Novel technique to study nuclear isomers via atomic processes

B.Q. Lee,[1] S.Q. Lim,[1] G. Kessedjian,[2] C. Sage,[2] A. Chebboubi,[2]
U. Köester,[3] M.W. Reed,[1] T. Kibédi,[1] and A.E. Stuchbery[1]

[1]*Department of Nuclear Physics, The Australian National University, ACT 2601, Australia*
[2]*LPSC, 53 rue des Martyrs, F-38026 Grenoble, Cedex, France*
[3]*Institut Laue Langevin, 6 rue Jules Horowitz, F-38042, Grenoble, France*

Nuclear isomers can decay through multiple processes; in many cases the dominant mechanism is internal conversion (IC). This is an excitation of an atomic-electron resulting in ionization and the creation of atomic vacancies. These vacancies are propagated towards the outer-shells by the emission of X-rays and Auger electrons. Auger-electron emission increases the ionic charge of decaying ions thus affecting the charge-state distribution.

We propose a novel technique to identify and study nuclear isomers by investigating the charge-state distribution of residual ions following isomeric decays. This technique is based on the fact that the residual charge-state distribution is sensitive to the internal conversion coefficient (number of IC events occurring), which could be used to extract useful information about nuclear isomers.

As a proof of concept, the technique has been applied to study nuclear isomers in ^{144}Cs. The residual charge-state distribution of ^{144}Cs following isomeric decays has been measured using the Lohengrin fission fragment mass spectrometer at the Institut Laue-Langevin, France [1]. Based on a level scheme proposed in Ref. [1], we simulated the nuclear cascade decays and the subsequent emissions of X-rays and Auger electrons in ^{144}Cs using an Auger cascade model [2]. The simulations started in pre-ionized ions since an equilibrium charge-state distribution ($\overline{q} \approx 20$) was established after the ions passed through a nickel foil 0.3 mm away from the ^{235}U target.

The simulation provides very good agreement with the experimental measurement and has enabled the extraction of a limit on the isomeric lifetime, an isomeric ratio, and deduction of the unknown level X [1] to be a state at 92.2 keV.

---

[1] T. Rzaca-Urban, et al., *Phys. Rev. C* **80**, 064317 (2009).
[2] B.Q. Lee, et al., *Comp. Math. Meth. Med.* 651475 (2012).