Short Communications

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Coherent scattering amplitude of ^{240}Pu and ^{242}Pu.*

By G. H. LANDER and M. H. MUELLER, *Materials Science Division, Argonne National Laboratory, Argonne, Illinois, U.S.A.*

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The coherent scattering lengths of ^{240}Pu and ^{242}Pu are $0{\cdot}35 \pm 0{\cdot}01$ and $0{\cdot}81 \pm 0{\cdot}01$ ($\times 10^{-12}$) cm, respectively. Absorption cross sections are 205 ± 10 and ~ 15 barns, respectively, at 0·08 eV (1·0 Å).

The most abundant isotope of plutonium, ^{239}Pu, has an absorption plus fission cross section of 1020 barns for thermal neutrons (0·0253 eV), and such a high value makes its use impractical for thermal-neutron studies. While investigating the magnetic properties of plutonium compounds, we recently acquired gram quantities of the 240 and 242 isotopes, which have much smaller cross sections.

The ^{240}Pu sample was examined in the form of the dioxide, PuO_2, which has the CaF_2 structure. Analysis of plutonium metal indicated that the total contamination of both ^{239}Pu and ^{241}Pu was 1·52%. The oxide sample was prepared by firing in air at 700°C, and the lattice parameter was $5{\cdot}391 \pm 0{\cdot}001$ Å. No evidence for a second phase was found from either the X-ray or neutron powder patterns. A spectrochemical analysis indicated no major contaminants, and an additional analysis for uranium indicated a content of less than 0·1%. The total cross section of the sample was measured relative to nickel, and was determined as 215 ± 10 barns. After correcting for the high cross sections of the 239 and 241 isotopes, the cross section for ^{240}Pu at 0·08 eV is 205 ± 10 barns. Values in the literature are 250 (*Chart of the Nuclides*, 1961) and 180 barns (Brookhaven National Laboratory, 1965). Based on a value of $0{\cdot}577 \times 10^{-12}$ cm for oxygen, the scattering length of ^{240}Pu was determined, from the integrated intensities of a neutron powder pattern, as $0{\cdot}35 \pm 0{\cdot}01$ ($\times 10^{-12}$) cm. The quoted error is the standard deviation in the least-squares refinement. The R value, using the first seven peaks, was 1·2%; the overall temperature factor was $0{\cdot}35 \pm 0{\cdot}10$ Å^2, and the oxygen content $2{\cdot}01 \pm 0{\cdot}03$. Using the scale factor given by the calibration against nickel, correlation between the scattering length and the oxygen occupational parameter is only 0·1. Susceptibility measurements on stoichiometric PuO_2 (Raphael & Lallement, 1968) indicate that the susceptibility is independent of temperature, and neutron patterns taken at 4·2 and 300°K confirm the absence of any magnetic ordering. Green, Arnold, Leary & Nereson (1970) reported a value of $0{\cdot}38 \times 10^{-12}$ cm for the scattering length of ^{240}Pu, which is in reasonable agreement with our value. Since their sample contained 6% ^{239}Pu and additional phases, the present result is probably the more reliable.

The scattering length of ^{242}Pu was found during the study of the magnetic properties of the compound $PuAl_2$. The sample was prepared by arc-melting weighed amounts of the metals, and the resulting weight loss was very small. $PuAl_2$ has the $C15$ (Cu_2Mg) structure with a lattice parameter of 7·834 Å. No additional phases were observed, and the plutonium metal contained less than 0·1% of other plutonium isotopes. A comparison between the intensities of the X-ray, in which the plutonium dominates the scattering, and neutron powder patterns established that the compound was fully ordered. Based on a value of $0{\cdot}345 \times 10^{-12}$ cm for Al (Koester, 1971), the scattering length for ^{242}Pu is $0{\cdot}81 \pm 0{\cdot}01$ ($\times 10^{-12}$) cm. The R value for the neutron refinement, which used the first ten intensities, was 1·1%, and the overall temperature factor was $0{\cdot}55 \pm 0{\cdot}10$ Å^2. Absorption cross section for the ^{242}Pu is given as $19{\cdot}2 \pm 3{\cdot}3$ barns for thermal (0·0253 eV) neutrons by Coté, Bollinger, Barnes & Diamond (1959). Considering the almost complete transmission of our sample to 0·07 eV ($\lambda = 1{\cdot}22$ Å) neutrons, and the known weight and packing fraction of the material, we estimate that the absorption cross section is approximately 15 barns.

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