Angle-resolved $e^- + C_{60}$ elastic scattering cross section versus Ramsauer minima in partial elastic scattering cross sections

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Synopsis Ramsauer-type minima in $e^- + C_{60}$ partial electron elastic scattering cross sections, brought about by C_{60} polarization, and their exposition to light in the angle-differential scattering cross section are revealed and detailed.

Work [1], devoted to the study of electron elastic scattering off endofullerenes $A@C_{60}$, predicted the emergence of Ramsauer-type minima in partial scattering cross sections σ_ℓ with $\ell = s$, p, d and f, due to polarization of $A@C_{60}$ by scattering electrons. The energy positions of the minima were somewhat different from one another. For this reason, they were unresolved in the total scattering cross section $\sigma_{\rm total} = \sum \sigma_\ell$. However, there are good reasons to expect that the minima should be resolved in the angle-differential scattering cross section $\frac{d\sigma}{d\Omega}$, since the position of a minimum depends on the scattering angle. This constitutes the primary aim of the present work, namely, to investigate the extent to which Ramsauer minima in σ_ℓs might be exposed to light in $\frac{d\sigma}{d\Omega}$.

In the present paper, for the sake of simplicity, we focus on electron elastic scattering off an empty C_{60}, $e^- + C_{60}$. As in [1], we model C_{60} by an attractive spherical potential $U_{\rm c}(r)$ of certain depth U_0, inner radius r_0 and thickness Δ. The impact of the polarization potential $V_{\rm pol}(r)$ of C_{60} on scattering electrons is taken into account in the framework of a static dipole-polarization approximation: $V_{\rm pol}(r) \approx -\alpha/[2(r^2+b^2)^2]$. Here, α is the static polarizability of C_{60} and b is a parameter of the order of r_0. Our model, thus, accounts for the motion of scattering electrons in the field of an effective potential $U_{\rm eff}(r) = U_{\rm c}(r) + V_{\rm pol}(r)$.

Calculated partial σ_ℓs and $\frac{d\sigma}{d\Omega}$ at 80° (the calculation accounted for fourteen partial waves, up to $\ell_{\rm max} = 13$), as a case study, are depicted in Fig. 1 along with corresponding experimental data [2] borrowed from [3].

First, Fig. 1 demonstrates a reasonable qualitative and semi-quantitative agreement between theory and experiment. The utilized in the present work simple approximation is, thus, proven to be surprisingly usable.

Second, one can see from Fig. 1 that the positions of the Ramsauer minima in σ_s ($\varepsilon \approx 0.25$ eV), σ_d ($\varepsilon \approx 0.99$ eV) and σ_f ($\varepsilon \approx 1.48$ eV) approximately (for reasons) match the positions of the first, second and third lower energy minima in $\frac{d\sigma}{d\Omega}$, respectively.

It is, thus, shown in the present work that (a) the simple model utilized in the present paper is usable and (b) the angle-differential cross section $\frac{d\sigma}{d\Omega}$ allows one to expose to light the existence of Ramsauer minima in electron scattering of partial electronic waves.

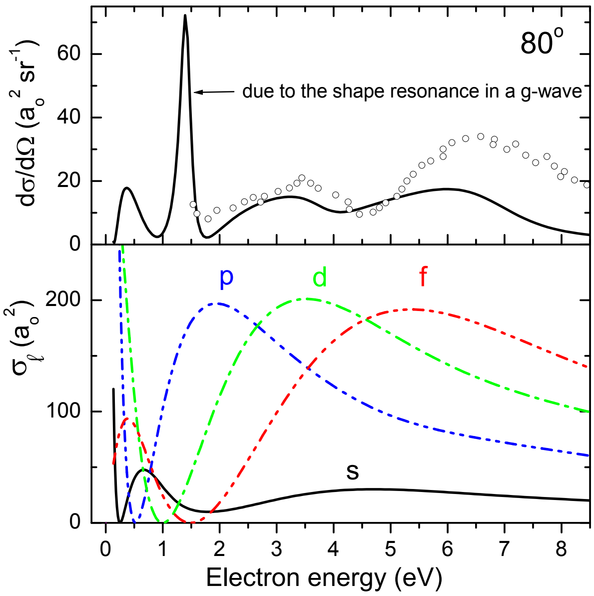

Figure 1. Top panel, calculated $\frac{d\sigma}{d\Omega}$ ($\theta = 80°$, open circles - experiment [2]) and, bottom panel, partial σ_ℓs for $e^- + C_{60}$ elastic scattering. Parameters of the utilized model (in atomic units): $r_0 = 5.26$, $U_0 = -0.26$, $\Delta = 2.91$, and $\alpha = 850$.

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References

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