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State-to-state interference in electron induced resonant Auger decay

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Synopsis In 205 - 214 eV energy range we have measured a series of (e, 2e) spectra emitted in course of an inelastic electron scattering on argon. At 457.3 eV projectile energy a lack of coincidence electron yield was observed in the spectral plane at energies of about 210 eV. This is interpreted as a state-to-state interference effect which occurs due to indistinguishability of the scattered electron - Auger electron pair emitted by the neighbouring [2p3/2]3d and [2p3/2]4d resonances.

Suppose that two resonances, \( R' \) and \( R'' \) are created by electron scattering on the atomic ground state and that they can decay by electron emission into the same final state \( F \):

\[
\text{Ar} + e^- (E_0) \rightarrow R' + e_p^q \rightarrow F + e_p^q + e_p^q \\
\rightarrow R'' + e_p^q + e_p^q \rightarrow F + e_p^q + e_p^q.
\]

Electron pairs \((E_a, E_b)\) are observed in coincidence by two electron analyzers and the necessary condition for the interference is that the energy of the scattered electron from one reaction path equals energy of Auger electron released along the other reaction path: in that case the electron pairs \((e_p^q, e_p^q)\) and \((e_p^q, e_p^q)\) are indistinguishable. For given states the interference occurs at unique electron impact energy \(E_0 = E_{R'} + E_{R''} - E_F\). We have selected Ar\(^+\) \([3p^2]1^D 3d^2 4p^2 D\) with excitation energy \(E_F = 37.15 - 37.40\) eV since these final states are populated with reasonable intensity from both resonances: \([2p3/2]3d\) with excitation energy \(E_{R'} = 246.92\) eV and \([2p3/2]4d\) with excitation energy \(E_{R''} = 247.66\) eV. Here, the state-to-state interference is expected to occur at \(E_0 = 457.3\) eV and for electron pairs (209.6 eV, 210.4 eV) and (210.4 eV, 209.6 eV).

The electron-electron coincidence experiment was performed at University of Miskolc by two electrostatic spectrometers, a single and a double pass cylindrical mirror analyser with HWHM energy resolution of 0.45% and 0.25%, respectively. They were mounted on the same axis, perpendicular to the electron projectile beam and in near vicinity of the gas entrance into the chamber. Large accepted solid angle (0.015×4π sr), essential to accumulate statistically significant data in reasonable time, was provided by 5° wide entrance cones.

Our simulation of the (e, 2e) spectral plane is based on known resonance energies [1] and known decay branching ratios from photon impact experiments [2]. In addition, the missing branching ratios for the resonant Auger decay of [2p3/2]4p state (given essentially by amplitude \(B\) in Fig. 1) were provided by coincidence measurements at 350 eV electron impact energy, where also the Ar 2p energy loss spectrum was measured. We found that our model reproduces quite well the experimental data except for the PCI shift of "normal" Auger lines (due to the presence of additional slow ejected electron) and the missing intensity at 210 eV which is explained by destructive interference of amplitudes \(A'\) and \(A''\) pertaining to two interfering electron pairs.

Fig. 1. A cut through the two “interference” points in (e,2e) spectral plane, projected onto \(E_a\) axis.

References


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