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REPORT TO THE DOE NUCLEAR DATA COMMITTEE
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A. NUCLEAR DATA APPLICATIONS-MEASUREMENTS

1. Measurement of the ${}^6,{}^7\text{Li}(n,{}^4\text{He})$ Cross Sections at $E_n = 14$ MeV (Goldberg, Haight, Kneff*)

Helium production by neutron bombardment of materials is of interest in the design of fusion reactors. Lithium, in various chemical forms, is proposed as a blanket material for nearly all fusion reactors based on the D-T fuel cycle. Further, the tritium breeding reactions on the lithium isotopes are major contributors to the total helium production. Investigation of the helium production may therefore shed light on the tritium production mechanism.

We have measured the helium produced when isotopic samples of lithium are bombarded with 15-MeV neutrons. The neutrons were produced with a rotating target neutron source (RTNS-I). After irradiation the ${}^4\text{He}$ was determined by isotopic dilution mass spectrometry. Preliminary values of the cross sections are 515 mb for the ${}^7\text{Li}(n,{}^4\text{He})$ reaction and 334 mb for the ${}^6\text{Li}(n,{}^4\text{He})$ reaction with uncertainties of about 5%.

2. Neutron Elastic and Inelastic Scattering from Carbon Near 14 MeV (Haight, Hansen, Wong, and Pohl)

Recent measurements^{1,2} have suggested that the ${}^{12}\text{C}(n,n'\alpha)$ reaction cross section and the kerma factor for carbon depend strongly on the incident neutron energy near 14 MeV. Because the total cross section does not vary strongly at these energies, significant variations should be observable in the elastic or the discrete inelastic scattering cross sections as functions of energy.

We have therefore measured the elastic and discrete inelastic cross sections for neutrons on carbon at five energies between 13.5 and 14.6 MeV. Both the angle-integrated cross sections and the shapes of the angular distributions are observed to change with incident neutron energy. Preliminary data indicate a rapid and irregular rise of the ${}^{12}\text{C}(n,n'\alpha)$ cross section in this energy region.

* Rockwell International, Canoga Park, CA 91304.

¹ R. C. Haight, S. M. Grimes, R. G. Johnson, and H. H. Barschall, Nuclear Science and Engineering (in press).

² P. M. DeLuca, Jr., H. H. Barschall, R. C. Haight, and J. C. McDonald (to be published.).

3. Neutron Capture Cross Sections for ^{46}Ca and ^{48}Ca at Stellar Temperatures (Mathews, Käppeler*)

Stellar neutron capture cross sections have been measured for the heavy calcium isotopes by neutron activation using a spectrum of neutrons from the $^7\text{Li}(p,n)^7\text{Be}$ reaction which closely approximates a $kT = 25$ keV Maxwellian distribution. Corrections for geometry and sample scattering were checked by measuring with various sample thicknesses and extrapolating to zero thickness. The preliminary cross sections, normalized to the $kT = 25$ keV-averaged ENDF-B/V ^{197}Au capture cross section, are 6.4 ± 0.5 mb for ^{46}Ca and 1.9 ± 0.5 mb for ^{48}Ca . The measured cross sections indicate that it is not possible to account for the nucleosynthetic origin of ^{46}Ca and ^{48}Ca in a simple equilibrium neutron capture environment without subsequent selective depletion of ^{46}Ca .

4. Revised Neutron Capture Cross Sections for $^{142},^{143},^{144}\text{Nd}$ (Mathews, Käppeler*)

The neutron capture cross sections for Nd isotopes we reported in last year's report to the Nuclear Data Committee have been revised after it was discovered that hydrogenation of the samples introduced a significant background correction. The new $kT = 30$ keV cross sections (averaged over the energy region 6 to 200 keV) are 51 ± 4 mb for ^{142}Nd , 258 ± 11 mb for ^{143}Nd , and 123 ± 6 mb for ^{144}Nd . These cross sections have been fit with a power law to extrapolate to other energies and for applications at other temperatures:

$$\begin{aligned}\langle\sigma\rangle &= 49(E/30)^{-0.664} & ^{142}\text{Nd} \\ \langle\sigma\rangle &= 259(E/30)^{-0.675} & ^{143}\text{Nd} \\ \langle\sigma\rangle &= 118(E/30)^{-0.694} & ^{144}\text{Nd}\end{aligned}$$

where $\langle\sigma\rangle$ is in mb and E in keV.

The new ^{142}Nd cross section is consistent with other s-process only isotopes, and indicates that there is no peculiarity in the s-process in this region as previously discussed.

5. Fragment Angular Distribution for Neutron Fission of ^{232}Th (Becker, Bauer)

The $^{232}\text{Th}(n,f)$ fission fragment angular distributions have been measured for incident energies from 0.7 to 10 MeV using the white source of neutrons produced at the 100-MeV LLNL Electron Linear Accelerator Facility

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and a recently developed multi-wire counter to detect the fission fragments. Time-of-flight techniques were used with a resolution of ≈ 90 ps/m. Thick thorium foils were mounted parallel to the multi-wire planes and at 30 degrees to the neutron beam direction. Fragments from thermal fission of ^{235}U were used as an isotropy reference. The ^{232}Th fragment angular distributions obtained with this arrangement were parameterized by the Legendre polynomial expansion $W(\theta) = 1 + A_2P_2(\cos\theta) + A_4P_4(\cos\theta)$. Resulting coefficients for 40-keV neutron energy bins within the incident neutron energy interval $0.72 \leq E_n(\text{MeV}) \leq 3.04$ are illustrated in Fig. A-1.

Fig. A-1. Legendre polynomial expansion coefficients for the fission fragment angular distribution produced in the $^{232}\text{Th}(n,f)$ reaction. The neutron energy bin width is 40 keV.

6. Neutron Differential Scattering Measurements in the Actinide Region (Hansen, Pohl, Wong, Haight)

Elastic and inelastic (unresolved) differential cross sections have been measured for neutrons scattered from ^{232}Th , ^{238}U and ^{239}Pu

at 14.1 MeV. The measurements cover the angular range from 9.2° to 159° . They are part of a program at LLNL to measure neutron scattering cross sections in the energy region from 14 to 30 MeV. These measurements are of interest to the fusion-fission reactor program and are intended to supply data in a region of the periodic table where differential scattering measurements at energies $E > 10$ MeV are scarce.

Since these nuclei are characterized by large and permanent quadrupole (β_2) and hexadecapole (β_4) nuclear deformations, the analysis of the data was done using the Tamura coupled-channel (CC) formalism. For ^{232}Th and ^{238}U , the ground state and the low-lying 2^+ , 4^+ , and 6^+ levels were included in the CC calculations. For ^{239}Pu , in addition to the g.s., the $3/2^+$, $5/2^+$ and $7/2^+$ levels were also included. Very good agreement with the measured angular distributions was obtained using the optical model parameters and deformation parameters β_2 , β_4 of Klepatskij *et al.*³ Their global set had been optimized for the actinide region in the energy interval 0.1-15 MeV, and in the present calculations no change in these parameters was required to fit the data. Since our measurements do not resolve the elastically scattered neutrons from those inelastically scattered from the low-lying excited levels ($E_{\text{ex}} < 200$ keV), the data were compared with the sum of the calculated differential cross sections for the g.s. and inelastic levels included in the CC calculations. It is interesting to note that although the sum of the integrated inelastic cross sections is less than 10% of the total elastic cross section, the calculated inelastic differential cross sections are comparable to the elastic differential cross sections beyond 80° . We find good agreement between the calculations and measurements for the elastic-plus-inelastic angular distributions.

7. Nuclear Structure of ^{244}Am Investigated with the (n,γ) Reaction
(von Egidy,* Hoff, Loughheed, White, Börner,** Schreckenbach,** Warner,** Barreau,** and Hungerford*)

Secondary gamma rays and conversion electrons following the $^{243}\text{Am}(n,\gamma)^{244}\text{Am}$ reaction have been studied with crystal spectrometers and an electron spectrometer, respectively, at the Institut Laue-Langevin at Grenoble. Primary gamma rays following thermal neutron capture in ^{243}Am have also been measured. A level scheme for ^{244}Am has been constructed containing 67 excited levels. The levels are interpreted in terms of coupled proton and neutron Nilsson configurations. The results are found to be in good agreement with a semiempirical model in which excitation energies in odd-odd nuclei are calculated from those in adjacent nuclei (see Table A-1).

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** Institut Laue-Langevin, 38042 Grenoble, France.

³ A. B. Klepatskij, V. A. Kon'shin, and E. Sh. Sukhovitskij, INDC (CCP)-161/L, 9 (1981).

TABLE A-1. Comparison of experimental and predicted band head energies and rotational parameters for ^{244}Am .

Configuration	Band head energy (keV)		Rotational parameter A (keV)	
	E(model)	E(exp.)	A(model)	A(exp.)
$1^+ \{5/2^+ 1642 \uparrow 1 - 7/2^+ 1624 \uparrow 1\}$	60	85	3.0	3.4
$1^- \{5/2^- 1523 \uparrow 1 - 7/2^+ 1624 \uparrow 1\}$	161	173	5.4	5.3
$2^- \{3/2^- 1521 \uparrow 1 - 7/2^+ 1624 \uparrow 1\}$	235	259	5.8	5.8
$0^- \{5/2^- 1523 \uparrow 1 - 5/2^+ 1622 \uparrow 1\}$	319 (1^-)	286 (1^-)	5.4	5.3
$3^+ \{1/2^+ 1400 \uparrow 1 - 7/2^+ 1624 \uparrow 1\}$	(336)	345	(5.4)	5.2
$0^+ \{7/2^+ 1633 \uparrow 1 - 7/2^+ 1624 \uparrow 1\}$	362	374	6.9	(6.0)
$2^+ \{5/2^+ 1642 \uparrow 1 - 1/2^+ 1631 \uparrow 1\}$	451	(416)	3.1	(2.7)
$2^+ \{5/2^- 1523 \uparrow 1 - 9/2^- 1734 \uparrow 1\}$	426	417	4.2	4.1
$3^- \{5/2^- 1523 \uparrow 1 - 1/2^+ 1631 \uparrow 1\}$	442	418	5.7	5.6
$0^+ \{5/2^+ 1642 \uparrow 1 - 5/2^+ 1622 \uparrow 1\}$	463 (2^+)	(475) (2^+)	3.0	--
$2^- \{5/2^- 1523 \uparrow 1 - 1/2^+ 1631 \uparrow 1\}$	488	482	5.7	6.6
$2^- \{5/2^+ 1642 \uparrow 1 - 9/2^- 1734 \uparrow 1\}$	538	514	2.6	3.2
$2^+ \{3/2^+ 1651 \uparrow 1 - 7/2^+ 1624 \uparrow 1\}$	(395)	612	(6.2)	5.8
$1^+ \{5/2^- 1523 \uparrow 1 - 7/2^- 1743 \uparrow 1\}$	665	(668)		--
$1^- \{3/2^- 1521 \uparrow 1 - 5/2^+ 1622 \uparrow 1\}$	586		5.7	
	}	678	}	5.1
$1^- \{5/2^+ 1642 \uparrow 1 - 7/2^- 1743 \uparrow 1\}$	826		3.1	
Average deviations:	± 19 (for 9 bands)		$\pm 7\%$ (for 8 bands)	

8. Determination of the Conversion Coefficients of the M4 Transition in ^{193m}Ir (Gunnink, Lindner, Nagle, and Sisson)

An essentially massless source of ^{193m}Ir , free of radioactive contaminants except for a small amount of ^{192}Ir , was produced by thermal-neutron irradiation of ^{192}Os . The osmium was exhaustively removed and a carrier-free iridium fraction isolated. From this, sources were prepared for 4π β counting, for low-energy photon detection, and for conversion-electron energy and intensity determinations.

Absolute e^-/γ ratios were determined for the K-through-O shells. Because electron energies were determined with a windowless silicon diode, resolution could not equal that of a magnetic β spectrometer. We relied instead on the use of the GRPANL computer program⁴ and the good statistics of the large number of accumulated events for the analysis of our data. The measured ratios, as well as those calculated by Rösel, *et al.*⁵ are given in Table A-2.

TABLE A-2. ^{193m}Ir conversion coefficients.

Subshell	$\alpha(\text{obs}) \times 10^{-2}$	$\alpha(\text{calc})^a \times 10^{-2}$
K ^b	1.04 (-) ^c	1.03
L1	27.4 (3.0)	27.7
L2	5.5 (3.3)	4.9
L3	113.0 (3.0)	118.0
M1 (+ 1/2M2)	10.5 (3.3)	10.1
M3 (+1/2M2)	37.5 (3.1)	39.5
M4 + M5	3.1 (4.9)	3.4
N	13.4 (3.2)	14.0
O	1.9 (4.2)	2.2

^a Interpolated from tables of Ref. 5.

^b From K x-ray data only.

^c Values in parentheses are estimated % standard deviations.

⁴ R. Gunnink and W. D. Ruhter, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-52917 (1980).

⁵ F. Rösel, H. M. Fries, K. Alder, and H. C. Pauli, *At. Dat. & Nucl. Data Tables*, 21, Nos. 4 & 5, 292 (1978).

Most of the tabulated uncertainty resulted from the statistics of the measured $80.22 (\pm 0.02)$ keV unconverted γ transition. The discrepancy for the L2 coefficient appears to be real.

Because of the sample purity, we were able to follow the decay through many half-lives. We found a value of 10.53 ± 0.04 d, in good agreement with the value reported by Bayhurst, *et al.*⁶

9. Study of the Gamma-Ray and Conversion-Electron Decay of the ^{238}U Shape Isomer (Kantele,* Stöfl, Ussery,** Decman, Henry, Estep, Hoff, Struble, and Mann)

We have measured both the gamma-ray and conversion-electron transitions that follow the decay of the 200-ns ^{238}U shape isomer, the only fissioning shape isomer known to decay by these modes. The reaction used to populate the shape isomer was the ^{238}U (d,pn) reaction at a deuteron energy of 18 MeV. We observed for the first time an E0 conversion-electron transition following the decay of the isomeric state (see Fig. A-2). This E0 transition established experimentally that the ^{238}U shape isomer has a spin and parity of 0^+ . The production cross section of the 2512.7-keV E2 transition was determined to be $42 \pm 12 \mu\text{b}$. This cross section is less than half the only previous measurement of $90 \pm 23 \mu\text{b}$ by Russo *et al.*⁷ On the basis of the energy difference between the isomer energy, as determined by the E2 gamma ray into the 44.9-keV first-excited state and the E0 conversion-electron energies, the binding energy of the K-electrons is found to be 115.2 ± 2.1 keV. The binding energy of K-electrons in U is 115.6 keV, giving further confidence to assigning the observed transitions to ^{238}U . The total production cross section of the shape isomer is approximately 120 μb obtained by summing the cross sections of all decay branches, including unobserved gamma rays. Percent decay branches are shown in Fig. A-2. Because the production cross section of the ^{238}U ground state by the (d,pn) reaction is 150 to 250 mb,⁷ an isomer ratio of 2 to 12×10^{-4} is obtained.

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⁶ B. P. Bayhurst, J. S. Gilmore, R. J. Prestwood, J. B. Wilhelmy, N. Jarmie, B. H. Erkila, and R. A. Hardekopf, *Phys. Rev.*, C 12, 451 (1975).

⁷ P. A. Russo, J. Pedersen, and R. Vanderbosch, *Nucl. Phys.* A240, 13 (1975).

Fig. A-2. Decay scheme for ^{238}U -shape isomer.

10. Levels of ^{244}Cm Populated by the Beta Decay of 10-Hour ^{244}Am and 26-Minute $^{244\text{m}}\text{Am}$ (Hoff, von Egidy, Loughheed, White, Börner,* Schreckenbach,* Barreau,* and Warner**)

Gamma rays and conversion electrons were measured for the ^{244}Am beta decay isomers in a ^{243}Am target undergoing neutron capture in a high-flux reactor. New transitions accompanying beta decay of 26-min $^{244\text{m}}\text{Am}$ were observed. These include 984.92-keV and 977.80-keV E0 transitions assigned to the de-excitation of a first-excited 0^+ band in ^{244}Cm with level energies of 984.91 (0^+) and 1020.76 (2^+) keV. (See Fig. A-3). The ratio of reduced transition probabilities $B(E0)/B(E2)$ for this 0^+ level is 1.5 ± 0.2 .

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** Institut Laue-Langevin and Brookhaven National Laboratory, Upton, NY 11973.

Fig. A-3. Levels of ^{244}Cm from gamma transitions accompanying beta decay of ^{244}Am isomers. Transition intensities ($I_{\gamma} + I_{ce}$) per 100 neutron captures are listed following gamma-ray energies and multipolarities.

B. NUCLEAR DATA APPLICATIONS-CALCULATIONS

1. Tests of Microscopic Optical Models for Neutron and Proton Scattering on Light Nuclei in the Range 14-45 MeV (Dietrich, Back, Hansen, Pohl, Poppe, Wong, Petrovich,* Finlay,** Perler,** Konzett,*** Eversheim,*** Rioux,*** and Larimer***)

As part of an effort to evaluate systematically the ability of microscopic optical models to predict elastic neutron scattering, we have begun a series of measurements and calculations of elastic scattering of both neutrons and protons on light nuclei. Previously reported^{1,2,3} portions of this investigation have shown that calculations using microscopic optical potentials of both the Jeukenne-Lejeune-Mahaux (JLM)⁴ and Brieva-Rook⁵ form yield reasonable agreement with scattering data for medium and heavy nuclei if the real and imaginary parts of the optical potentials are normalized by factors that are smoothly varying with energy and target mass. These types of potentials are expected to be less reliable for the light nuclei, because of ambiguities in the application of the local density approximation, and because of exchange effects associated with nuclear recoil, which are not included in the simple folding-model treatment. Nevertheless, a study³ of 14.6-MeV neutron scattering on targets for $A > 9$ has shown that the JLM potentials reproduce the angular distributions well for target masses as low as ^{12}C ; the Brieva-Rook potentials are less successful in reproducing the shapes at back angles (>100 degrees).

To provide data for further tests of the microscopic models in light nuclei, we have measured polarized proton scattering from ^6Li and ^{14}C in the range 25-45 MeV at the LBL 88" cyclotron. Measurements with a polarized beam are useful because they are particularly sensitive to the recoil exchange effects. Elastic scattering angular distributions have also been measured for 24-MeV neutrons on ^{13}C at Ohio University, and are being

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** Ohio University, Athens, OH 45701.

*** Lawrence Berkeley Laboratory, Berkeley, CA 94720.

¹ F. S. Dietrich et al., Phys. Rev. Lett. 51, 1629 (1983).

² S. Mellema et al., Phys. Rev. C 28, 2267 (1983).

³ L. F. Hansen et al., LLNL report UCID-18987; to be submitted to Phys. Rev. C.

⁴ J. P. Jeukenne, A. Lejeune, and C. Mahaux, Phys. Rev. C 16, 80 (1977).

⁵ F. A. Brieva and J. R. Rook, Nucl. Phys. A 291, 299, 317 (1977).

analyzed together with data from the same laboratory on ^{12}C in the range 20-26 MeV.

Analysis completed up to the present time shows that the JLM potentials yield excellent reproduction of the ^{12}C and ^{13}C neutron scattering results. However, the same treatment yields very poor analyzing powers. The agreement for the analyzing powers is significantly improved by including a phenomenological ℓ -dependent term in the calculation, of a form suggested by calculations⁶ that explicitly include exchange effects neglected in the simple folding model.

2. A New Dynamic Model for Fission (Mustafa and Kumar*)

We developed a dynamic deformation model (DDM) for fission that combines a dynamic deformation model for nuclear structure with an appropriate choice of nucleus-nucleus force acting between nascent fission fragments.⁷ We used this dynamic model to calculate zero-point energy, inertial masses, fission barriers, and half-lives. The four main points of the model are outlined below:

1. The DDM has been successfully tested for the structural properties of spherical, transitional, and deformed nuclei from ^{12}C to ^{240}Pu [masses, E_2^+ , $B(E2)$, ...].⁸ The DDM uses the microscopic-macroscopic method of calculating the potential energy of deformation and the Bohr Hamiltonian method of calculating the energy of zero-point motion. The Cranking-Generator Coordinate method is used to calculate inertial masses.

2. We emphasize the choice of the nucleus-nucleus force between nascent fragments. The force was chosen so as to reproduce spontaneous fission half-lives of ^{240}Pu and $^{260}\text{104}$, which vary by 20 orders of magnitude over a small mass region. The very sensitive nature of fission half-lives gives us a handle on the fragment interaction force.

3. The energy of zero-point motion is a very critical quantity, along with inertial masses and asymptotic fragment interaction, in calculating fission half-lives. We find that the zero-point energy is not a constant for different types of nuclei, but varies appreciably from ^{208}Pb to ^{240}Pu to superheavy nuclei.

* Tennessee Technological Univ., Cookeville, TN 38501.

⁵ D. J. Stubea et al., Phys. Rev. C 17, 447 (1978).

⁷ K. Kumar and M. G. Mustafa, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-89694 (1983), submitted to Phys. Letters.

⁸ K. Kumar, Collective Bands in Nuclei, D. H. Wilkinson, ed., Pergamon Press, London (1982).

4. The spontaneous fission half-lives were calculated by first minimizing the two-dimensional action integral for each charge/mass split and then adding the contributions from each split.

The known fission half-lives have provided a very sensitive test of the model, and this should add confidence to the predictions for unknown regions.

3. The Necessity of Discrete-Level Modeling in Isomer Ratio Calculations for Neutron-Induced Reactions on Deformed Nuclei
(Gardner, Gardner, and Hoff)

The recent development of a technique for modeling level structure in deformed odd-odd nuclei⁹ has enabled us to calculate isomer ratios in agreement with experiment for the reactions: $^{175}\text{Lu}(n,\gamma)^{176\text{m}}_8\text{Lu}$, $^{175}\text{Lu}(n,2n)^{174\text{m}}_8\text{Lu}$, $^{237}\text{Np}(n,2n)^{236\text{m}}_9\text{Np}$, $^{241}\text{Am}(n,\gamma)^{242\text{m}}_8\text{Am}$, and $^{243}\text{Am}(n,\gamma)^{244\text{m}}_8\text{Am}$. The calculations were of the Hauser-Feshbach type, with complete conservation of angular momentum and parity in the gamma-ray cascades. Below about 1500 keV in each product nucleus, we have replaced the conventional level density expression with a modeled discrete level set based on estimates of single-particle and rotational excitations. Among the discrete levels, the gamma-ray transitions were assumed to take place within a rotational band by M1 transitions, with no interband crossing except from the band head. The band heads de-excite by E1 and M1 transitions, using an E^3 energy dependence and the additional selection rule $\delta K = 0, \pm 1$. The M1 transitions are taken to be intrinsically faster than the E1 transitions by a factor of six.

The number of discrete levels used in each product nucleus was (in parenthesis): $^{174}\text{Lu}(433)$, $^{176}\text{Lu}(291)$, $^{236}\text{Np}(714)$, $^{242}\text{Am}(788)$, and $^{244}\text{Am}(769)$. Up to 30 gamma-ray branches were allowed from each band head. If a band head could not de-excite without violating the δK selection rule, it was identified as a potential isomeric state.

Figure B-1 illustrates our results for the reaction $^{175}\text{Lu}(n,\gamma)^{176\text{m}}_8\text{Lu}$. The lower curves give the best agreement with an m/g ratio derived from recent experimental work. Beer and Käppeler¹⁰ measured the $^{175}\text{Lu}(n,\gamma)^{176\text{m}}_8\text{Lu}$ cross section to be 0.906 b at about 30 keV,

⁹ R. W. Hoff, J. Kern, R. Piepenbring, and J. P. Boisson, Nuclear Chemistry Division Annual Report FY83, Lawrence Livermore National Laboratory, Livermore, CA, UCAR-10062-83/1 (1983), pp. 218-223.

¹⁰ H. Beer and F. Käppeler, Phys. Rev. C 21, 534 (1980).

while Allen et al.¹¹ measured it to be 0.958 b. The total $^{175}\text{Lu}(n,\gamma)$ cross section at 30 keV ranges from about 1.2 b^{12,13} to 1.4 b,¹⁴ leading to an experimental m/g ratio between 1.8 and 4.0.

For the ^{236}Np isomer ratio calculation, our level scheme assigns the long-lived ^{236}Np isomer ($1.2 \times 10^5\text{y}$) to be the ground 6^- level and the 22.5h ^{236}Np to be the 1^+ isomer. Our preliminary calculation of the ratio of the long-lived to short-lived isomer is in good agreement with the measured value of 0.35 reported by Myers et al.¹⁵ Further details of this work may be found in Ref. 16.

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- ¹¹ B. J. Allen, G. C. Lowenthal, J. W. Boldeman, and J. R. deLoeter, Proc. 4th Intern. Symp. on Neutron-Capture Gamma-Ray Spectroscopy and Related Topics (the Institute of Physics, Bristol and London, 1982), Conf. Series No. 62, p. 573.
- ¹² H. Beer, F. Käppeler, and K. Wisshak, Proc. Intern. Conf. on Nuclear Cross Sections for Technology, Knoxville, TN, 1979, NBS Special Publication 594, p. 340.
- ¹³ R. L. Macklin, D. M. Drake and J. J. Mañanify, LANL Report La-7024-MS (1977)
- ¹⁴ R. L. Macklin and J. H. Gibbons, Phys. Rev. **159**, 1007 (1967).
- ¹⁵ W. A. Myers, M. Lindner, and R. S. Newbury, J. Inorg. Nucl. Chem. **37**, 637 (1975).
- ¹⁶ D. G. Gardner, M. A. Gardner, and R. W. Hoff, Nuclear Chemistry Division Annual Report FY83, Lawrence Livermore National Laboratory, Livermore, CA, UCAR-10062-83/1 (1983), pp. 51-55.

Fig. B-1. $^{175}\text{Lu}(n,\gamma)^{176}\text{Lu}$ isomer ratio as a function of incident neutron energy. Solid curves show results obtained when the full set of 291 levels for ^{176}Lu was truncated; essentially no difference was obtained for calculations C and D, with 109 and 291 levels, respectively. The dashed curve shows an earlier calculation, with an older set of ^{176}Lu levels. The data are derived from Refs. 10-14.

C. NUCLEAR DATA APPLICATIONS-EVALUATIONS

1. A Reevaluation for ENDL of $\sigma(n,f)$ and $\bar{\nu}_p$ for ^{235}U and ^{239}Pu from 100 keV to 20 MeV¹ (Howerton and White)

Reevaluations of the neutron-induced fission cross sections from 100 keV to 20 MeV and $\bar{\nu}_p(E)$ from thermal to 20 MeV for ^{235}U and ^{239}Pu have been completed and entered into the Livermore Evaluated Nuclear Data Library (ENDL). For $^{235}\text{U}(n,f)$ the recent evaluation of W. P. Poenitz² of Argonne National Laboratory has been adopted as the $^{235}\text{U}(n,f)$ ENDL standard. The $^{239}\text{Pu}/^{235}\text{U}$ fission cross section ratio measurements of Carlson and Behrens,³

¹ R. J. Howerton and R. M. White, Lawrence Livermore National Laboratory report UCID-19973 (1984).

² W. P. Poenitz, "Evaluation of $^{235}\text{U}(n,f)$ Between 100 keV and 20 MeV," Argonne National Laboratory, ANL/NDM-45 (1979).

³ G. W. Carlson and J. W. Behrens, Nucl. Sci. Eng. **66**, 205 (1978).

Kari,⁴ Weston and Todd,⁵ and Meadows,⁶ have been used as the basis for the new $^{239}\text{Pu}(n,f)$ ENDL evaluation.

For $\bar{\nu}_p(E)$ ratio values of Soleihac, et al.⁷ were renormalized to the currently accepted value for ^{252}Cf $\bar{\nu}_{sf}$ and used as the basis for the present ENDL evaluation. Results of criticality calculations using the new evaluated cross sections and $\bar{\nu}_p(E)$ have been compared for various critical mass assemblies. Also, Monte Carlo calculations using these new evaluations have been compared with experimental data from the LLNL 14-MeV pulsed sphere measurements.⁸

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- ⁴ K. Kari, "Messung der Spaltquerschnitte von ^{239}Pu an ^{240}Pu Relative zum Spaltquerschnitt von ^{235}U and Streuquerschnitte $H(n,p)$ in dem Neutronenenergiebereich Zwischen 0,5-20 MeV," Kernforschungszentrum Karlsruhe, Kfk2673 (1978).
- ⁵ L. W. Weston and J. H. Todd, Nucl. Sci. Eng. 84, 248 (1983).
- ⁶ J. W. Meadows, "The Fission Cross Sections of Some Thorium, Uranium, Neptunium and Plutonium Isotopes Relative to ^{235}U ," Argonne National Laboratory, ANL/NDM-83 (1983).
- ⁷ M. Soleihac, J. Frehaut, J. Garian, M. Labat, and J. Percheran, J. Nuclear Energy, 23, 257 (1969). Revised by authors in 1976 (ECSIL Reference 211).
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