

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

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In a series of  $^{48}\text{Ti}$  bombardments of  $^{144}\text{Sm}$  the decay energy of the  $^{189}\text{Bi}^m$  ( $\pi s_{1/2}$ )  $\alpha$  transition that proceeds to the ( $\pi s_{1/2}$ ) ground state of  $^{185}\text{Tl}$  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  $N = 126$  <sup>1</sup>). Similar behavior is seen for intruder states in even-even Pb, and odd-odd Tl nuclei <sup>2</sup>).

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 <sup>3</sup>). 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* <sup>4</sup>) 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  $E_\alpha$  of 7206(10) keV <sup>5</sup>) that has been contradicted <sup>6</sup>) by a recently measured  $E_\alpha$  of 7.43(3) MeV. To resolve this discrepancy we reinvestigated the  $\alpha$  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  $\alpha$  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  $\alpha$  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  $^{189}\text{Bi}$  to the  $(\pi s_{1/2})$   $^{185}\text{Tl}$  ground state, the transition from the  $(\pi h_{9/2})$  ground state of  $^{189}\text{Bi}$  to the  $(\pi h_{9/2})$  isomer of  $^{185}\text{Tl}$ , and  $\alpha$  particles from  $^{186}\text{Pb}$ . Our  $Q_\alpha$  of 7.46(4) MeV for  $^{189}\text{Bi}^m$ , combined with that of the previously known  $^{189}\text{Bi}$   $Q_\alpha$ , 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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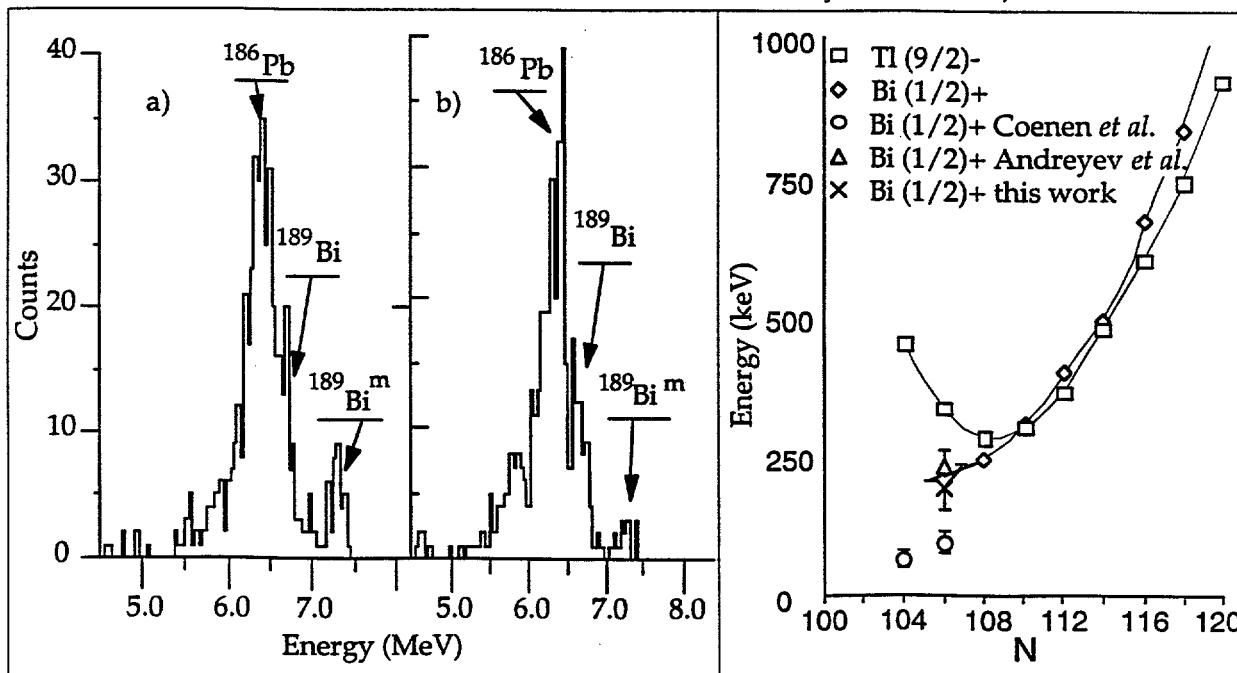


Figure 1.  $\alpha$  spectra observed during the experiment. Parts a) and b) refer to spectra accumulated in the first two detectors.

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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