NUCLEAR STRUCTURE STUDIES OF LIGHT-MASS RADON ISOTOPES USING THE $^{209}Bi(^{6}Li, xn\gamma)$ REACTIONS

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The methods of in-beam γ-ray spectroscopy, employing the relatively energetic ^{6}Li beams available at IUCF, are being used to study the proton-rich isotopes ^{209}Rn and ^{210}Rn. Although the unique properties of (ion,xnγ) reactions have been exploited in many parts of the periodic table to study nuclei which are far from the line of stability and hence often otherwise inaccessible, little attention has been devoted thus far to the interesting region beyond bismuth.

Two points on the excitation functions for the $^{209}Bi(^{6}Li, 5n\gamma)^{210}Rn$ and $^{209}Bi(^{6}Li, 6n\gamma)^{209}Rn$ fusion-evaporation reactions have been measured by bombarding self-supporting targets of ^{209}Bi with 55 MeV and 65 MeV ^{6}Li ions. In addition to measuring in-beam singles to determine the intensities of relatively prompt γ-transitions, off-line measurements of target residual γ-activities were made for periods of 1-2 hours following each bombardment. While additional bombardments at other energies are still needed to complete the excitation functions and hence to assign prompt γ-transitions to specific nuclides, cross sections for the ^{6}Li-induced reactions have been determined from analysis of the off-line activity measurements. Some of our preliminary cross section results for ^{6}Li reactions on ^{209}Bi are shown in Table 1. At 65 MeV, which is probably close to the optimum for the 6n reaction, some 7n reaction leading to ^{208}Rn was expected but not observed. While the γ rays in the decay of ^{208}Rn (24 min; 80% EC) are unknown, the γ rays are known in the decay of the daughter, ^{208}At (1.6 hr; 99% EC), but were not seen in the decay spectra. The 6n cross section was determined from the daughter ^{209}At activity rather than from the parent ^{209}Rn, where the γ branching is uncertain. At both energies the expected growth of the ^{209}At activity was observed with no evidence for direct production of ^{209}At.

Table 1. Measured cross sections for production of selected nuclei by (^{6}Li, xn) Reactions on ^{209}Bi target.

Reaction	Cross Section (mb) 55 MeV	65 MeV
$(^{6}Li, 7n)^{208}Rn$	--	--
$(^{6}Li, 6n)^{209}Rn$	157	615
$(^{6}Li, 4n)^{211}Rn$	182	--
$(^{6}Li, d3n)^{210}At$	189	185

The cross section for the 5n reaction cannot be determined from our decay data. The residual nuclide, ^{210}Rn, decays primarily by α emission to the ground state of 8.8-day ^{206}Po with a very weak 4% EC branch to ^{210}At. The γ rays associated with the EC decay of ^{210}Rn are unknown. However, transitions from the decay of ^{210}At are being produced directly. Entrance channel breakup of the ^{6}Li ion into α + d followed by the $^{209}Bi(\alpha,3n)$ ^{210}At reaction is the most likely mechanism. The optimum α-particle energy for this reaction is estimated to be 40 MeV from a simple semi-empirical relationship. Assuming the α particle, after breakup, carries 2/3 of the ^{6}Li energy, it would have 36.7 and 43.3 MeV respectively at bombarding energies of 55 and 65 MeV. Therefore one would expect, as observed, the cross sections for the (^{6}Li, d3n)^{210}At reaction to be similar at the two bombarding energies.

In addition to the in-beam singles and off-line activity measruements, we have measured in-beam γ-γ coincidences ($\sim$ 30 x 10^{6} events) from ^{6}Li + ^{209}Bi reactions at 65 MeV. Using two Ge(Li) detectors at 90^{o} with respect to the beam direction, 4-parameter (E_1,E_2,γ-γ TAC,γ-RF TAC) coincidence data were recorded event by event and stored on magnetic tape. The tapes have been sorted off-line using the University of Michigan Amdahl 470v/6 computer and analysis of the results is in progress.

The bulk of the experimental work will be completed in the near future by measuring additional points on the excitation functions and by measuring γ-ray angular distributions.

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