The Decay of $^{208}\text{Tl}$. Gamma-Ray Measurement

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Received June 9, 1969

The gamma rays following the decay of $^{208}\text{Tl}$ have been studied using a separated $^{208}\text{Tl}$-source and a Ge(Li)-detector. A decay scheme is proposed, with levels in $^{208}\text{Pb}$ at 3,920, 4,126 and 4,180 keV in addition to previously well-established levels. No support was found for $\beta$-branching to levels above 4.2 MeV.

Introduction

The decay of ThB($^{212}\text{Pb}$) and its daughters has been thoroughly studied in the past; special emphasis was laid on the conversion electron spectrum, the lines of which are used as standards in beta-ray spectroscopy.\(^1\)

In a recent paper, Ostertag and Lauterjung\(^2\) suggest for the $^{208}\text{Tl}$-decay a decay scheme somewhat disagreeing with the decay schemes given in Refs. \(^3\) and \(^4\). From their measurements of the $\beta$-ray spectrum they claim a 4\% branch to one or more levels at about 4.3 MeV in $^{208}\text{Pb}$ and no direct $\beta$-feeding of the 3.96 MeV level.

A high-resolution gamma-ray spectrum may be expected to reveal the gamma rays depopulating the levels at 4.3 MeV. These gamma rays should be expected to populate the well-established level at 3.96 MeV and hence to appear in the region 3—400 keV.

Previous measurements of the gamma-ray spectrum from the decay of $^{208}\text{Tl}$ have been performed on sources of ThB with NaI scintillation detectors and coincidence techniques. In such spectra, it is difficult to avoid contributions from other ThB daughters, and weak lines in the $^{208}\text{Tl}$-decay may thus be obscured. It was therefore decided to measure a gamma-ray spectrum using a Ge(Li)-detector and a separated $^{208}\text{Tl}$-source.

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Experimental Procedure

The source of $^{208}$Tl was separated from ThB and ThC by means of a recoil collecting method used by Lassen and Hornstrup. The collection of $^{208}$Tl took place in open air on aluminum plates. Two pairs of plates mounted 60 cm apart on an aluminum rail were used. At any time during the experiment, one pair was located close to the detector while the other pair was surrounding the ThB+C source. A voltage of about 200 volts was supplied to the source relative to the plates. Every third minute, the pairs were automatically interchanged by turning the rail. A large block of lead was used to screen the detector against radiation from the ThB+C source.

The detector was a 3 cc Ge(Li) planar detector with a measured resolution of 3 keV FWHM at 1 MeV. The electronic equipment was a Tennelec amplifier system (Tc 130 and Tc 200) and a Nuclear Data 4096 channel pulse height analyser. In an auxiliary gamma-gamma coincidence experiment, a 20 cc Ge(Li) coaxial detector was used together with a scintillation detector having a $3 \times 3''$ diam. NaI crystal.*

Results

In the measurements of singles, the intensity ratio $I_{583}/I_{239}$ of the gamma transitions at 583 and 239 keV in $^{208}$Pb and $^{212}$Bi, respectively, was enhanced by a factor of 1,000 relative to a source of ThB. The statistical error was so small that lines in the energy region $>100$ keV with intensities $\geq 0.05\%$ of the total number of decays could be distinguished from the Compton background. The energies and intensities are listed in the Table. In general, our results are in good agreement with those of Buschmann and Kantele.

The gamma-gamma coincidence spectrum measured on a source of $^{228}$Th showed the lines at 928 and 983 keV to be fully coincident with the 583 keV transition.

Analysis

The decay scheme in Fig. 1 shows all the observed gamma lines. All transitions and levels are arranged by means of energy fits and comparisons with other types of experiments, e.g., $(p, p')^8$, $^{206}$Pb$(t, p)^{208}$Pb

* The setup was put at our disposal by O. B. Nielsen.