NOV 13 1963

CONF-327-3

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Total Neutron Average Cross Sections in the keV Region
and the Optical Model*

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Many workers have recently attempted to evaluate the P-wave strength function from a measurement of average capture cross sections or average total cross sections in the kiloelectron volt region. The primary interest of these measurements has been to determine the strength of the spin-orbit potential in the optical model. In view of the interest in determining the size of the spin-orbit coupling and in view of the considerable disagreement in the previously published P-wave strength functions, the Brookhaven group has undertaken to measure the average total neutron cross sections from 10 to 100 keV in the region of the P-wave giant resonance. The following elements were studied: Nb, Mo, Rh, Ag, Cd, and In. The work was carried out at the BNL-AECL fast chopper facility at Chalk River,

* Work supported by the United States Atomic Energy Commission.

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using an 88-meter flight path and a nominal resolution of 15 nsec/meter.

Preliminary studies of the fast neutron leakage through the rotor indicated that meaningful cross sections can be obtained up to 150 keV; above that energy background corrections become impractically large.

The average transmission obtained in these experiments must be corrected for sample thickness effects in order to obtain average cross sections; the sample thicknesses were chosen so as to limit these corrections to a few percent over the energy range considered, except in the case of Mo, where the larger neutron widths necessitated correction factors of up to 8%. The approach in the analysis we have used differs somewhat from conventional strength function analyses. We have attempted to fit our data to cross sections calculated directly from optical model computer programs; in particular, we have used the "Abacus" code due to Auerbach. With this procedure one can obtain fits to a particular element; within the accuracy of our measurements, however, it is not possible to obtain a unique fit. We, therefore, further demand that the same set of optical model parameters fit all the six elements in the group we have run. We have compared our data to the spherical optical model of the surface absorption type, using a derivative type of surface absorption:

$$\frac{4W \exp(r-R)/b}{(1 + \exp(\frac{r-R}{b}))^2}$$

Figure 1 shows several fits for the six elements considered. In these fits, we have fixed the nuclear diffuseness parameter a at 0.52 F,

the width parameter b in the imaginary potential at 0.40 F, and the radius parameter r_0 at 1.25 F. The real part of the potential, V_0 , was varied from 50 to 55 MeV, the imaginary part, W , from 6 to 9 MeV, and the spin-orbit part, V_{so} , from 8 to 16 MeV. The brackets in the figure list the values of V_0 , W , and V_{so} , respectively, followed by the deduced P-wave and S-wave strength functions as calculated by extrapolating the curves to 1.0 keV. The set of V_0 , W , and V_{so} , which gives the best over-all fit to the six elements is $V_0 = 51.5$ MeV, $W = 7$ MeV, and $V_{so} = 8$ MeV. The disagreements in the worst cases, Ag, Cd, and In, are about 10%, which is perhaps not unreasonable considering that the same parameters were used in fitting all elements. An examination of these fits suggests that better agreement might be obtained by using different potential parameters to calculate the S-wave and P-wave compound nucleus cross sections. A similar conclusion has been advanced by Krueger and Margolis. The large W required by these fits seems to rule out any possibility in observing a splitting of the 3P giant resonance by the spin-orbit coupling term.

Fig. 1