

STUDY OF $^{189}\text{Bi}^m$ α DECAY

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In a series of ^{48}Ti bombardments of ^{144}Sm the decay energy of the $^{189}\text{Bi}^m$ ($\pi s_{1/2}$) α 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 $^{189}\text{Bi}^m$ 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 $^{189}\text{Bi}^m$ that implies a continued drop at $N=106$ for the $s_{1/2}$ intruder state. This excitation energy is based on an E_α of 7206(10) keV ⁵) that has been contradicted ⁶) by a recently measured E_α of 7.43(3) MeV. To resolve this discrepancy we reinvestigated the α decay of $^{189}\text{Bi}^m$.

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

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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_{α} of 7.46(4) MeV for $^{189}\text{Bi}^m$, combined with that of the previously known ^{189}Bi Q_{α} , establishes the excitation energy of $^{189}\text{Bi}^m$ 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 $^{189}\text{Bi}^m$ 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 $N \approx 110$. However, the value deduced by Coenen *et al.* of 92(10) keV for the $^{189}\text{Bi}^m$ energy shows a continued drop at $N < 108$ for the $\pi s_{1/2}$ intruder state. In contrast, our $^{189}\text{Bi}^m$ 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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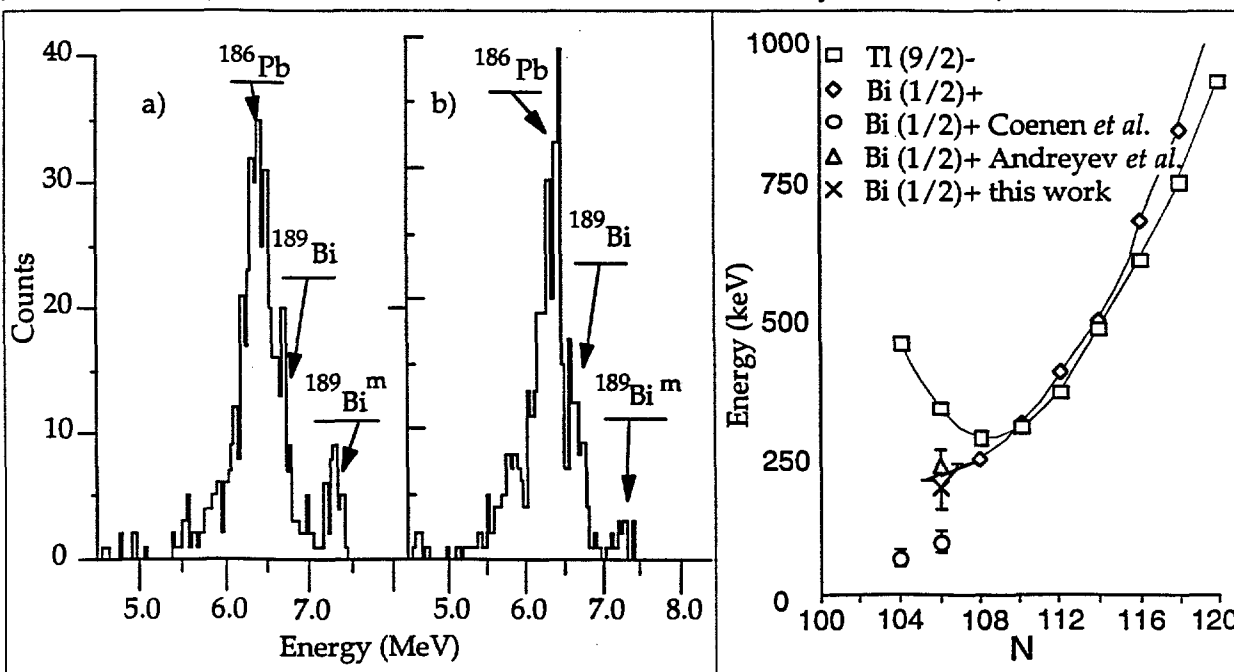


Figure 1. α spectra observed during the experiment. Parts a) and b) refer to spectra accumulated in the first two detectors.

Figure 2. Plot of the intruder state excitation energies versus N for odd-mass Tl ($\pi h_{9/2}$) and Bi ($\pi s_{1/2}$) isotopes.

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