CUSP FORMATION IN CLASSICAL TRAJECTORY MONTE-CARLO CALCULATIONS OF SINGLE ATOMIC IONIZATION BY THE IMPACT OF NEUTRAL PROJECTILES

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The velocity distribution of electrons emitted in atomic collisions often exhibits a peak centered at the velocity \( v_P \) of the incident projectile. Classical-trajectory Monte-Carlo (CTMC) simulations provide an excellent description of this structure whenever the interaction between the electron and the outgoing projectile is of a Coulomb [1] or even of a dipolar type [2]. However, serious doubts were recently cast over the general validity of any classical approach for the description of more general atom-atom ionization collisions [3]. These questionings are due to the visualization of the cusp as the result of a smooth continuation across the ionization limit of capture into highly excited electron-projectile bound states. By mimicking a bound spectrum accumulating at zero energy by a continuum, any classical description would succeed in describing the “electron capture to the continuum” divergence observed whenever the electron-projectile interaction is of Coulomb or dipolar nature. But, whenever the electron-projectile interaction decreases faster than a dipole potential at large distances, the energy spectrum does not accumulate at zero energy, and any classical description should be doomed to failure. Our purpose in this communication is to elucidate, through CTMC calculations [4], this limitation of the classical description of cusp formation. To this end we consider the ECC peak formed in He-Ar ionization collisions for the case of neutral He outgoing projectiles in the 2\(^1\)S metastable state, as first measured by the Debrecen group in 1989 [5]. Both the experimental data and the quantum-mechanical calculations show a cusp that is much sharper than the one produced by He\(^{2+}\) projectiles [6]. This phenomenon was attributed to a low-lying virtual state on the electron-projectile system [7], an effect that no classical description can reproduce. Actually, in this communication we demonstrate that the CTMC calculation produces a peak that is much broader and smaller than for a Coulomb interaction, a result that testifies against any supposedly classical origin of the ECC phenomenon.

References