RELATIVE Pu\textsuperscript{239} BREEDING RATIO IN NATURAL URANIUM-ORDINARY WATER LATTICES

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Measurements were performed of the quotient of breeding ratios in uranium-water lattices and a uranium-graphite lattice at the start of conversion. The plutonium breeding ratio in uranium-water lattices for certain lattice spacings is larger than in a uranium-graphite lattice.

Introduction

An important index of the operation of a nuclear reactor which breeds plutonium is the Pu\textsuperscript{239} breeding ratio, which is defined as the ratio of the number of Pu\textsuperscript{239} nuclei \( N_p \) produced in the reactor to the number of consumed U\textsuperscript{235} nuclei \( N_u \):

\[
P = \frac{N_p}{N_u}.
\]

At the present time the parameter of uranium-water lattices which are required for the computation of the breeding ratio are not sufficiently well known. It is therefore important to verify the results of a computation by experimental means.

In the present work we measured the quotient of the breeding ratios in uranium-water lattices and in a uranium-graphite reactor whose parameters have been well investigated:

\[
\frac{P_{\text{water}}}{P_{\text{graphite}}} = \frac{(N_p)_{\text{water}}}{(N_p)_{\text{graphite}}} \frac{(N_u)_{\text{graphite}}}{(N_u)_{\text{water}}}
\]

We studied triangular lattices (with 45, 55 and 60 mm spacings) composed of natural uranium and ordinary water as moderator.

The lattices were composed of aviallite tubes 43 x 1.0 mm in diameter containing uranium slugs 35 mm in diameter and 100 mm long. The slugs were sheathed in 1 mm aluminum. The experiments were performed on physical uranium-water reactors with a natural uranium zone measuring about 1 m (Fig. 1).

The uranium-graphite reactor had a square lattice with 200 mm spacing. The slugs of natural metallic uranium with the same dimensions as in the uranium-water lattices were not provided with aluminum sheathing.

Experimental Method

1. Determination of \( \frac{(N_u)_{\text{water}}}{(N_u)_{\text{graphite}}} \)
Fig. 1. Diagram of a physical uranium-water reactor. ❶ ) channels with enriched uranium slugs; ❷ ) channels with natural uranium slugs; ❸ ) channels with experimental slug.

It is well known that the production of Pu\textsuperscript{239} in a reactor occurs according to the following scheme:

\[
\text{Pu}\textsuperscript{239} \rightarrow \text{Np}\textsuperscript{239} \rightarrow \text{Pu}\textsuperscript{239}. 
\]

Since the measurements are relative, the determination of the number of Pu\textsuperscript{239} nuclei produced in a uranium slug can be reduced to the measurement of the \(\beta\)-activity of Pu\textsuperscript{239}. In order to determine the relative quantity of Pu\textsuperscript{239} we used disks of natural uranium 35 mm in diameter and 0.1 mm thick placed between the ends of separated sections of a uranium slug (Fig. 2). The experimental slug was inserted into the lattice and irradiated with a neutron beam of \( \sim 10^7 \) neutrons/cm\(^2\)/sec. for 30 min. The irradiation times in the uranium-water lattices and the uranium-graphite lattice were identical. After irradiation the uranium disk was chemically cleansed of fission fragments and of the products of natural radioactive decay of uranium by sodium-uranyl-acetate precipitation. The purified uranium was pressed into tablets (of \( \sim 200 \) mg/cm\(^2\) density) whose \(\beta\)-activity was measured with constant geometry by a Geiger counter. The background of natural uranium decay products was disregarded since it amounted to only one percent of the measured effect. Measurements of the \(\beta\)-activity of the purified uranium for 1 to 1.5 hours showed that the half-life was 23.5 \( \pm 0.2 \) min, which agrees with the

\* The effect of Np\textsuperscript{239} consumption during the irradiation period was negligibly small.