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ASTR FAST NEUTRON SPECTRA

by

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Nuclear emulsions have been used to measure the fast neutron spectra of the ASTR for several shield configurations. The measured spectra will be compared with those calculated by use of the Moments Method.

Although the application of nuclear emulsions is marginal in the mixed radiation field of a reactor and considered tedious to an extreme, we have resorted to this technique. In the past year, desire for fast neutron spectral measurements has overridden reluctance to enter the nuclear plate business.

The technique, or more appropriately, the art of using nuclear emulsions has been highly developed in recent years, particularly by Louis Rosen at Los Alamos. We are indebted to him for his extremely useful counsel on various processing and reading techniques.

PROCEDURE

Ilford type E-2 emulsions (200 microns thick) were used in a collimated geometry to obtain direct-beam fast neutron spectra for two shield configurations of the Aircraft Shield Test Reactor; minimum side water shielding (Configuration 3) and maximum side water shielding (Configuration 5). During the exposures the reactor was mounted in the Nuclear Test Aircraft. Exposures were made at 105° to the forward centerline. Plates for determining background were placed in the collimator adjacent to the exposed plates, but out of the direct neutron beam. From 1.0 to 1.5 tracks per field of view ($100\mu \times 100\mu$ grid) were obtained for the exposures of 1×10^8 neutrons/cm², which required about an hour. An acceptance angle of $+17^\circ$ was used. Conventional corrections for solid angle, emulsion thickness, and variation in n-p cross sections were applied to the data.

A total of 1300 tracks were recorded from the first exposed plate and compared to the distribution for the first 500 tracks. Since the shape did not significantly vary, only 700 tracks were read from the exposure for the second configuration. The statistics in each energy interval vary from 10 to 25 percent (Fig. 1).

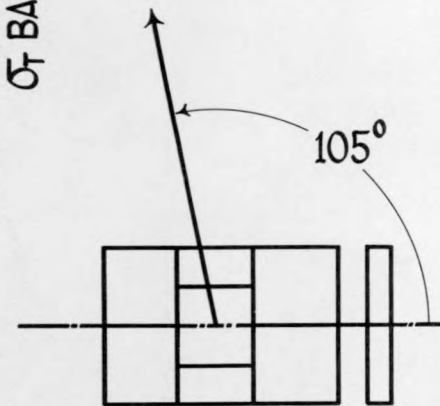
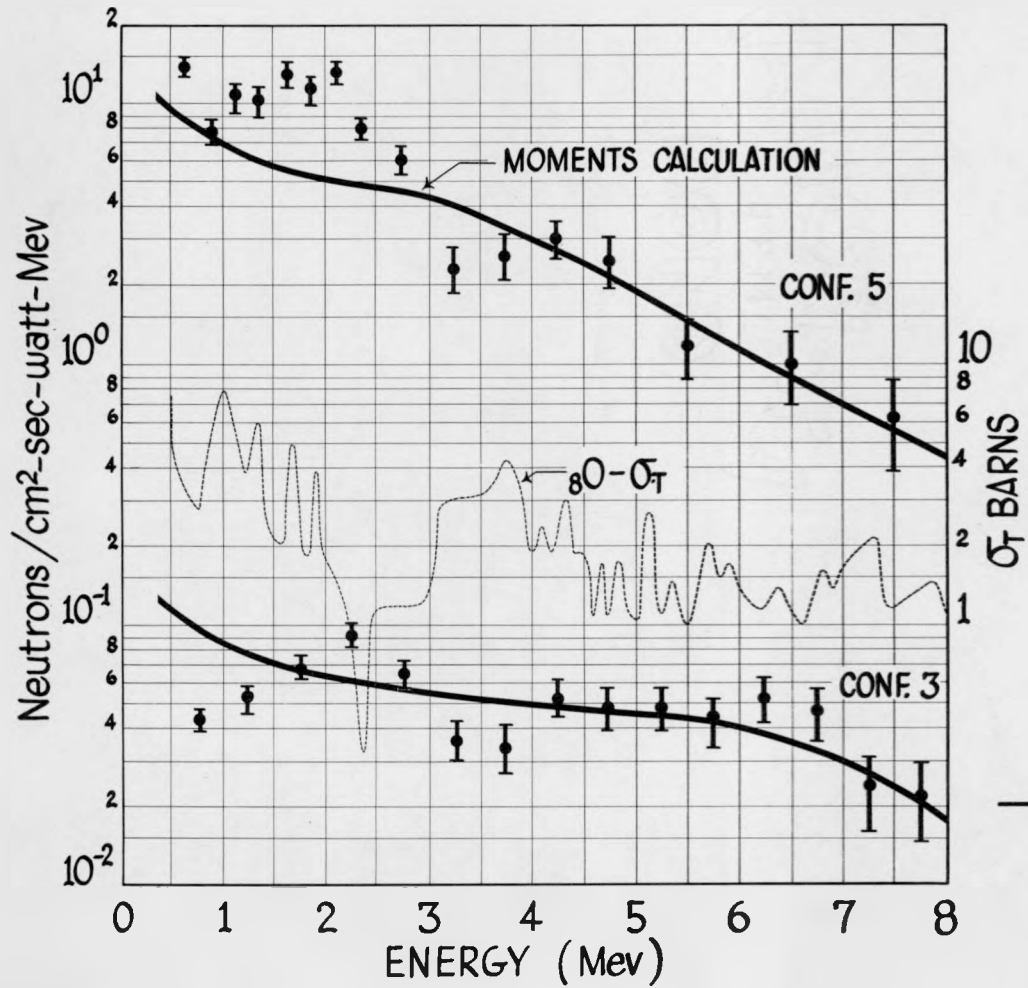
RESULTS

The two spectra are shown in Figure 1. The solid lines are the neutron spectra calculated by the Moments Method for each of the two reactor configurations. The "Moments" spectra agree rather well with the measured results. Configuration 5 is characterized by water and lead shielding on the side of the reactor; Configuration 3 by an additional 14 inches of water. Hence, a comparison of the measurements with the total neutron cross section for oxygen yields qualitative explanations for the prominent peaks and dips displayed in both spectra. The oxygen total cross section is shown on the figure as given in Supplement 1 of BNL-325.

A cursory comparison was also made with the Cochran-Henry spectra (Ref. 1). The comparison is favorable; the present results have somewhat better resolution than the previous spectrometer results. Still another comparison of immediate interest can be made. All neutron scattering and penetration calculations have been based on an effective neutron energy obtained by averaging the energy against the BSF spectrum (Ref. 1) times the total cross section for air and the flux-to-dose conversion. The familiar effective energy of 3.25 Mev results from this calculation. Accordingly, the present results have been used to complete the effective neutron energy; 2.5 Mev was obtained for the soft spectrum of Configuration 5 and about 3.9 Mev for the harder spectrum of Configuration 3. These values are based on the modified single collision dose (Ref. 2). Somewhat smaller values (2.2 and 3.6 Mev) are obtained if the calculation is based on the multiple collision dose (Ref. 3).

Since the neutron scattering cross sections for air are not strong functions of energy, these new values should not significantly alter scattered dose rate predictions for an unshielded detector. However, calculations for a shielded detector will be affected, and these new effective energies provide a basis for new estimates.

ASTR FAST NEUTRON SPECTRA



3

Additional exposures were made to obtain the angular distribution at the shield surface; these plates were successful exposures, but have not yet been read.

The results obtained thus far indicate that the use of emulsions for reactor direct-beam fast neutron spectra is feasible; therefore, further measurements are in order.

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