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POST OFFICE BOX P
OAK RIDGE, TENNESSEEORNL
CENTRAL FILES NUMBER

CF- 56-3-44

External Transmittal Authorized

COPY NO. 5

DATE: March 7, 1956

SUBJECT: REACTOR PHYSICS AT ORNL (Tripartite Conference
on Nuclear Constants, Chalk River, Jan. 10-12, 1956)

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REACTOR PHYSICS AT OAK RIDGE NATIONAL LABORATORY

Robert A. Charpie

(Presented at Tripartite Conference on Nuclear Constants,
Chalk River, January 10-12, 1956)

The Oak Ridge National Laboratory program in reactor physics can be divided into two major portions -- experimental and theoretical work. The experimental program can be conveniently divided into fission physics and the measurement of integral parameters of multiplying systems. As we are not concerned extensively with heterogeneous reactors at Oak Ridge, our reactor physics is aimed principally at studying general reactor problems.

Since the ORNL work concerning ν as a function of energy, the fission cross sections for the even isotopes of uranium in the Mev range, and the present state of measurements of the capture cross sections of fissionable materials in the kilovolt range, have previously been reported to this Conference, I will not review them here but will refer you to Mr. Fowler's paper.*

In our fission physics program, F. J. Muckenthaler has measured the quantities ν , σ_f , and σ_a for the plutonium isotopes Pu^{239} , Pu^{240} , and Pu^{241} . A report on this work is presently being prepared. Two other interesting experiments in fission physics work are concerned with the measurement of the fission neutron spectrum of U^{233} and the age of U^{233} neutrons in water. At Oak Ridge we have been interested in the breeding possibilities of the thermal neutron system. Accordingly, we would like to know $n(E)dE$ for U^{233} . This has been measured by comparing the U^{233}

* ORNL 56-2-106

fission spectrum to the U^{235} fission spectrum in the graphite pile lid tank. The preliminary results indicate a slightly lower average neutron energy for the U^{233} fission neutrons although the errors are such that the two spectra may be identical. Further work to clarify this point is planned.

Another integral experiment in which we are greatly interested is a measurement of the transport mean free path as a function of temperature. The main difficulty we encountered in using the pulsed neutron source technique arose because of the small samples we used. Very large admixtures of higher harmonics occurred tending to make interpretation difficult.

In our experiments, Campbell and Stelson have replaced the usual neutron detectors by anthracene crystals so that the time decay of the thermal neutron flux shape is measured by detecting the capture gammas accompanying leakage and absorption. The entire sample is surrounded by a thin sheet of cadmium -- thus permitting us to distinguish the capture gammas of the leakage neutrons from the volume capture gammas of the sample by means of pulse height analysis.

Our main interest in this experiment is in making transport mean free path measurements at high temperatures.

The final area in which we have been making some interesting measurements has to do with the critical mass of swimming pool reactors under various conditions of reflection. There has been a considerable vacuum in that portion of neutron multiplication theory dealing with beam holes and experimental cavities in the neighborhood of a reactor core. This is, of course, to be expected since the boundary conditions at such

interfaces are exceedingly complicated. As an intermediate approach to this problem we have reflected our swimming pool reactor with different combinations of material on different lateral faces in order to see if we can compute reliably the effect of varying the lateral reflectors.

Let me turn now to the theoretical questions which we have been investigating. Our primary interest has been in the evaluation of slowing down models. We have now programmed for the ORACLE a series of calculations, each of which adopts a somewhat different model for the neutron slowing down. We have considered age diffusion theory, the Selengut-Goertzel theory (a variation of age theory in which hydrogen scattering is treated correctly in energy although no attempt is made to take account of the proper correlation of angle and energy), the consistent P_1 method, and finally, the S_n method. We are now in the process of comparing the predictions of these various theories with a series of cold, clean critical experiments for simple geometries which are well-known experimentally. We hope to determine a useful range of application of each of the usual slowing down theories.

A second problem which has recently been completed by Bate, Coveyou, and Osborn has to do with the study of the temperature of the neutron distribution in a capturing moderator. As you know, if a moderator has an absorption cross section, even one which varies inversely with the velocity, then the low energy end of the thermal distribution is lower than in a corresponding Maxwell-Boltzmann distribution and the peak of the distribution is shifted to somewhat higher temperatures. If the moderator absorption cross section is significant, one would expect that this effect would result in a significant difference between the material temperature

and the neutron temperature. We recognize, of course, that the neutron temperature is very difficult to define in the case where the thermal neutron distribution is substantially different from the Maxwell-Boltzmann distribution which one would predict for a non-absorbing moderator. I refer you to the forthcoming issue of the Journal of Nuclear Energy for the complete results.

Our experience with Monte Carlo in the temperature program has led us to program two routines for the ORACLE -- one for determining the age in mixtures, and one for determining the resonance escape probability by the Monte Carlo technique. We do not have a sufficiently extensive experience at this time to report reliably on the validity of the Monte Carlo approach. We have just completed the two-dimensional reactor codes which are designed to study the problems of programming control rods in high-powered research reactors and the effects of voids and varying lateral reflectors in reactors of the swimming pool type.

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