Identification of an Interference between the E1 and M2 Transition Amplitudes for the Lyman-α_1 Decay in Hydrogen-like Uranium:

Multipolmixing (E1/M2) Observed for an Atomic Transition

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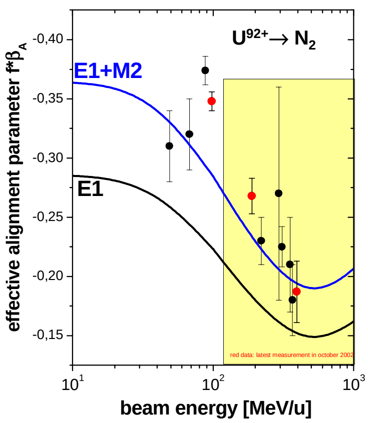
*We report on an interference between the leading **E1** decay channel and the weak **M2** branch which was identified recently for the case of the Lyman-α_1 ($2p_{3/2} \rightarrow 1s_{1/2}$) transition in hydrogen-like ions. This interference is found to affect considerably the angular distribution of the emitted photons. Similarly, it also effects the linear polarization of the Lyman-α_1 radiation. For the particular case of the Lyman-α_1 transition in the hydrogen-like uranium following electron capture, the former deviation between the experimental and theoretical findings for the alignment of the excited ion state [1] is removed when the interference correction is taken into account [2]. Also, one may expect similar sizeable corrections for any other atomic transitions in the high-Z regime where beside the leading **E1** term, higher multipole contributions are small but allowed.*

[1] Th. Stöhlker et al., PRL **79**, 3270 (1997).
[2] A. Surzhykov et al., PRL **88**, 153001 (2002).

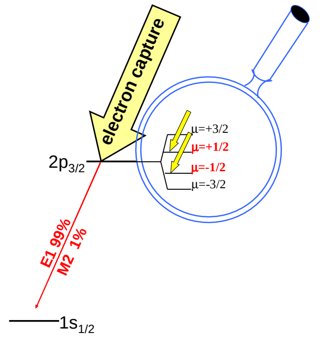
Multipolmixing

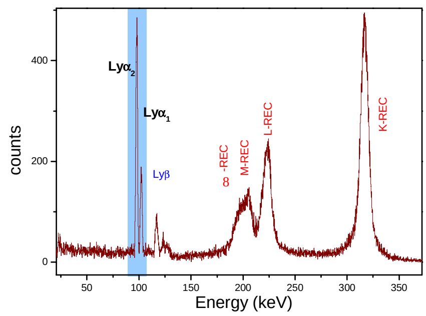
Considering the M2 decay in addition to the E1, the former deviation between theoretical prediction (black line) and experimental results is removed (red line).



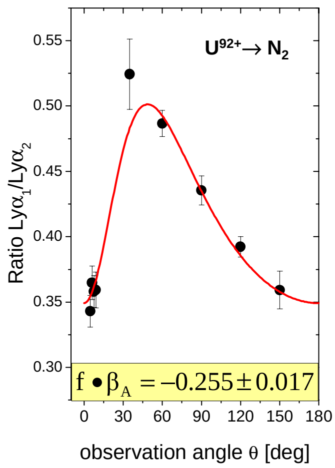
$$W(\theta) \propto 1 + f\left(\frac{a_{M2}}{a_{E1}}\right) \cdot \beta_A \cdot \left[1 - \frac{3}{2}\sin^2\theta\right]$$

Strong Alignment Observed for the $2p_{3/2}$ State Populated by REC





Observed Angular Distribution for the $2p_{3/2}$ (Lyα_1) Decay



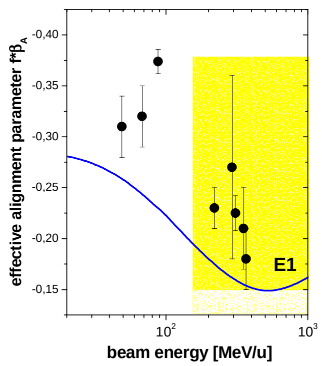
In order to reduce possible systematic uncertainties, the angular distribution of the intensity of the investigated Ly-α_1 transition ($2p_{3/2} \rightarrow 1s_{1/2}$) was normalized to the Ly-α_2 radiation ($2s_{1/2}, 2p_{1/2} \rightarrow 1s_{1/2}$) which is isotropic in the emitter frame.

Observed Intensity Ratio

$$\frac{W_{Ly\alpha_1}(\theta_l)}{W_{Ly\alpha_2}(\theta_l)} \propto \left[1 + \beta_A\left(1 - \frac{3}{2}\frac{\sin^2\theta_l}{\gamma^2(1-\beta\cos\theta_l)^2}\right)\right]$$

Transformation to the emitter frame

$$W(\theta) \propto 1 + \beta_A\left[1 - \frac{3}{2}\sin^2\theta\right] \qquad \beta_A = \frac{1}{2}\,\frac{\sigma\begin{pmatrix}3 & 3\\ 2 & 2\end{pmatrix} - \sigma\begin{pmatrix}3 & 1\\ 2 & 2\end{pmatrix}}{\sigma\begin{pmatrix}3 & 3\\ 2 & 2\end{pmatrix} + \sigma\begin{pmatrix}3 & 1\\ 2 & 2\end{pmatrix}}$$



Comparison experiment / theory assuming a decay of the $2p_{3/2}$ state by electric dipole transitions only. Experimental data deviates from theoretical prediction by 30% in the energy regime of relevance (>200 MeV/u).

Relative M2-Contribution to the Decay of the $2p_{3/2}$ state in H-like Uranium

$$f\left(\frac{a_{M2}}{a_{E1}}\right) = 1.38 \pm 0.07 \Rightarrow \frac{\langle\|M2\|\rangle}{\langle\|E1\|\rangle} = 0.11 \pm 0.02 \Rightarrow \frac{\Gamma_{M2}}{\Gamma_{E1}} = 0.012 \pm 0.004$$