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IRON-FILTERED NEUTRON BEAMS-A NEW APPROACH TO PRECISION TIME-OF-FLIGHT CROSS SECTION MEASUREMENTS

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By placing thick filters in a white-source time-of-flight neutron beam, it is possible to obtain a low-background transmitted beam of bands of neutrons with energies corresponding to thecross section minima in the filter. Iron filters varying in thickness from 2" to 20" were placed in the 25 m spectrometer of the RPI LINAC: for filters 6" and thicker, over ten distinct neutron energy bands were observed below 1 MeV. In particular the band at 24.3 keV is ~2 keV wide and is separated by more than 45 keV from the next nearest energy band. In the upper half of figure 1 are plotted the relative neutron intensities near 24 keV for neutrons filtered by 2", 8", 14" and 20" of 'pure' Armco iron. A ^{10}B-NaI detector was used for this measurement. For the thicker filters the peak counting rate is about 500 times greater than background (as measured in the wings), and this small background can readily be determined, permitting high accuracy cross section measurements near 24 keV. Measurements using this technique have already been reported[1] for the total cross section of iron near the resonance-interference minima.

For capture cross section measurements 8" of iron was used for the filter and a 1.25-m liquid scintillator was used to detect neutron captures. These results are plotted in the lower half of figure 1 for two relatively short runs on the LINAC with samples of depleted U and Ta. The high peak-to-background

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ratios of 46:1 for Ta and 9:1 for U provide an ideal low-background environment for capture measurements with a minimum of time-dependent background effects (caused by neutrons scattered into the scintillator).

A preliminary filtered-beam capture measurement was carried out for the following samples: 0.020" Au, 0.020" In, 0.020" Ta and 0.030" depleted U (99.8% ^{238}U and 0.2% ^{235}U). The capture detection efficiency was obtained by measuring the capture pulse-height spectra and by extrapolating to zero bias. The ratios of the measured capture cross sections near 24 keV were determined to be

$$\sigma(U) : \sigma(Au) : \sigma(In) : \sigma(Ta) = (0.54) : (0.68) : (0.96) : (1{:}00).$$

These ratios have not yet been corrected for multiple scattering, resonance self-shielding or gamma ray escape; an overall uncertainty of about $\pm$ 8% is estimated for each number.

This technique provides us with an accurate effective cross section measurement over a narrow energy interval. These data can then be used to normalize the data from continuous cross section measurements. Since this filtered beam data is for a narrow but finite energy range, in order to obtain maximum accuracy, one must take into account the fluctuations from average in the cross section ($\pm$5% for ^{238}U) resulting from a limited number of resonances sampled in this interval. Thus the filtered-beam method must be complemented by high-resolution, white-source TOF measurements to pin down these fluctuations caused by nuclear statistics.

1. Block, Alfieri, and Turinsky, Differential and Area Analysis of Iron Total Cross Section (accepted for presentation at the Amer. Nucl. Soc. Las Vegas Meeting, June 1972).

FIGURE CAPTION

In the upper half of this figure are plotted the ^{10}B-NaI neutron counting rate vs. neutron time of flight for a pulsed neutron beam passing through 2", 8", 14" and 20" of iron. The peak transmission through each filter is shown in parentheses. In the lower half of this figure are plotted the capture counting rate vs. neutron time of flight for capture in depleted U and Ta samples. Both sets of data were obtained with the LINAC operating at 500 pps and with pulse widths of 50 and 500 nsec respectively for the transmission and capture measurements.

Figure 1

RELATIVE NEUTRON INTENSITY FOR 2", 8", 14", AND 20" IRON FILTERS