Beta-delayed neutron spectroscopy with an ion trap

S. A. Caldwell[1,2], J. A. Clark[1], A. Pérez Galván[1], G. Savard[1,2], N. D. Scielzo[3], R. M. Yee[3,4], P. F. Bertone[1], F. Buchinger[5], C. M. Deibel[6], J. Fallis[7], J. P. Greene[1], S. Gulick[5], D. Lascar[1,8], A. F. Levand[1], G. Li[5], E. B. Norman[3,4], S. Padgett[3], M. Pedretti[3], R. E. Segel[1,8], K. S. Sharma[9], M. G. Sternberg[1,2], J. Van Schelt[1,2], B. J. Zabransky[1]

[1] *Argonne National Laboratory, Argonne, IL 60439, USA*
[2] *University of Chicago, Chicago, IL 60637, USA*
[3] *Lawrence Livermore National Laboratory, Livermore, CA 94550, USA*
[4] *University of California, Berkeley, CA 94720, USA*
[5] *McGill University, Montreal, QC H3A 0G4, Canada*
[6] *Louisiana State University, Baton Rouge, LA 70803, USA*
[7] *TRIUMF, Vancouver, BC V6T 2A3, Canada*
[8] *Northwestern University, Evanston, IL 60208, USA*
[9] *University of Manitoba, Winnipeg, MB R3T 2N2, Canada*

The properties of β-delayed neutron (βn) emission are important in basic and applied nuclear physics. The neutron spectra and branching ratios of βn emitters reflect the evolution of nuclear structure in neutron-rich nuclei. Branching ratios can affect the population of heavy elements in the universe resulting from the astrophysical r process. Energy spectra and branching ratios of βn emitters are also important to stockpile stewardship and the safe design of nuclear reactors. Recently we demonstrated a novel technique for βn spectroscopy using $^{137}I^+$ ions confined to a $\sim$1mm^3 volume within a Paul trap [1, 2]. By measuring the time-of-flight spectrum of ions recoiling from both the β and βn processes, the βn branching ratio and spectrum can be determined. This recoil-ion technique has several advantages over techniques that rely on neutron detection: the recoil ions are easily detectable; complications due to scattered neutrons and γ-rays are avoided; and the βn branching ratio can be extracted in several different ways. Our demonstration measurement achieved an absolute precision of $\sim$1% in the βn branching ratio and 10-20% energy resolution in the neutron spectrum over the range 200-1500 keV, with 30 ions/sec delivered to the trap. A campaign of measurements is currently underway at Argonne with a 10$\times$ improvement in coincident detection efficiency and energy resolution reaching $\sim$3%. A further-upgraded version of this experiment is planned at Argonne's CARIBU facility. The recoil-ion technique will be described and the status of the current campaign and future prospects for the CARIBU experiment will be discussed. Prepared by ANL under Contract DE-AC02-06CH11357, LLNL under Contract DE-AC52-07NA27344, and Northwestern U. under Contract DE-FG02-98ER41086.

References

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