

THE MULTIPLICITY OF K X-RAYS EMITTED IN (${}^6\text{Li}, xn$) REACTIONS

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We reported earlier¹ the first direct measurements of the multiplicity ($\langle M_K \rangle$) of K X-rays emitted from fusion residues, and the application of such measurements to the determination of absolute residue-production cross sections. In (${}^6\text{Li}, xn$) reactions initiated on targets in the gold region at bombarding energies of 75, 85, and 95 MeV, we observed typically an average of 2-3 K X-rays emitted per evaporation residue produced. The only reasonable mechanism known which could produce so many X-rays is repeated internal conversion in the midst of the γ -cascade de-exciting the evaporation residues. From a number of indirect experimental constraints, we argued¹ that ~ 2 K X-rays arise, in all the neutron-poor Tl and Pb isotopes populated, from a narrow spin region ($12 \lesssim J \lesssim 20$) dominated by low-energy M1 transitions. In the Tl isotopes, approximately one additional X-ray should be expected from conversion of known low-spin transitions.²

We have since extended our measurements of $\langle M_K \rangle$ (via detection of X-ray-X-ray coincidences¹) for ${}^6\text{Li}$ bombardment of ${}^{181}\text{Ta}$, ${}^{194,198}\text{Pt}$, ${}^{197}\text{Au}$, and ${}^{208}\text{Pb}$ to lower (55 MeV) and higher (120 MeV) bombarding energies. These measurements were intended both to provide additional information on the origin of the X-rays and to determine absolute total (${}^6\text{Li}, xn$) cross sections to complement charged-particle measurements of cross sections for other compound-nucleus decay channels. The results of our $\langle M_K \rangle$ measurements over the entire range for ${}^{198}\text{Pt}$ and ${}^{197}\text{Au}$ targets are shown in Fig. 1. The observed fall-off of $\langle M_K \rangle$ at the lowest energy for both targets is consistent with our previous arguments concerning the origin of the X-rays, since in the

(${}^6\text{Li}, xn$) residues produced at $E_{\text{Li}}=55$ MeV, the spin region assumed responsible for much of the internal conversion will be only partially populated.

The observed constancy of $\langle M_K \rangle$ for each target over the range from $E_{\text{Li}}=75$ to 120 MeV is surprising. Not only does the mean spin of the residues increase appreciably over this energy range, but in addition the dominant residue shifts by ~ 4 amu. The insensitivity of $\langle M_K \rangle$ to the neutron excess of the populated residues is also apparent in the near-equality of results for the ${}^{194}\text{Pt}$ and ${}^{198}\text{Pt}$ targets (see also Ref. 1). The data seem to suggest a small "island" of highly converting high-spin transitions which persists remarkably over a long string of isotopes, without particular regard for the presence of unpaired nucleons. One conceivable scenario for the nuclear structure responsible for this observation is that there occur in all of these isotopes

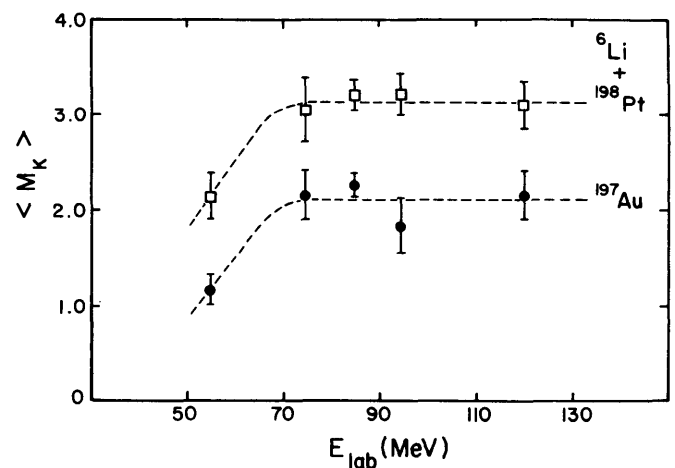


Figure 1. Bombarding energy dependence of the mean number $\langle M_K \rangle$ of K X-rays emitted per (${}^6\text{Li}, xn$) reaction product for targets of ${}^{198}\text{Pt}$ and ${}^{197}\text{Au}$. The values of $\langle M_K \rangle$ were measured by the X-ray-X-ray coincidence technique described in Ref. 1. The dashed curves are intended to guide the eye.

high-K (oblate) deformation-aligned rotational bands built upon few quasi-particle configurations. The high K of such bands would favor M1 over E2 transitions among members of the band³. If the associated moment of inertia were equal to the rigid sphere value (i.e., if pairing effects were unimportant and the deformation mild) and the mean spin of the band members were $\approx 16\hbar$, we would expect a number of M1 transitions of ≈ 160 keV; each such transition would yield a K X-ray $\approx 60\%$ of the time.

There are indeed a number of such strongly coupled rotational bands which have been identified at low excitation in the neutron-poor ($A=189-199$) Tl isotopes.^{2,4} However, there is essentially no relevant information available about the energy levels in the Pb isotopes in the appropriate region of spin. We have therefore run very recently an X- γ and γ - γ coincidence experiment (using one large-volume Ge(Li) and two intrinsic Ge detectors), designed to search for low-energy γ -rays from the proposed highly converting transitions, with particular emphasis on (the previously unknown) transitions feeding the 12^+ isomeric state ($T_{1/2} = 212$ ns) in ^{198}Pb . The ^{198}Pb was populated with a high value of $\langle M_K \rangle$ (≈ 2.0) in 68-MeV $^7\text{Li}+^{197}\text{Au}$, and with lower $\langle M_K \rangle$ (≈ 1.1) in 55 MeV $^6\text{Li}+^{197}\text{Au}$, in order to seek correlations between the X-ray multiplicity and features of the γ -ray coincidence yields. The high-

statistics singles γ spectra acquired reveal a large number of weak, previously unidentified, lines between ~ 100 and ~ 300 keV. Association of these lines with particular nuclides, and information on the (singles) angular distributions (and hence multipolarities), await replay of the ~ 50 event tapes collected.

One additional recent extension to our X-ray program has involved accurate measurements of the absolute cross sections for target (atomic-collision) X-ray production at $E_{^6\text{Li}} = 55$ MeV, made simultaneously with measurements of the forward-angle (Rutherford) elastic scattering cross section using left-right monitor detectors in the 64"-diameter scattering chamber. We are particularly interested in the results for a series of Pt isotopes ($A=194, 195, 196, 198$), since our previous similar measurements at higher bombarding energy suggested a possible small, but unexpected, isotopic dependence of the target X-ray cross section. The data from this experiment are currently being analyzed.

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THE DECAY OF HOT, HIGH-SPIN NUCLEI PRODUCED IN ^6Li -INDUCED FUSION

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We are continuing our program of measurements and statistical model analysis of the competition among decay modes of compound nuclei (CN) formed at high spin (up to $\sim 35 \hbar$) and excitation energy (up to ~ 100 MeV)

in ^6Li -induced fusion reactions. Our aim has been to measure as many observables characterizing the decay as possible, in order to constrain the statistical model analysis to a much greater degree than in