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(e,2e) coincidence study on the coherence of the $2s^2(^1S)$ and $2p^2(^1D)$autoionizing states of He

B. Paripás* [1], B. Palásthy* [2] and K. Tőkési† [3]

*Institute of Physics, University of Miskolc, 3515 Miskolc-Egyetemváros, Hungary
†Institute for Nuclear Research, Hungarian Academy of Sciences (MTA Atomki), Debrecen, Hungary

Synopsis The electron impact excitation of the autoionizing states of helium, their subsequent decay into the same He^+1s^{-1} final ionic state, and the interference of these processes have been studied. A constant ionic state (e,2e) experiment (CIS) is performed, isolating the final state by keeping the sum of the energies of the scattered-ejected electron pairs constant. The focus of this work is on the exchange interference of the $2s^2(^1S)$ and $2p^2(^1D)$ autoionizing states of helium. At around the critical energy fast variations were observed in the CIS spectra, which indicates the presence of exchange interference effects.

The coherence of autoionizing states of helium is studied via the measurement of interference of the given states. We concentrated the possible state-to-state interferences of the $2s^2(^1S)$ and $2p^2(^1D)$ autoionizing resonances at energies 57.8 eV and 59.9 eV (decaying to the same simple He^+1s^{-1} final state with E_F = 24.6 eV.), and their possible interference that was previously studied by others in a different way [1]. This state-to-state (exchange) interference (which is essentially differs from the Fano interference) occurs at a unique (critical) electron impact energy where the energy of the scattered electron from one reaction path equals the energy of the ejected electron released along the other path and vice versa: in that case the scattered-emitted electron pairs are indistinguishable.

Electron pairs are observed in coincidence by two cylindrical mirror analysers. Our experimental approach is based on the measurement of CIS (constant ionic state) spectra for the final state. These spectra were recorded in coincidence mode, by scanning simultaneously the transmission energies of the spectrometers in the opposite direction, so as to keep the sum of transmission energies constant.

Our "box" type cylindrical mirror analysers (CMA) have similar structure [2], but slightly different energy resolutions (A: 0,55%; B: 0,78% (FWHM)) and accepted scattering angular ranges (A: 43°-137°; B: 65°-115°).

Around the critical energy, a few tenths of eV modification in primary energy causes a significant change in the CIS spectra (Fig. 1.). Namely the overlapping peaks split into two in a resonance-like way, which can indicate the state-to-state interference effect [3].

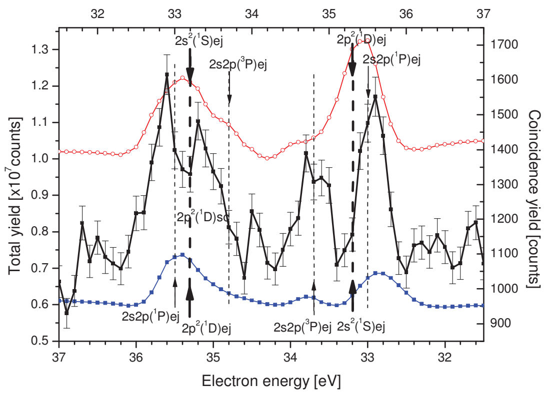

Figure 1. The CIS spectrum measured at 93.1 eV primary energy with E_0-E_F = E_A+E_B = 68.5 eV [3]. The energy spectrum measured by the A (open red circles, upper energy scale) and by the B (full blue squares, lower energy scale) spectrometers are also shown. The corresponding scattered-ejected electron peak-pairs are just opposite in the two spectra and shown by dashed lines. The spectrum in the middle is the coincidence CIS spectrum, in which the random coincidences (≈ 20%) are already subtracted. The error bars contain the statistical error of this background removal, too.

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[1]E-mail: fizpari@uni-miskolc.hu [2]E-mail: fizpalb@uni-miskolc.hu [3]E-mail: tokesi@atomki.mta.hu