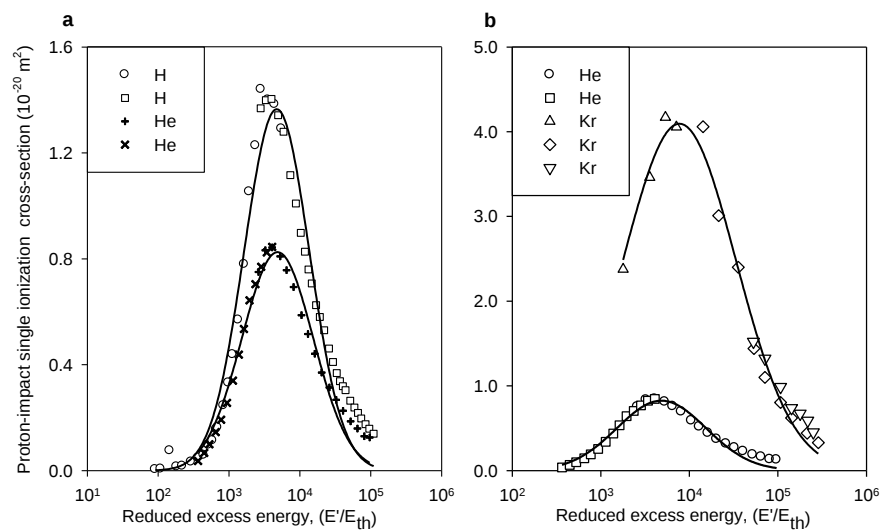


Fig. S3 Single ionization by proton impact. **a**, H: $\square$ [8], $\circ$ [9] ($R^2=0.953$), He: $+$ [10], $\times$ [11] ($R^2=0.967$). **b**, He: $\circ$ [10], $\square$ [11] ($R^2=0.967$), Kr: $\triangle$ [12], $\diamond$ [13], ∇ [14] ($R^2=0.981$).

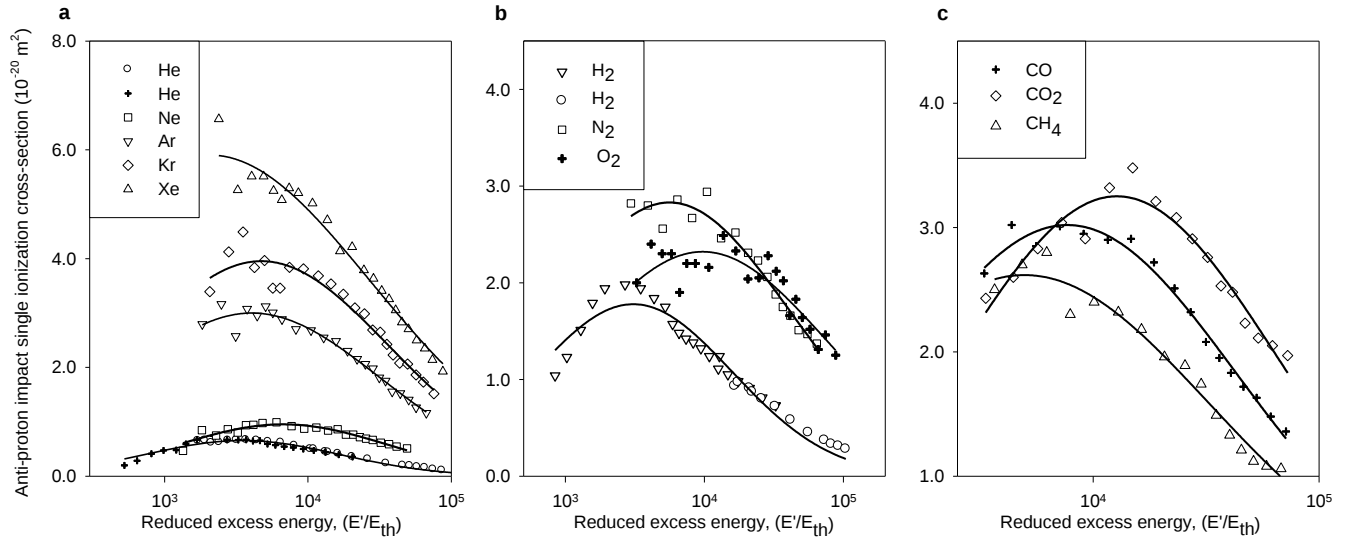


Fig. S4 Single ionization by anti-proton impact. **a**, He: + [15], $\circ$ [16], Ne: $\square$, Ar: ∇ , Kr: $\diamond$, Xe: $\triangle$ [17] ($R^2 > 0.883$). **b**, H_2 : ∇ [15], $\circ$ [18], N_2 : $\square$ [19], O_2 : + [20] ($R^2 > 0.779$). **c**, CO: +, CO_2 : $\diamond$, CH_4 : $\triangle$ [19] ($R^2 > 0.935$).

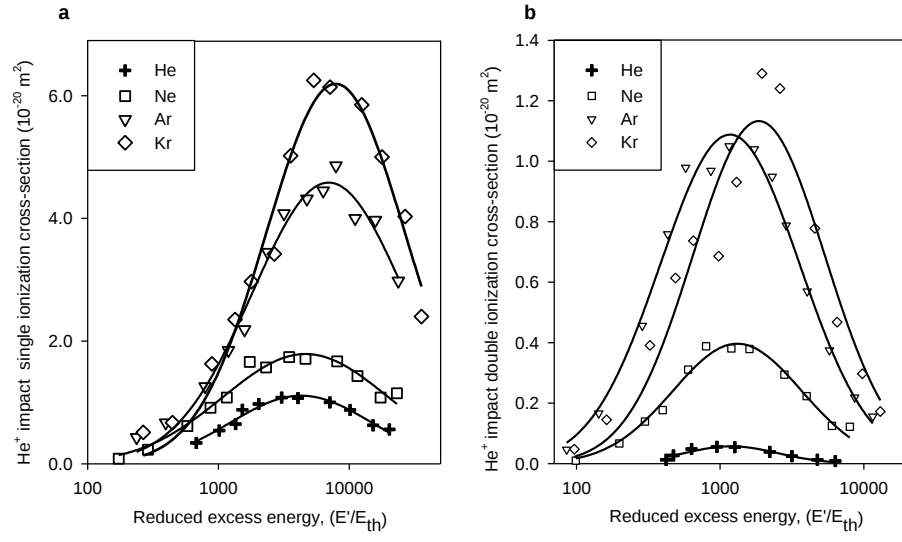


Fig. S5 Ionization by He⁺ impact. **a**, Single ionization He: +, Ne: □, Ar: ▽, Kr: ◇ [21] ($R^2 > 0.960$). **b**, Double ionization by He⁺ impact on Noble gases. He: +, Ne: □, Ar: ▽, Kr: ◇ [21] ($R^2 > 0.908$).

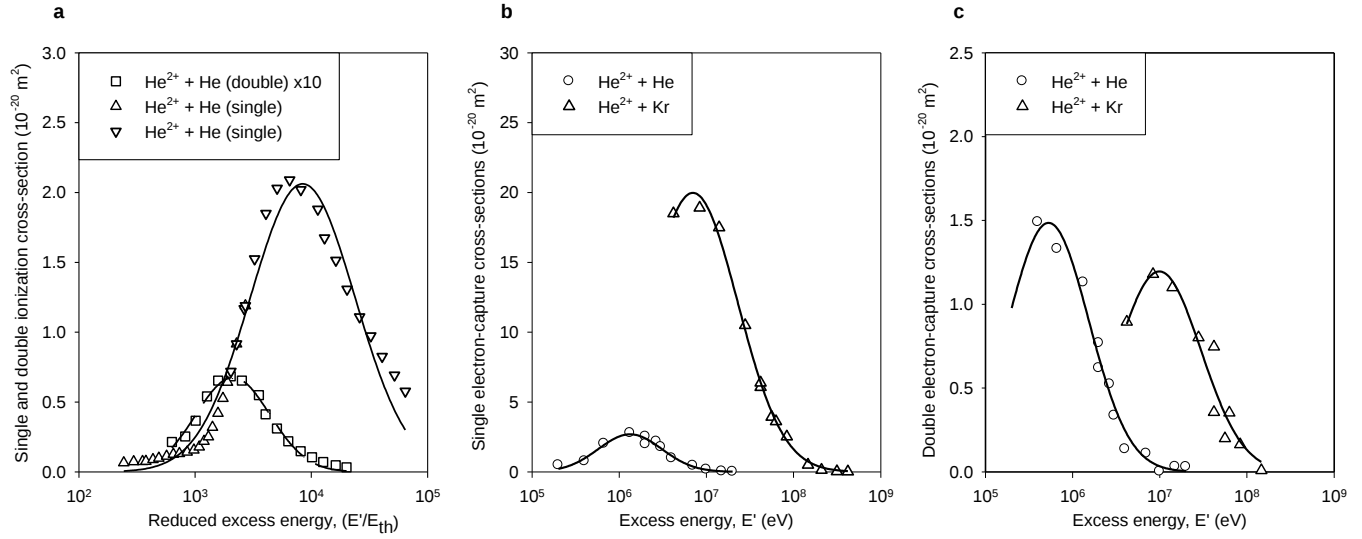


Fig. S6 Ionization and electron capture by He^{2+} impact. **a**, Single ionization of He: ∇ [10], $\triangle$ [11] ($R^2 = 0.965$); double ionization of He: $\square$ [10] ($R^2 = 0.982$). **b**, Single and **c**, double-electron capture from He and Kr [22] (symbols) ($R^2 > 0.96$ and > 0.93 , respectively). In **b** and **c**, the data are plotted versus E' since $E_{th} = 0$ for double-electron capture from H.

References for Supplementary Information

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