Positron scattering upon a "simple" endohedral

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Synopsis We developed a simple approach to study the elastic scattering of positrons upon endohedrals. The most essential feature of this approach is that it permits to take into account the formation during the collision process of a “virtual positronium”. As a concrete example we consider the scattering upon simplest endohedral $He@C_{60}$

1. At the first glance the problem of scattering of a positron e^+ upon a multi-atomic formation is much simpler than the treatment of scattering of electrons e^- upon the same target. The simplification in case of e^+ has to come from the absence of exchange between the projectile and the target constituencies.

2. However, already long ago from studies of $e^+ + He$ collisions [1] it became clear that this process is qualitatively different from the $e^- + He$ not simply because of the projectile sign alteration and lack of exchange for e^+. It was demonstrated that in addition one has to account for the strong interaction between e^+ and virtually excited target electrons e^-.

3. To account this interaction means to solve at least a three-particle problem, namely that of the collision between e^+ and e^- in the field of He^+ ion. We developed in [1] an approach that drastically simplifies the problem by neglecting the modification of e^+ and e^- wave functions due to these particles strong attraction. But we take into account the energy shift of the pair of these particles due to virtual positronium Ps formation by adding to the virtual excitation energy the free Ps ionization potential I_{Ps}.

4. The suggested method describes satisfactorily the experimental data on low-energy $e^+ + He$ elastic scattering. It qualitatively explain the reason why the cross-section for $e^+ + He$ is much smaller than that of $e^+ + He$.

5. The very same approach is now developed for scattering of e^+ upon endohedral $He@C_{60}$. In the frame of this approach, we solve the following equation to determine the radial part of the e^+ wave function $P_{El}^{e^+ He@C_{60}}(r)$ in the atomic system of units:

$$\left(-\frac{1}{2}\frac{d^2}{dr^2} - \frac{Z}{r} + \hat{V}_H(r) + W_{C_{60}}(r) + V_{C_{60}}^{e^+ pol}(r) + \frac{l(l+1)}{2r^2} + E\right) P_{El}^{e^+ He@C_{60}}(r) = 0 \qquad (1)$$

6. The following relation expresses the C_{60} polarization potential using its polarizability: $V_{C_{60}}^{e+pol}(r) = -\alpha_{C_{60}(+)} / 2(r^2 + b^2)^2$. We assume that $\alpha_{C_{60}(+)} \equiv \alpha_{C_{60}(-)}(I_{Ps})$, where $\alpha_{C_{60}(-)}(\omega)$ is known to us C_{60} dipole polarizability. Polarization of He with a proper shift of virtual excitation energies is also taken into account.

7. The Figure presents results of our calculations of elastic scattering of e^+ and e^- upon $He@C_{60}$ comparing it to results for e^++C_{60} collision. The figure demonstrates the prominent role of He as well as the properties of the projectile.

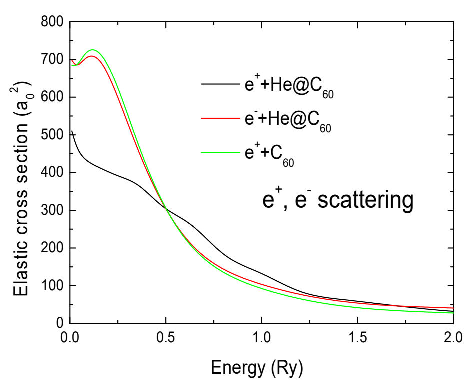

Figure 1. Elastic scattering cross-section

8. The same approach one can apply to more complex fullerenes $A@C_N$ with $N \neq 60$ and $A \neq He$.

References

[1] M. Ya. Amusia *et al.* 1976 *J. Phys. B*, ***9***, *17*, *L531-534*

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