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# STUDY OF $^{189}$Bi$^{m}$ $\alpha$ DECAY

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In a series of $^{48}$Ti bombardments of $^{144}$Sm the decay energy of the $^{189}$Bi$^{m}$ ($\pi s_{1/2}$) $\alpha$ transition that proceeds to the ($\pi s_{1/2}$) ground state of $^{185}$Tl was measured to be 7.30(4) MeV. This result establishes the excitation energy of $^{189}$Bi$^{m}$ as 190(40) keV rather than the adopted 92(10)-keV value. Our data thus indicate a leveling off in excitation energy at $N \approx 106$ for the $s_{1/2}$ intruder state in odd-A Bi isotopes.

In the spherical shell model, the proton $1h_{9/2}$ orbital lies above the Z = 82 closed shell while the $3s_{1/2}$ orbital lies below. Any $1h_{9/2}$ configurations in Z < 82 nuclei and $3s_{1/2}$ configurations in Z > 82 nuclei are referred to as proton "intruder" states. A great deal of recent work has clearly shown that $1h_{9/2}$ intruder configurations exist in odd-A Tl and Au isotopes and demonstrated a parabolic dependence of their excitation energy with a minimum when the neutron number is midway between the major shell closures of N = 82 and N = 126 [1)]. Similar behavior is seen for intruder states in even-even Pb, and odd-odd Tl nuclei [2)].

While the picture presented above for the $1h_{9/2}$ intruder in Z < 82 nuclei is convincing, it was actually the odd-mass Bi isotopes that provided the first evidence for intruder states in the Z = 82 region [3)]. However, the parabolic dependence of the $s_{1/2}$ level energies in odd-A Bi isotopes came into question with the value reported by Coenen *et al* [4)] of 92(10) keV for $^{189}$Bi$^{m}$ that implies a continued drop at N=106 for the $s_{1/2}$ intruder state This excitation energy is based on an $E_\alpha$ of 7206(10) keV [5)] that has been contradicted [6)] by a recently measured $E_\alpha$ of 7.43(3) MeV. To resolve this discrepancy we reinvestigated the $\alpha$ decay of $^{189}$Bi$^{m}$.

Bismuth-189 was produced in the $^{144}$Sm($^{48}$Ti,p2n) reaction utilizing beams of 215, 220, and 230 MeV from the Lawrence Berkeley Laboratory 88-Inch Cyclotron. Its $\alpha$ decay was observed by using a rapidly rotating recoil catcher wheel system (described in

Ref 7). Catcher foils on the edge of the wheel stop the recoils that are then rotated between two arrays of six Si detectors in series.

Figure 1 shows the α spectra observed in the first two detectors, at 225 MeV and a wheel speed of 240 rpm. One sees the 7.30(4) MeV transition from the ($\pi s_{1/2}$) isomer of $^{189}$Bi to the ($\pi s_{1/2}$) $^{185}$Tl ground state, the transition from the ($\pi h_{9/2}$) ground state of $^{189}$Bi to the ($\pi h_{9/2}$) isomer of $^{185}$Tl, and α particles from $^{186}$Pb. Our $Q_\alpha$ of 7.46(4) MeV for $^{189}$Bi$^m$, combined with that of the previously known $^{189}$Bi $Q_\alpha$, establishes the excitation energy of $^{189}$Bi$^m$ as 190(40) keV. On the basis of these data and results obtained at a wheel speed of 500 rpm, a half-life of 7.0(2) ms for $^{189}$Bi$^m$ was determined.

Figure 2 shows level energies of the intruder states in odd-A Tl and Bi nuclei plotted vs. N. The Tl $\pi h_{9/2}$ levels fall on a parabola-shaped curve with a minimum at N ≈ 110. However, the value deduced by Coenen *et al* of 92(10) keV for the $^{189}$Bi$^m$ energy shows a continued drop at N < 108 for the $\pi s_{1/2}$ intruder state. In contrast, our $^{189}$Bi$^m$ energy and that of Ref. 6 indicate that the $s_{1/2}$ level energies, at least down to N=106, exhibit the same parabolic behavior as the $h_{9/2}$ states.


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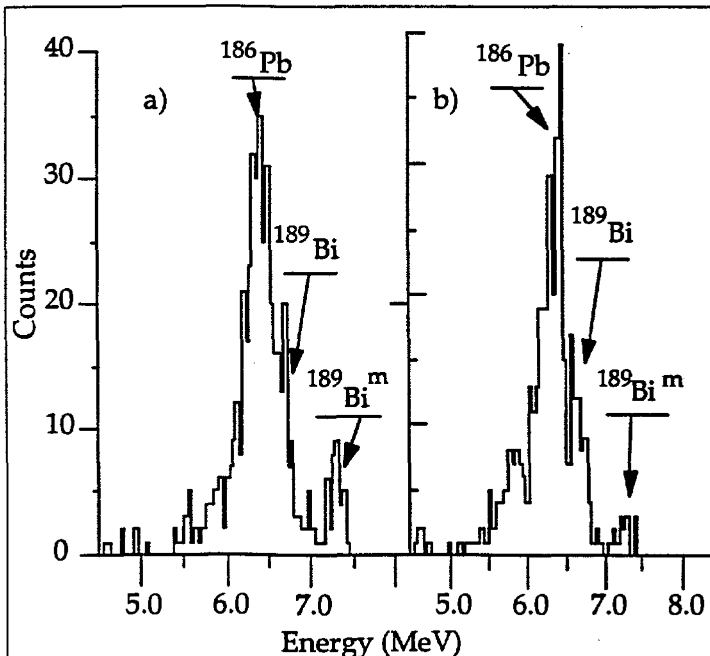


Figure 1. α spectra observed during the experiment. Parts a) and b) refer to spectra accumulated in the first two detectors.

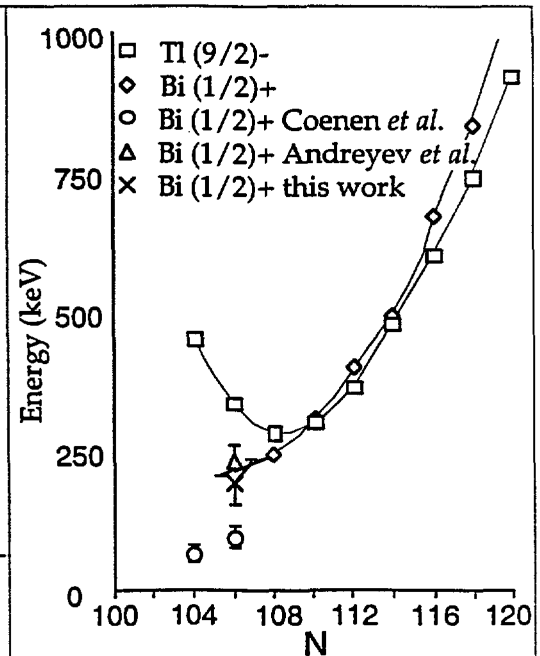


Figure 2. Plot of the intruder state excitation energies versus N for odd-mass Tl ($\pi h9/2$) and Bi ($\pi s1/2$) isotopes.

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