Photoionization and Photoabsorption in the Rydberg resonance region

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Synopsis Hickman's theory (1984, *J. Phys. B* **17** L101), developed for dielectronic recombination, is extended to photoionization.

As illustrative example of the presented theory, we choose photoionization of $1s^2 2s^2$ ground level of beryllium atom (Be). Between 2s and 2p ionization thresholds are 2 Rydberg series of autoionizing levels, 2pnl and 2pnd ($n \geq 3$), interfering with $2s\varepsilon p$ continuum ($0 \leq \varepsilon \leq 0.285508$).

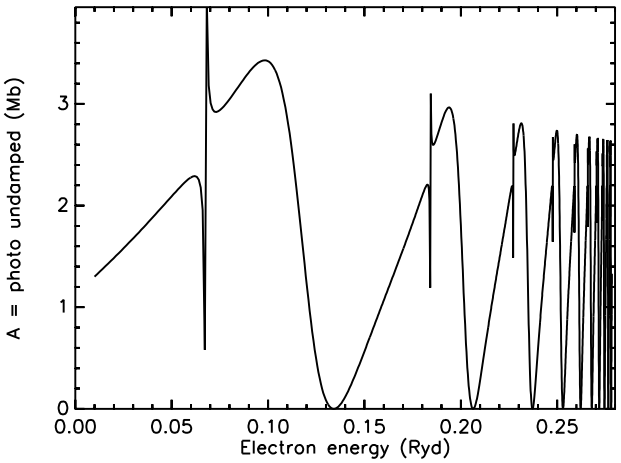

Figure 1. Be photoabsorption/photoionization cross-sections obtained from QDT (Dubau et. al, 1973)

From 1966, Seaton developed the Quantum Defect Theory (QDT) (see review [1]), especially for Rydberg series interaction with continuum: analytical expression of scattering matrix **S** as function of electron energy ε. From QDT, Dubau and Wells [2] obtained (1). They also tabulated coefficients (a, b_2, b_3, χ'_{22}, χ'_{33}) used to draw Fig. 1 ($\varepsilon = 0.285508 - 1/\nu^2$)

$$|\mathscr{H}_1(\mathbf{S})|^2 = |a|^2 \left| 1 + \frac{b_2}{\exp(-2i\pi\nu) - \chi'_{22}} + \frac{b_3}{\exp(-2i\pi\nu) - \chi'_{33}} \right|^2 \qquad (1)$$

To introduce radiative resonance decay for dielectronic recombination, Hickman [3] replaced ν real by ν_c complex in the QDT expression of **S**. We can do the same in (1): $\varepsilon + i\Gamma_r = 0.285508 - 1/\nu_c^2$. Photoabsorption (Fig 2 (a)) becomes now different of photoionization (Fig 2 (b)). Present photoabsorption cross-section (Fig 2 (a)), including inner-electron 2p radiative decay, was obtained by convolution of Fig (1) data with a Lorentzian of Γ_r width.

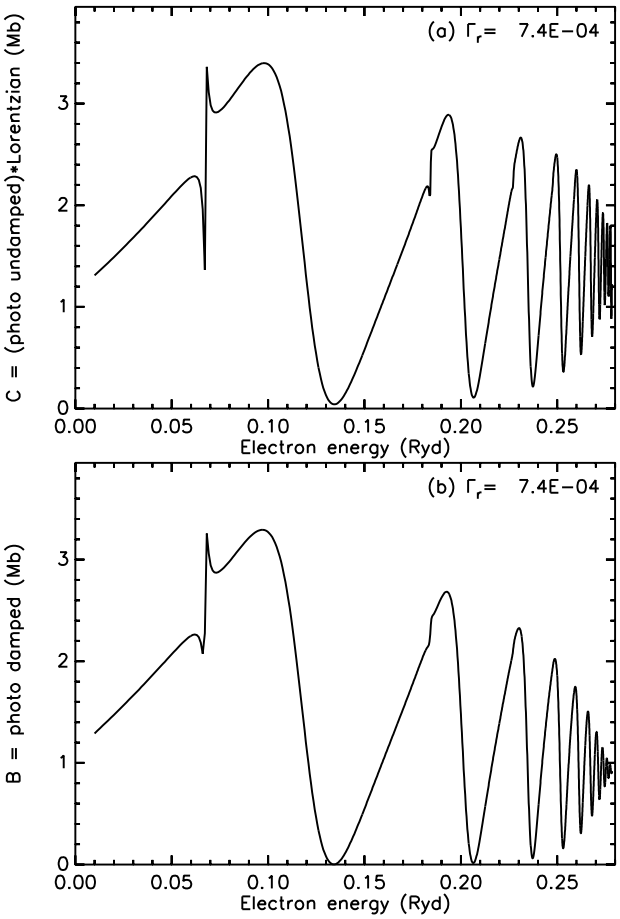

Figure 2. Synthetic photoabsorption (a) /photoionization (b) cross-sections including 2p radiative decay: width $\Gamma_r = 7.4 \times 10^{-4}$ Ryd (non-physical for Be)

For isolated resonances, it is also possible to directly compute photoionization and photoabsorption cross-sections including radiative decay, e.g. Zabaydullin and Dubau [4].

References

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[2] J. Dubau, J. Wells *1973 J. Phys. B* **6** 1452

[3] A. P. Hickman *1984 J. Phys. B* **17** L101

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