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STRUCTURE AND COLLECTIVITY VERY FAR FROM STABILITY: COULOMB EXCITATION OF RADIOACTIVE NUCLEAR BEAMS IN INVERSE KINEMATICS

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Theoretical studies of the evolution of nuclear structure towards the neutron drip line suggest that such extremely neutron rich nuclei may exhibit new types of structure and collectivity as a consequence of a diffuse, low-density neutron skin.[1,2] In medium and heavy nuclei, one scenario envisions a shell model potential that resembles a harmonic oscillator plus $l \cdot s$ term, only, which will give rise to new magic numbers and affect the appearance of collective modes of excitation that arise from j sequencing within shells. Acquiring the data needed to reveal these novel features and phenomena is a challenge that can only be addressed by a new generation of radioactive nuclear beam (RNB) facilities and then only by experiments with a very high degree of selectivity and sensitivity to structural features. Recent work[3,4] has shown that knowledge of the energies of the first excited 2^+ and 4^+ states of even-even nuclei together with the reduced transition probability $B(E2;0_1^+\rightarrow 2_1^+)$ is sufficient to classify nuclei in terms of a new tripartite scheme where deviations from the universal trajectory of the scheme can signal new magic numbers, hexadecapole deformations, axial asymmetry, and oblate-prolate coexistence.

We have developed several techniques to obtain the necessary data by low energy Coulomb excitation of RNBs in inverse kinematics on low Z targets. Under these conditions only the first one or two states of the RNB nuclei are excited and data analysis is quite simple. Here we focus our attention of one of these approaches, the measurement of internal conversion electrons associated with the decay, in flight, of Coulomb-excited nuclei. In this test-of-concept experiment stable beams of ^{188}Os were accelerated to 267 MeV using the Yale University tandem Van de Graaff and Coulomb excited by a 0.43 mg/cm^2 ^{12}C target foil positioned upstream from an array of 300 μm thick, 7.5 mm

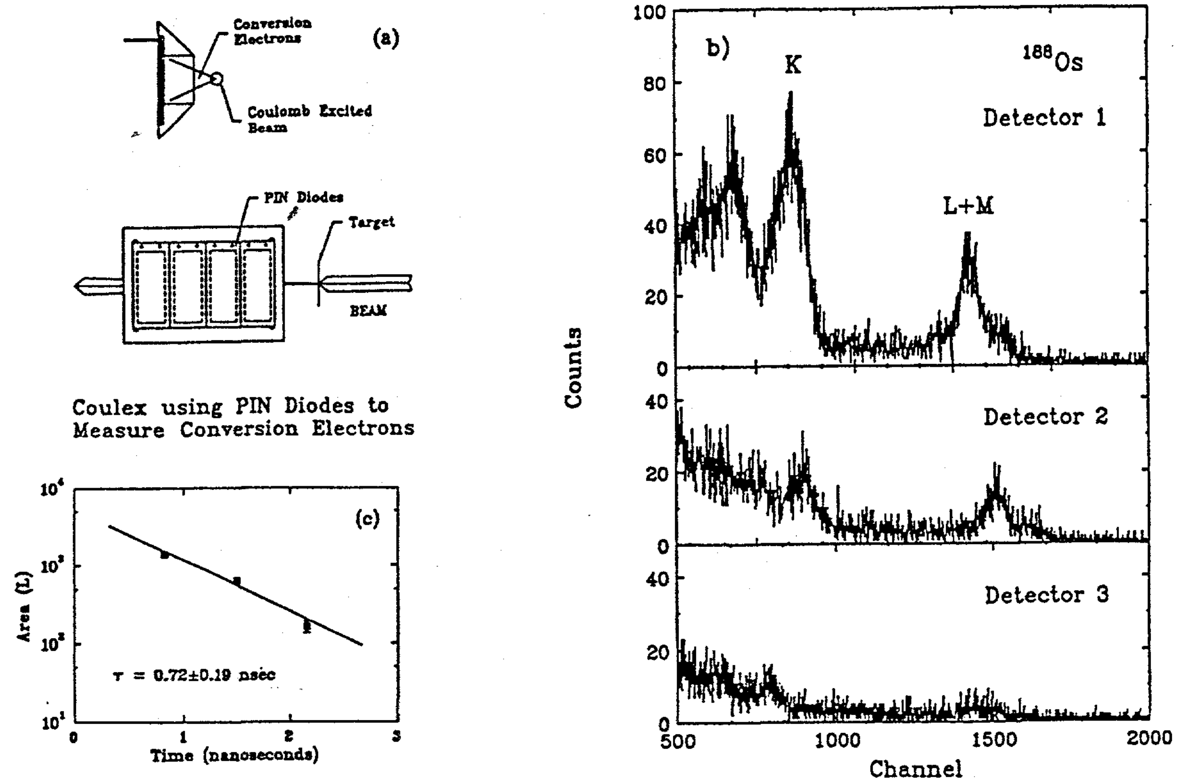

Fig 1. (a) A schematic of the PIN diode detector array, (b) the conversion electron spectra from the first three PIN diodes for ^{188}Os, and (c) the decay curve of the ^{188}Os 2_1^+ level L electrons.

x 20 mm active area, windowless, Si PIN diodes, which were accurately positioned along the beam direction and collimated so that each detector viewed a known time window for the transmitted, Coulomb-excited ^{188}Os beam (Fig. 1a). The electron spectra recorded in three PIN diodes located sequentially along the flight path downstream from the target are shown in Fig. 1b. Although the detector resolution is not optimized in these spectra, the K and L, M composite conversion electron lines from the 155.04 keV $2_1^+ \rightarrow 0_1^+$ transition are clearly resolved and seen to diminish in intensity with distance from the ^{12}C target. Fig. 1c is a plot of the area of the L peaks against time. These data yield a mean life for the ^{188}Os 2_1^+ state of 720(190) ps and B(E2;$0_1^+ \rightarrow 2_1^+$) of 3.49(87) e^2b^2 which can be compared to the adopted values[5)] of 990(27) ps and 2.54(6) e^2b^2.

These preliminary results serve to illustrate the significant advantages of this approach for future RNB measurements. The choice of inverse kinematics assures a narrowly focused beam of transmitted Coulomb-excited nuclei and the use of PIN diode electron detectors provides a highly efficient means for detecting conversion electrons emitted during decay in flight while simultaneously being largely insensitive to ambient background radiations that are expected to be significant at RNB facilities. This technique should be generally applicable to medium and heavy deformed RNB nuclei with lifetimes >200 ps that are available at rates of 10^5 s^{-1} or higher.

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