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Nuclear Excitation by Electron Capture in Excited Ions

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Nuclear excitation by electron capture (NEEC) was initially proposed in 1976 by Goldanskii and Namiot [1] as the inverse internal conversion process.
The recent observation of NEEC in the ^{93}Mo isomer depletion [2] caused a lively discussion [3, 4] and sparked new interest: the measured excitation probability P_{exc} is unexpectedly larger than what is predicted by the state-of-the-art theoretical model, differing by nine orders of magnitude [5]. A recent work [6], accounting for the difference between NEEC and NEEC-RT, where the target electrons are initially bound, slightly increased this theoretical limit.
The authors showed that the depletion probability increases by several orders of magnitude in case of the L-shell. However, these L-channels do not contribute significantly to the P_{exc} because the charge state required for an L-vacancy to be present is greater than the averaged charge state (q_{mean}) at the resonance condition [5].
In fact, the evaluation of the NEEC cross section has been carried out widely using the assumption that the ion is in its electronic ground state prior to the capture (for brevity, GSA), inhibiting the capture in the innermost-shells as soon as the atomic orbitals fill up.
In our work, we studied the particular case of ^{73}Ge. If ground state assumption is used, NEEC into K-shell cannot occur: in all the cases the energy released through a K-capture exceeds the nuclear transition energy and NEEC is forbidden.
By lifting this restriction and considering NEEC in excited ions (NEEC-EXI), we show for ^{73}Ge that many more capture channels emerge [7]. These excited electronic configurations make NEEC through K-capture now possible, with new channels having resonance strengths larger than any other obtained under GSA.
These considerations can be relevant in out-of-equilibrium scenarios. Here, excited electronic configurations might be more likely to occur and the same can hold true for the beam-based setup where ^{93}Mo depletion has been observed. Under NEEC-EXI, although the K-capture remains strictly forbidden for ^{93}Mo, the presence of vacancies in the L-shell at the resonance condition — even for lower charge states than q_{mean}— could make the contribution of L-channels no longer insignificant for the total excitation probability.

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