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First observation of coherence in a highly charged ion

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Synopsis We report the first observation of correlated x rays emitted by a heavy highly charged ion such as hydrogenlike uranium in the process of radiative recombination. The angular correlations between these x rays for the first time revealed a coherence of the populated state in this ion. The results also indicate a strong contribution of the spin–orbit interaction in radiative recombination.

Radiative recombination (RR) into highly charged ions offers a unique opportunity to study its time-reverse the fundamental process of the photoelectric effect in the otherwise inaccessible regime of hard x rays and strong Coulomb fields. Using the experimental storage ring ESR in GSI Darmstadt we have studied the RR into the excited $2p_{3/2}$ state of hydrogenlike uranium ions. This state decays to the ground state $1s_{1/2}$ by emitting a Lyα_1 x ray. In the experiment the RR and the Lyα_1 x rays were detected in time-coincidences using a setup of large germanium detectors, representing the first observation of the correlated x rays emitted by heavy highly charged ions [1].

We observed that the angular distribution the Lyα_1 x rays is strongly correlated with the emission direction of the RR x ray. To interpret this observation we consider a non statistical population of the magnetic sublevels (alignment) of the $2p_{3/2}$ state. When the RR x ray is not observed, as was the case in all previous alignment experiments with highly charged ions, the populated state is axially symmetric around the collision direction, and, therefore, its magnetic sublevels are populated incoherently. In contrast, in the present experiment, this state is populated *coherently*. Therefore, it loses its symmetry with respect to the collision axis. Figure 1 shows the effect of the coherence on the electric charge density distribution of the $2p_{3/2}$ state. The alignment axis of this distribution attains a finite angle γ with respect to the electron propagation direction. This angle is neither 0° nor 90° which manifests the coherence of the populated state. We extracted the alignment angle of the charge cloud from the measured angular distribution of the Lyα_1 x rays revealing for the first time the coherence in a heavy highly charged ion. Moreover, the experimental results indicate a strong contribution of the spin-orbit interaction to the RR process and, therefore, to the fundamental process of the photoelectric effect.

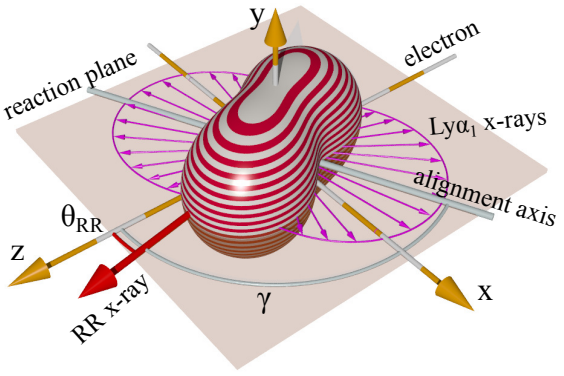

Figure 1. The angular density distribution of the charge cloud of the RR-populated $2p_{3/2}$ state when the RR x ray is observed.

References

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