Similarity between Ps-atom and electron-atom scattering

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Recently observed similarities between the positroinum (Ps) scattering and the electron scattering from a number of atoms and molecules [1,2] suggest that both processes are largely controlled by the same interactions. Plotted as a function of the projectile velocity, the total electron and Ps cross sections are close and even show similar resonance-like features. In this work we calculate Ps scattering from Ar and Kr using the *impulse approximation* (IA), which is applicable above the Ps ionization threshold because Ps is diffuse and weakly-bound compared with noble-gas atoms. Our results lend theoretical support to the similarity of electron-atom and Ps-atom scattering.

The main assumption of IA is that during the scattering event only one of the constituent particles in Ps interacts with the target. The Ps-atom scattering amplitude is hence the sum of two terms [3],

$$f_{ba}(\mathbf{p}_f,\mathbf{p}_i) = 2\int g_b^*(\mathbf{q}) f^-(\mathbf{v}_f^-,\mathbf{v}_i^-) g_a(\mathbf{q}+\Delta\mathbf{p}/2)d^3\mathbf{q} + 2\int g_b^*(\mathbf{q}) f^+(\mathbf{v}_f^+,\mathbf{v}_i^+) g_a(\mathbf{q}-\Delta\mathbf{p}/2)d^3\mathbf{q}\,, \tag{1}$$

where $\Delta\mathbf{p} = \mathbf{p}_f - \mathbf{p}_i$ is the change in the Ps momentum, a and b are the initial and final internal states of Ps, $g_a(\mathbf{q})$ is the Ps internal wave function in momentum space, and $f^{\pm}(\mathbf{v}',\mathbf{v})$ are the positron-atom and electron-atom scattering amplitudes for the velocities $\mathbf{v}_i^{\pm} = \mathbf{p}_i/2 - \Delta\mathbf{p}/2 \pm \mathbf{q}$, $\mathbf{v}_f^{\pm} = \mathbf{p}_i/2 + \Delta\mathbf{p}/2 \pm \mathbf{q}$. The electron and positron scattering amplitudes are derived from polarized-orbital calculations [4,5]. Our total Ps-Kr scattering cross sections agree well with the measurements [1] above $v = 0.5$ a.u., although, in contrast to observations, the calculated peak is very weak. Similar results have also been obtained for Ar.

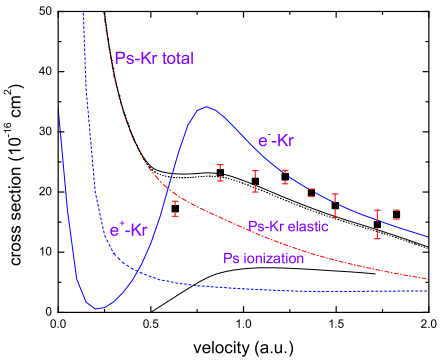

Figure 1: *e^--Kr, e^+-Kr and Ps-Kr scattering cross sections. Dotted black line is the sum of elastic and ionization [3] cross section; the line "Ps-Kr total" also contains contribution from excitation of the $n = 2$ levels of Ps. Experimental data (squares) are from Ref. [1]. Data for e^--Kr and e^+-Kr scattering are from [4,5]. Cross sections for e^+ at $v > 1.3$ a.u. were obtained by extrapolation from [4].*

References

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