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Cross Section Program at ORNL, August 1, 1961 - Nov. 15, 1961

J. A. Harvey and H. B. Willard

ABSTRACT

This memo reviews the cross section program at ORNL for the period August 1, 1961 through November 15, 1961.

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1. High Resolution Total Cross-Section Measurements on W^{184} --- F. A. Khan (Visiting Investigator from AEC, Pakistan), W. J. Gavin (ORINS Summer Student Trainee), and J. A. Harvey

The following is an abstract of a paper presented at the Chicago Meeting of the American Physical Society, November 24-25, 1961:

The ORNL fast chopper and associated equipment were utilized in measuring the transmissions of a sample of normal W and a sample enriched in W^{184} (95%) from 100 to 2000 ev with a resolution of 10 nanoseconds per meter using the 180 meter flight path. Data were analyzed on an IBM 7090 computer using an area analysis program (S. E. Atta and J. A. Harvey, to be published) which computes the reduced neutron widths for the resonances for assumed total widths. Effects of resolution and Doppler broadening on the line shape were taken into account in computing transmissions which are compared with the experimental transmissions. Resonance parameters, the strength function and the capture resonance integral of W^{184} will be obtained from the data.

2. Parameters of Neutron Resonances in Pa^{231} --- J. R. Patterson (Research Participant from Clemson College; now at Rockford College) and J. A. Harvey

The following is an abstract submitted for presentation at the New York Meeting of the American Physical Society, January 24-27, 1962:

Transmission measurements on a 50-gram sample of Pa^{231} (3.4×10^4 year half-life) have been made using the ORNL fast chopper time-of-flight spectrometers. Measurements were made from 0.04 to 50 ev with the 45-meter flight path spectrometer with an energy resolution of $\sim 1.5\%$. Using the 180-meter flight path spectrometer with an energy resolution of 0.2%, the data were extended to 200 ev. The data have been analyzed to give parameters of the resonances using programs written for the IBM-7090 which include resolution and Doppler broadening. The shape analysis program has been used for the first eight resonances up to 3.5 ev. The radiation widths of these resonances vary from $(38 \pm 2) \times 10^{-3}$ to $(47 \pm 2) \times 10^{-3}$ ev. The area analysis program has been used to obtain neutron widths of the resonances up to 75 ev. The s-wave strength function computed from these resonances is $(0.8 \pm 0.2) \times 10^{-4}$ and the average level spacing per spin state for the resonances up to 25 ev is 1.0 ± 0.2 ev.

3. Fast Chopper Transmission Measurements on Sn Isotopes --- Faruq A. Khan (Visiting Investigator from AEC, Pakistan) and J. A. Harvey

High resolution (10 nsec/m) transmission measurements have been made



on the tin isotopes 116, 118, and 120 and ~ 10 resonances have been found in each isotope up to ~ 2 kev. Similar measurements will also be made on the other isotopes as soon as they are transferred to the cross section pool.

4. Shape and Area Analysis of Low Energy Neutron Resonances Using an IBM-7090 Computer ----- J. A. Harvey and S. E. Atta

A detailed report on this work has been written and is in process of publication as an ORNL report.

5. Average Resonance Parameters for Nuclei Near $A = 100$ ---- A. K. Furr (Duke University), R. H. Rohrer, and H. W. Newson (Duke University)

The following is an abstract submitted for presentation at the New York Meeting of the American Physical Society, January 24-27, 1962:

Activation experiments have been carried out for Zr^{96} , Mo^{98} , Mo^{100} , Rh^{103} , Ag^{107} , Ag^{109} , In^{115} , I^{127} , and Au^{197} using a beam of pile neutrons filtered by B^{10} absorbers of varying thicknesses. The shapes of the activation curves as a function of the thickness of the B^{10} filters, corrected for the contribution of neutrons with energies greater than 100 kev, have been analyzed for average parameters. Average s- and p-wave γ -ray strength functions $\langle \Gamma_{\gamma}/D_0 \rangle_l$ and neutron strength functions $\langle \Gamma_n^l/D_0 \rangle$ have been obtained using known thermal activation cross sections and the resonant integral of I^{127} to normalize the data. Neutron capture cross sections for neutron energies up to 200 kev have been computed from the above average resonance parameters which are generally in good agreement with the shapes of the previously reported experimental cross sections measured as a function of energy by activation techniques (L. W. Weston, K. K. Seth, E. G. Bilpuch, and H. W. Newson, *Annals of Physics* 10, 477 (1960)). The p-wave neutron strength functions $\langle \Gamma_n^1/D_0 \rangle$ derived from the analysis of our activation curves confirm the indication (L. W. Weston et al, *Annals of Physics* 10, 477 (1960) and K. K. Seth, R. H. Tobony, L. W. Weston, and H. W. Newson, *Bull. Am. Phys. Soc. (II)*, 6, 252 (1961)) that the p-wave giant resonances, predicted near $A = 100$ by the simple optical model, is split into a $P_{3/2}$, $P_{1/2}$ doublet by a strong spin orbit coupling potential.

6. Measurement of $\alpha = \frac{\sigma_c}{\sigma_f}$ as a Function of Neutron Energy ---- G. DeSaussure and L. W. Weston

This experiment is still in a very preliminary stage and no result has yet been obtained.

A fission chamber has been constructed, containing about 4.5 g of U^{235} . This chamber is placed in the center of the 1.2-m diameter liquid scintillator

tank constructed by R. L. Macklin. The chamber is bombarded by pulsed 30-keV neutrons produced at the 3-Mv Van de Graaff by the p,n reaction on Li at threshold. The ratio of the scintillator pulse-height spectrum in anti-coincidence with the fission chamber to that in coincidence with the fission chamber will provide a value of α for U^{235} at 30 keV. The corrections to this measurement are still being evaluated.

Similar measurements will be performed at 65 keV using the p,n reaction on T, just above threshold, and eventually using the neutrons below 20 keV of the RPI Linac.

Measurements on α for U^{233} and for Pu^{239} will be made using the Diven technique and determining the neutron energy by time-of-flight at the 3-Mv Van de Graaff. It is hoped that the neutron energy covered will be from 10 keV to 500 keV.

7. Activation Cross Section of Gold with 30 keV Neutrons ---- J. H. Neiler
and H. W. Schmitt

A series of gold activation measurements using 30 keV neutrons from the $Li^7(p,n)Be^7$ reaction at threshold is in progress. The purpose of these measurements is to investigate the possibility that room-scattered neutrons affect gold activation measurements. Various geometries and arrangements are being tried.

8. Neutron Cross Section of Pb^{208} ---- J. L. Folwer and Mary Jo Mader

Since the measurements of the total neutron cross section of Pb^{208} have shown a $J = 7/2$ level at 1.75 MeV (J. L. Fowler and E. C. Campbell, Bull. Am. Phys. Soc. 6, 251 (1961)), calculations have been performed to check whether this level is associated with the $g_{7/2}$ member of the 2g doublet split by spin orbit coupling; the other member of this doublet being the $2g_{9/2}$ ground state of Pb^{209} .

The Wood-Saxon form of the phenomenological potential with the diffuseness parameter (6.7 fermis) used by Blomqvist and Wahlborn (Arkiv. fur Fysik 16, 545 (1959)) was adjusted to give the $4s_{1/2}$ state and the $s_{1/2}$ phase shift. With the Thomas form of spin orbit coupling, one finds that a single particle $2g_{7/2}$ level at 1.75 MeV neutron energy would have a width of approximately 100 keV which is about 10 times the observed width of the 1.75 MeV level.

9. A Nonlocal Potential Model for the Scattering of Neutrons by Nuclei ----
F. G. Perey and B. Buck

An energy independent nonlocal optical potential for the scattering of neutrons from nuclei has been solved numerically, on the IBM-7090, in its full integro-differential form. The most successful attempt at fitting the neutron data between 4 and 15 MeV with a local optical model is the work of Bjorklund

and Fernbach. The fixed nonlocal model in this energy range gives as good a fit to the data as the energy dependent model. The fact that the parameters are neither A or E dependent enables one to fill the gaps in the experimental data if such need arises.

Below 4 Mev the compound elastic scattering contributions can be added, when the nonelastic total cross sections have been measured experimentally, and then the agreement with the data is good down to the regions of large resonances (at 1 to 2 Mev for most nuclei).

We will gladly consider providing theoretical cross sections in the range of 2 to 15 Mev to interested persons.

10. The Reactions $\text{Li}^7(\text{He}^3, n)\text{B}^9$ and $\text{Be}^9(\text{He}^3, n)\text{C}^{11}$ --- J. L. Duggan and M. M. Duncan (The University of Georgia), P. D. Miller, and R. F. Gabbard (ORINS Summer Research Participant from the University of Kentucky)

The following is an abstract submitted for presentation at the New York Meeting of the American Physical Society, January 24-27, 1962:

Distorted wave calculations have been made to fit previously reported measurements of the above reactions (P. D. Miller, J. L. Duggan and R. F. Gabbard, Bull. Am. Phys. Soc. 6, 60 (1961)). The IBM distorted wave code of Satchler et al (Bull. Am. Phys. Soc. 6, 66 (1961)) has been used. For the reaction $\text{Be}^9(\text{He}^3, n)\text{C}^{11}$ neutron angular distributions have been calculated at $E_{\text{He}^3} = 2.1$ Mev for the 1.99, 4.26, and 6.50 Mev states of C^{11} and tentative assignments of $(1/2^- \rightarrow 7/2^-)$, $(1/2^- \rightarrow 7/2^-)$ and $(3/2^-)$ have been made for these states. Excitation functions for these states have been calculated using the optical model parameters which fit the angular distributions. For the reaction $\text{Li}^7(\text{He}^3, n)\text{B}^9$ an angular distribution for the ground state neutron group has been calculated at $E_{\text{He}^3} = 2.1$ Mev and a tentative assignment of $(1/2^- \rightarrow 7/2^-)$ has been made. In addition a phase space analysis of the continuum neutrons for this reaction which are present for all neutron energies below that of the ground state has been attempted.

11. The $\text{C}^{13}(\text{He}^3, n)\text{O}^{15}$ Reaction ----- R. F. Gabbard (ORINS Summer Research Participant from the University of Kentucky) P. D. Miller, and J. L. Duggan (The University of Georgia)

A paper on this subject was presented at the Chicago Meeting of the American Physical Society, November 24-25, 1961.

12. The Reaction $\text{O}^{18}(\alpha, n)\text{Ne}^{21}$ ----- J. K. Bair and H. B. Willard

A paper on this subject was presented at the Chicago Meeting of the American Physical Society, November 24-25, 1961.

13. The $\text{Si}^{28}(\alpha,\alpha)\text{Si}^{28}$ Reaction ----- H. B. Willard and J. K. Bair

An abstract on this subject has been submitted for presentation at New York Meeting of the American Physical Society, January 24-27, 1962.

14. Coulomb Excitation of Osmium and Chromium Nuclei --- F. K. McGowan,
P. H. Stelson and R. L. Robinson

A paper on this subject was presented at the Conference on Electromagnetic Lifetimes and Properties of Nuclei, Gatlinburg, Tennessee, October 5-7, 1961.

15. Improvement in Pulse Shape Discrimination Using Multi-Alkali Cathode Photomultipliers ---- V. A. Pethe (Atomic Energy Establishment, Bombay, India) and J. H. Neiler

The following is an abstract submitted for presentation at the New York Meeting of the American Physical Society, January 24-27, 1962:

The "resolution" of the Brooks pulse shape discrimination circuit (F. D. Brooks, Nuclear Instr. and Methods 4, 151 (1959)) has been measured for two phototubes which were essentially identical in all respects except photocathode response. One tube was a standard RCA 7264 with S-11 response, the other was a developmental type RCA C-7273 with a multi-alkali photocathode having S-20 response. Appreciably better pulse shape discrimination at low energies was obtained with the tube having S-20 response. Measurements were made of the emission spectra of stilbene and anthracene using a grating monochromator and the C-7273 as detector. Relative spectra, uncorrected for monochromator and detector responses, were obtained for 2 mm thick crystals under bombardment by alphas and gamma rays. The emission spectra of both stilbene and anthracene show differences for alpha relative to gamma irradiation. The effect, which is an increase in the emission in both the ultra-violet and red region compared with that at the peak of the emission spectrum, is more pronounced with stilbene than with anthracene.

16. Large Liquid Scintillator Pulse Shape Calculations --- R. L. Macklin

Monte Carlo codes for calculating pulse height distributions in gamma-ray scintillation counters have been reported by C. D. Zerby and H. S. Moran of ORNL. These have been used for a mockup of the 1.2 meter liquid scintillator used in pulsed Van de Graaff neutron capture studies (J. H. Gibbons, et al, Phys. Rev. 122, 182 (1961)). A new Monte Carlo code has been used to combine the single gamma energy results into capture cascades using a constant nuclear temperature model. Total escape ranges up to about twelve per cent, depending chiefly on average multiplicity. The case of favored transitions to discrete excited states or to the ground state, as found in studies of gamma ray dis-

tribution following thermal neutron capture, has also been investigated.

The calculated pulse height distributions for a range of binding energies and multiplicities show very good agreement with the spectrum fractions found empirically (same reference as above). The estimation of spectrum fractions by extrapolation to zero pulse height had been one of the chief uncertainties in the reported cross sections.

17. Pulse Shape Discrimination of Li^6 -Loaded Glass Scintillators -- G. G. Slaughter, F. W. K. Firk (Visiting Investigator from AERE, Harwell, England), and R. J. Ginther (Naval Research Laboratory)

Bollinger and Thomas have shown (R.S.I. 32, 1044) that lithium and boron loaded glasses exhibit decay curves which differ for gamma ray and neutron (n, α) excitation. Since the ratio of scintillation intensity in the initial peak to the total intensity of a boron loaded glass was found to be essentially the same for neutron and gamma ray excitation, they concluded that the effect was too small for gamma ray discrimination to be possible in boron loaded glasses. At ORNL the ratio of peak to total scintillation intensity was investigated for several lithium-loaded glasses of varying compositions, including a glass which Ginther supplied which had some decay components which were quite long. However, none of the samples showed a large enough difference between the gamma ray and neutron loci (two dimensional plot of peak intensity versus total intensity) to indicate that pulse shape discrimination was possible.

18. A Source of Polarized Ions ---

J. E. Sherwood

A paper has been submitted for publication in Nuclear Instruments and Methods. The abstract is as follows:

A preliminary model of a source of polarized ions has been built in order to evaluate the feasibility and limitations of such an apparatus as an accelerator source. A current of 10^{-4} μa of polarized deuterons has been produced and the alignment demonstrated by observation of anisotropic neutron yield from the $\text{T}(d,n)\text{He}^4$ reaction. Experimental problems are discussed.

19. Tandem Van de Graaff ---

C. D. Moak

The ORNL Tandem accelerator began arriving in late July, 1961. Accelerated beam was first achieved on October 1. Voltage conditioning has been carried out to 5.5 Mv and beams have been accelerated for short periods up to 10.6-Mev energy. The machine is now in its shake-down phase, with large numbers of small faults being found and corrected. It is expected that acceptance tests should be finished sometime in December. Some research on a limited basis may begin as early as December 15.

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