Spins and Parities of Energy Levels in Pb^{208}

L. G. Elliott, R. L. Graham, J. Walker, and J. L. Wolfson
Physics Division, Atomic Energy of Canada Limited, Chalk River, Ontario, Canada
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MEASUREMENTS of the K internal conversion coefficients α_K of the 2.62, 0.583, 0.860, and 0.511 Mev γ-ray transitions in Pb^{208} following the decay of Tl^{208} (3.1 min) together with a determination of the angular correlations between selected pairs of these γ rays have recently been made at this laboratory. The results lead unambiguously to the spin and parity assignments shown in Fig. 1 with the sole assumption of zero spin and even parity for the ground state of Pb^{208}.

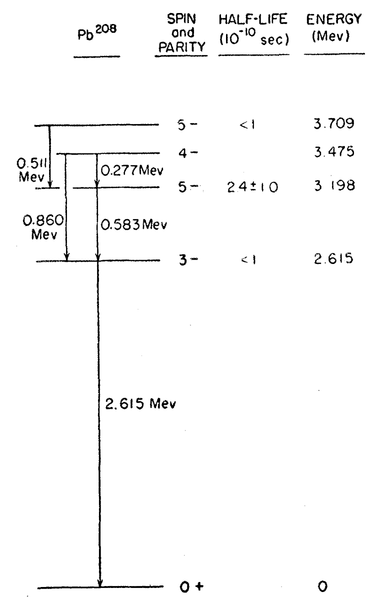

Fig. 1. Spins and parities of energy levels in Pb^{208}.

The α_K for the 2.62-Mev transition was found by measuring separately the quantum intensity q, and K internal conversion electron intensity e_K from a source of thorium active deposit. The q was found by comparison with the quantum intensity of the 2.76-Mev γ radiation from a standardized source of Na^{24} using a NaI(Tl) scintillation spectrometer. The e_K was determined by measurement of the "X" line intensity in a magnetic β-ray spectrometer having an accurately measured transmission. The α_K for the 0.583-Mev transition was found in a similar manner. The values obtained were $(1.78\pm0.12)\times10^{-3}$ and $(1.52\pm0.11)\times10^{-2}$ for the 2.62-Mev and 0.583-Mev transitions, respectively. The former is in good agreement with the theoretical value[1] of 1.86×10^{-3} for $E3$ radiation and the latter with the theoretical value[1] of 1.61×10^{-2} for $E2$ radiation. Both measured values are in agreement with those reported by Martin and Richardson.[2]

The angular correlation experiment was performed using a source of thorium active deposit in a $1N$ nitric acid solution with a small amount of $Pb(NO_3)_2$ added as carrier. The detectors were NaI(Tl) crystals and 6292 Dumont or 5819 RCA photomultipliers. Each channel of the coincidence circuit incorporated a single-channel pulse-height analyzer. By appropriate pulse-height selection coincidences between the 0.511-Mev γ ray and the 2.62-Mev γ ray were avoided entirely. Except for a 3 percent contribution caused by the Compton effect from the 0.860-Mev transition the true coincidences recorded were due entirely to those of the 0.583-Mev and 2.62-Mev cascade.

Coincidences were recorded at seven angles and the rates, corrected for (1) chance coincidences, (2) the contribution owing to the 0.860-Mev transition, and (3) the decay of the sample, are shown in Fig. 2. The experimental data are plotted as points, normalized to the value at 90°. The curves are the theoretical functions (corrected for the finite angular resolution) for the 0–3–5 assignment and the previously proposed assignments[2,3] 0–2–4 and 0–1–3. The experimental results are consistent only with the assignment 0–3–5.

Similar but less detailed measurements of α_K for the 0.86-Mev and 0.511-Mev γ rays and of the angular correlations of these γ rays with respect to the 2.62-Mev γ ray indicate: (1) an assignment of 4− for the 3.48-Mev level with an intensity ratio of $E2/M1=(6.5\pm6.5)\times10^{-4}$ and 180° phase difference for the 0.86-Mev γ ray, and (2) an assignment of 5− for the 3.71-Mev level with $E2/M1=1.7\pm0.3$ and 0° phase difference for the 0.511-Mev γ ray.

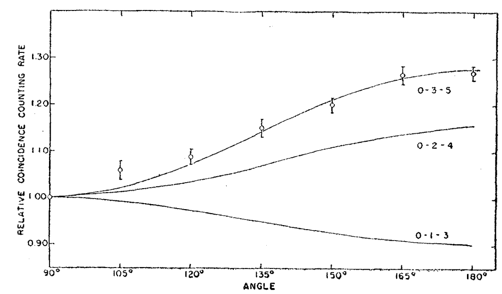

Fig. 2. Angular correlation between the 0.583-Mev and 2.615-Mev γ rays. The experimental data are plotted as points normalized to the value at 90°. The vertical bars represent the standard deviations. The curves are the theoretical functions corrected for the finite angular resolution for the assignments 0–3–5, 0–2–4, and 0–1–3.

Coincidences were observed in a double magnetic β-ray spectrometer between the β-ray continuum and the 0.583-Mev K internal conversion line, and indicate that the 0.583-Mev transition is delayed with a half-life of $(2.4\pm1.0)\times10^{-10}$ sec. Observed coincidences between the 0.583-Mev γ ray and the 2.62-Mev γ ray indicate a half-life of less than 1×10^{-10} sec. An upper limit of 1×10^{-10} sec for the half-life of the 0.511-Mev transition has also been obtained. These data are incorporated in Fig. 1.

A detailed investigation of the decay of Tl^{208} is being carried out and a complete report will be submitted for publication in the *Canadian Journal of Physics*.

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[2] D. G. E. Martin and H. O. W. Richardson, Proc. Phys. Soc. (London) **A63**, 223 (1950).
[3] H. E. Petch and M. W. Johns, Phys. Rev. **80**, 478 (1950).

Elastic Scattering of Intermediate-Energy Alpha Particles by Gold*

George W. Farwell and Harvey E. Wegner†
Department of Physics, University of Washington, Seattle, Washington
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THE elastic scattering by Au of alpha particles of energies 14 to 42 Mev has recently been observed in this laboratory. The variation of cross section with alpha-particle energy has been studied for scattering angles of 60° and 95° (lab system). At low bombarding energies, the cross section is given by the Rutherford formula for Coulomb scattering; at higher energies, the decrease in cross section with increasing alpha-particle energy is much more rapid.

The distance of closest approach of alpha particle and scattering nucleus, or apsidal distance, can be calculated for the classical