

Electron recombination with multicharged ions via chaotic many-electron states

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Synopsis Electron recombination with multicharged ions that have open f shells (e.g. Au^{25+} and W^{20+}) is dominated by chaotic many-electron resonances. They cause the fluorescence yield to dominate entirely at low energies leading to an enhancement of the recombination rate up to 1000 times. At higher energies the opening of many autoionization channels leads to a rapid decrease of the fluorescence yield. We apply the statistical theory to express the recombination cross section as a sum over the doorway (dielectronic) resonances.

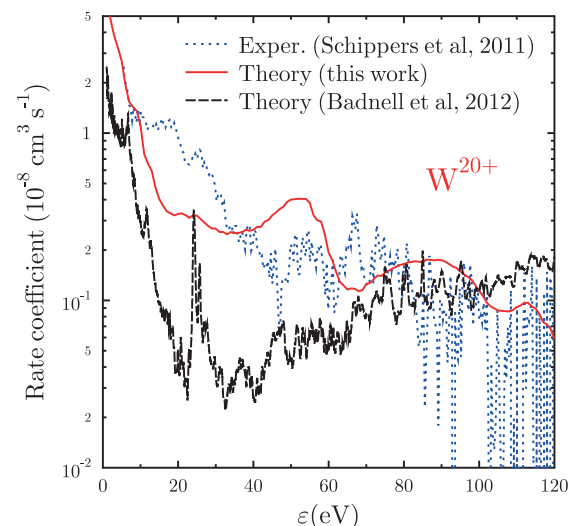
The electron recombination process at low energy is dominated by capture to a resonance state followed by fluorescence decay. The resonance state can either autoionize or radiate; when it radiatively decays to a level below the ionisation threshold, the capture is complete. Unlike in simple systems, the resonance state of a complex ion is a chaotic mix of many multiply-excited states. Each eigenstate $|\nu\rangle = \sum_k C_k^{(\nu)} |\varphi_k\rangle$ contains a large number N of *principal components* $|\varphi_k\rangle$ when the mixing is strong. Such eigenstates are called compound states. The only good quantum numbers are those exactly conserved due to the symmetry of the Hamiltonian of the ion: total angular momentum, its projection, and parity. Exact diagonalization of the many-electron Hamiltonian is impossible for the chaotic case. Fortunately, the statistical properties of the chaotic eigenstates enable one to avoid the determination of exact energy levels E_ν and compound state wave functions.

We have derived the recombination cross section of an electron with energy ε relative to threshold with a target ion (subscript i):

$$\sigma(\varepsilon) = \frac{\pi}{p^2} \frac{2J_\nu + 1}{2(2J_i + 1)} \omega_f \sum_k \frac{\Gamma_{ki}^{(a)} \Gamma_{\text{spr}}}{(E_i + \varepsilon - E_k)^2 + \frac{\Gamma_{\text{spr}}^2}{4}}$$

where sum goes over the 'doorway' dielectronic states only. $\omega_f = \Gamma^{(r)} / (\Gamma^{(a)} + \Gamma^{(r)})$ is the fluorescence yield within the energy interval $\Delta\varepsilon \ll \varepsilon$ where the spectrum is dense. Γ_{spr} realises the spreading of the doorway state φ_k among the resonances. E_k can be approximated simply by the diagonal Hamiltonian matrix element

$E_k = \langle \varphi_k | H | \varphi_k \rangle$. $\Gamma_{ki}^{(a)}$ is defined as an autoionization width of the doorway state. Our recent calculation based on the Slater determinants of the Hartree-Fock orbitals as doorway states is presented in the figure below.



References

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