## COMITATO NAZIONALE ENERGIA NUCLEARE dipartimento tecnologie intersettoriali di base

evaluation of ${ }^{242}$ cm neutron cross sections from $10^{-5} \mathrm{eV}$ to 15 MeV
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EVALUATION OF ${ }^{242} \mathrm{Cm}$ NEUTRON CROSS SECTIONS FROM $10^{-5} \mathrm{eV}$ TO 15 MeV
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Summary
An evaluation of neutron cross sections for ${ }^{242} \mathrm{Cm}$ is presented in the energy range from $10^{-5} \mathrm{eV}$ to 15 MeV , which includes the resolved resonance region ( $10^{-5} \mathrm{eV}-280 \mathrm{eV}$ ), the unresolved resonance region ( $280 \mathrm{eV}-10 \mathrm{KeV}$ ) and the continuum region (up to 15 MeV ).

## Riassunto

Si presenta una valutazione delle sezioni d'urto neutroniche dell'isotopo ${ }^{242} \mathrm{Cm}$ nell'intervallo energetico da $10^{-5} \mathrm{eV}$ a 15 MeV , comprendente la regione delle risonanze risolte (fino a 280 eV ), la regione delle risonanze non risolte (da 280 eV a 10 KeV ) e la regione del continuo (fino a 15 MeV ).

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# EVALUATION OF ${ }^{242} \mathrm{Cm}$ NEUTRON CROSS SECTIONS FROM $10^{-5} \mathrm{eV}$ TO 15 MeV 

G. Maino, E. Menapace, M. Motta, M. Vaccari (*)

## INTRODUCTION

${ }^{242}$
neutron data are generally requested, because this isotope is the alpha-decay precursor of 238 Pu . Since experimental information on ${ }^{242} \mathrm{Cm}$ is rather poor, the present evaluation is largely based on model calculations and takes into account systematics of data for neighbouring isotopes, mainly of the same Curium family.
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## RESOLVED RESONANCE REGION

$$
\left(E_{n}=1-280 \mathrm{eV}\right)
$$

The only experimental information we found on the resolved resonances is the total cross section measured by Artamonov et al. ${ }^{1}$ in the energy range $E=1-265 \mathrm{eV}$. Twelve resonances were identified and their neutron widths determined. For the first three the total widths were given, too. The origi nal data have been completed as follows:
i) the radiative widths of the first three resonances were deduced from the difference between total and neutron widths. For the second and the third resonance, however, the total widths are affected by large errors; consequently, the deduced radiation widths cannot be very reliable;
ii) for all the remaining resonances, the radiation widths were assumed equal to 38 meV , weighted average for the first three, not far from the constant value, 40 meV , adopted in ref. ${ }^{1}$ for analysis of the experimental data;
iii) a bound level was added, in order to reproduce the thermal capture cross section.

The evaluated resonance parameters are given in table I.
Figs. 1a-b-c show total, capture and elastic cross sections in the resolved resonance region, evaluated through a multilevel Breit-Wigner formula by means of the CRESO code ${ }^{2}$.

# UNRESOLVED RESONANCE REGION 

$$
\left(E_{n}=280 \mathrm{eV}-10 \mathrm{KeV}\right)
$$

In this energy range, neutron cross sections were evaluated by means of the strength function model, based on average parameters, for which one assumes a smooth variation with neutron energy. Unfortunately, the small number of experimental data in the resolved region makes it impossible to obtain good statistics from which to deduce average parameters.

Therefore, a number of values from literature, either evaluated or deduced from systematics, were jointly utilized to improve the evaluation.

An extensive discussion on the systematic trend in the Curium region of experimental and theoretical values for the neutron strength functions, $S$ and $S$, level density parameters, scattering radius, etc., has already been published ${ }^{3}$. Therefore, it will not be repeated here. Only a few comments will be made on the adopted average parameters, listed in table II:
i) $\bar{D}$, average spacing for s-wave resonances: the adopted value is
$\frac{D}{D}=(10.8 \pm 1.6) \mathrm{eV}$, somewhat smaller than the experimental one ${ }^{1}$
$\overline{\mathrm{D}}=(17.6 \pm 3.3) \mathrm{eV}$, because of a correction for missed resonances. Such correction was estimated by means of the CAVE code, based on a
likelihood function method described in ref. ${ }^{4}$ (see fig. 2).
The same J-level spacing was assumed for both parities.
ii) $\quad \bar{r}_{\gamma}$, average radiation width: the weighted mean value extracted from the experimental data of the first three resonance ${ }^{1}, \bar{\Gamma}_{\gamma}=(38 \pm 11) \mathrm{meV}$ was assumed for all $\mathrm{J}^{\Pi}$ - values.
iii) $S_{0}, s$-wave neutron strength function: the adopted value, $S_{0}=0.71 \times 10^{-4}$
lies within the error bars of the experimental result ${ }^{1}$,
( $0.64 \pm 0.32$ ) $\times 10^{-4}$, and is close to a previous evaluation ${ }^{5}$, which gave $\bar{S}_{0}=0.76 \times 10^{-4}$. The average reduced neutron width is assumed according to $\bar{\Gamma}_{n}^{O}=S_{o} \bar{D}$.
iv) $\quad S_{1}, ~ p$-wave neutron strength function: statistical model calculations and local systematics suggest a value $S_{1}=2.53 \times 10^{-4}$ from which $. \Gamma_{n J}^{1}=\overline{D S}_{1} / g_{J}$ is assumed.
$\bar{\Gamma}_{f}$, average fission width: statistical model calculations suggest a smooth increase of $\Gamma_{f}$ with $E_{n}$ for both $s-$ and p-wave neutrons in the interval $280 \mathrm{eV}-10 \mathrm{KeV}$. In this small energy range the trend has been approximated to a straight line. The values of $\Gamma_{f}$ at the ends of the unresolved region are given in table II.
vi) $R^{\prime}$, scattering radius: the value $R^{\prime}=8.9 \mathrm{fm}$ is derived from deformed optical model calculation of the shape elastic cross section performed in the KeV energy region.

THERMAL CROSS SECTIONS AND RESONANCE INTEGRALS

The adopted value of the capture cross section at $E_{=}=0.0253 \mathrm{eV}$ is $\sigma_{n \gamma}=16.0 \mathrm{~b}^{6}$. In order to reproduce this experimental value by means of the CRESO code ${ }^{2}$ from the evaluated resonance parameters, a bound level at $E_{0}=-2.4 \mathrm{eV}$, with $\Gamma_{\gamma}=38 \mathrm{meV}$, was added to the experimental resonances (see table I). Our calculated value is $\sigma_{\mathrm{n} \gamma}^{\mathrm{th}}=16.5 \mathrm{~b}$.

As for the fission cross section, a value $\sigma_{\mathrm{nf}}^{\mathrm{th}}=5.0 \mathrm{~b}^{6}$ seems to be reasonable. Thus, for calculation of the effective resonance integral, a $1 / v$ part of fission cross section was assumed so as to fairly reproduce the quoted value at $E_{n}=0.0253 \mathrm{eV}$.

The absorption resonance integral estimated in ref. 1 is $I_{a b s}=(115 \pm 53) \mathrm{b}$. Our calculated value, including the contributions from the resolved and unresolved regions; is $I_{a b s}=117 \mathrm{~b}$.

As for the reduced fission resonance integral, $I_{n f}$, a null value ${ }^{6}$ is assumed in the previous evaluation. No contribution to $I_{n f}$ is obtained from the resolved resonances in table $I$, since their fission widths are assumed to be negligible. A contribution $I_{n f}=10.81 \mathrm{~b}$ is obtained from the unresolved region, where $\bar{\Gamma}_{f}$ is different from zero. It should be noted that a correct computation of the $I_{n f}$ value must take into account not only the resonance but also the continuum contribution. In fact, the latter may be very large, as in the present case, leading to the calculated value $I_{n f}=11.6 \mathrm{~b}$. A more detailed discussion of the experimental values of thermal cross sections and resonance integrals may be found in ref. ${ }^{3}$.
average number, $\bar{v}$, of neutrons per fission
The following empirical relation ${ }^{7}$ is assumed between the average number of neutrons per spontaneous fission, $\bar{v}$, and the average number emitted in fission induced by thermal neutronsp, $\bar{v}_{\text {th }}$ :

$$
\begin{equation*}
\bar{v}_{\mathrm{th}} \simeq \bar{v}_{\mathrm{sp}}+0.101 \mathrm{~B}_{\mathrm{n}} \tag{1}
\end{equation*}
$$

where $B_{n}$ is the neutron binding energy in the compound nucleus.
From $\bar{v}_{\mathrm{sp}}=2.53^{7}$, we obtain $\bar{v}_{\text {th }}=3.17$. Finally, the dependence of $\bar{v}$ on the energy, $E_{n}$, of incident neutrons, is approximated by a semi-empirical law suggested by Howerton ${ }^{8}$. In the present case:

$$
\begin{equation*}
\bar{v}\left(E_{n}\right)=3.17+0.17 E_{n} \tag{2}
\end{equation*}
$$

## CONTINUUM REGION

$$
\left(E_{n}=10 \mathrm{KeV}-15 \mathrm{MeV}\right)
$$

Between 10 KeV and 15 MeV , optical and statistical model calculations were performed in order to obtain direct and compound nucleus contributions to the main processes in this energy region.

The reactions taken into account are: elastic, total inelastic, radiative capture, first- and second-chance fission, and ( $n, 2 n$ ). Other reactions, like ( $n, 3 n$ ) and third-chance fission, are negligible in the above interval.

The direct contributions to the elastic and level inelastic cross sections were evaluated by means of coupled-channel optical model calculations, using the JUPITOR code 9 for $E_{n}<8 \mathrm{MeV}$ and the ADAPE code 10 for $E_{n}>8 \mathrm{MeV}$, where an adiabatic approximation resulted good enough.

The parameters of the deformed optical potential, given in table III, are substantially those of ref. 11 , modified at low neutron energy as in ref. 12. As for the ground state quadrupole and hexadecapole deformations, $\beta_{2}$ and $\beta_{4}$, respectively, they are strictly related to the adopted radius parameter, $R_{0}$, for the central part of the potential. The choice $\beta_{2}=0.23$ is in agreement with the values suggested by Seeger and Howard 13 in the Actinide region, while $\beta_{4}=0$ agrees with the systematics in literature 14 .

The direct inelastic cross sections were calculated for the first three excited levels. In addition, angular distributions for elastic and inelastic channels were deduced by optical model calculations. A few examples are shown in Figs. $3 a, b, c, d, e$ and $f$.

Total elastic and inelastic cross sections were obtained by suming direct contributions to the corresponding "compound nucleus" contributions, calculated in the frame of the statistical Hauser-Feshbach formalism. Use was made of the HAUSER code ${ }^{15}$. As usual, "compound nucleus" angular distributions were assumed isotropic. The total angular distributions thus obtained, were. fitted by a Legendre polinomial expansion in order to have a compact representation with only a few parameters in the final file in ENDF/B format.

At this point, a few comments on some reactions are appropriate.
Fission, up to $E=15 \mathrm{MeV}$, consists of two contributions, first chance, $(n, f)$ and second chance ${ }^{n}\left(n, n^{\prime} f\right)$, calculated by means of the HAUSER code ${ }^{15}$. The calculated total fission cross section, and its second-chance contribution, are shown in fig. 4, for comparison with "empirical" total fission data obtained as the product of optical model reaction cross section $\sigma_{R}$ and experimental fission probabilities from ref. 16.

In order to estimate the second-chance fission, the branching ratios $P_{n}, P_{\gamma}$, and $P_{f}$ for neutron emission, $\gamma$-decay and fission, respectively, were determined as functions of excitation energy, spin and parity of the decaying nucleus, ${ }^{242}$ Cm.

The branching ratios were then introduced into the code 15 to evaluate the cross sections for the processes ( $n, n^{\prime} f$ ), ( $n, n^{\prime} \gamma$ ) and ( $n, 2 n$ ) in the frame of the evaporation model.

As a check of the adopted parameters, the experimental fission probability 16 of $\quad{ }^{242} \mathrm{Cm}$ as a fissioning nucleus was reproduced at excitation energies $E *$ corresponding to equivalent neutron energies $E_{n}=E^{*}-B_{n}$, where $B_{n}$ is the neutron binding energy in ${ }^{242} \mathrm{Cm}$.

Discrete levels and level density parameters for the three nuclei of interest in the various reaction channels, $241-42-43 \mathrm{Cm}$, are given in Tables IV, $V$ and VI. The discrete levels were taken from a recent compilation 18 , while the level density parameters referring to well-known semi-empirical formulae were adjusted so as to reproduce the cumulative number of discrete levels at low energy and, at higher energies, the trend of microscopic level density calculations 19 that match experimental s-wave spacings, $\bar{D}$, at $E *=B_{n}$. This theoretical approach permitted an estimate of level densities for ${ }^{242} \mathrm{Cm}$ and ${ }^{243} \mathrm{Cm}$ at deformations corresponding to the first peak of the fission barrier, where no direct experimental information exists.

The adopted fission barrier parameters for ${ }^{242} \mathrm{Cm}$ and ${ }^{243} \mathrm{Cm}$ are listed in table VII. They are the height, $E$, and curvature, 有 $\omega$, of the two barrier peaks, slightly modified with respect to ref. ${ }^{16}$, for a better fitting of the fission cross section.

No information is needed about the intermediate well since the outer saddle point is sensibly lower than the inner one; therefore, fission probabilities are evaluated in a complete damping approximation where the effect of quasibound states in the intermediate well is neglected.

All the cross sections calculated for neutron, gamma and fission channels in the energy range $10 \mathrm{KeV}-15 \mathrm{MeV}$ are plotted together in Fig. 5. Figs. $6 \mathrm{a}, \mathrm{b}, \mathrm{c}$ and $d$ show total radiative capture elastic and fission neutron cross sections, respectively, in the total range $10^{-5} \mathrm{eV}-15 \mathrm{MeV}$ covered in the present
evaluation
(*)
(*) The evaluated data were compiled and written in ENDF/B-IV format by using the SYSMF system of codes 20 .

## ENERGY SPECTRA OF EMITTED NEUTRONS

In order to describe the energy distributions of neutrons emitted in ( $n, 2 n$ ), fission and inelastic scattering processes the hypothesis was made that the pre-equilibrium component does not contribute to these channel reactions since it is expected to become relevant only at energies above $10-15 \mathrm{MeV}$, not considered in the present evaluation.

With this assumption, the neutron energy spectra can be well approximated by simple evaporative formulae:

$$
\begin{equation*}
g\left(E, E^{\prime}\right)=\beta E^{\prime} \exp \left[-E^{\prime} / \theta(E)\right] \tag{3}
\end{equation*}
$$

where $E^{\prime}$ stands for the energy of a neutron emitted in the ( $n, n^{\prime} \gamma$ ), ( $n, 2 n$ ) or ( $n, n^{\prime} f$ ) reactions, $B$ is a normalization factor and $\theta(E)$ can be interpreted as the excitation temperature of the residual nucleus after emission of an E'~ 0 neutron. The effective thresholds for these three reactions have been taken, respectively, at $E=0.29 \mathrm{MeV}, 6.97 \mathrm{MeV}$ and 5.80 MeV .

According to ref. 21 the spectrum of neutrons emitted from the fission fragments after first-chance fission is described by the Maxwellian formula:

$$
\begin{equation*}
f\left(E, E^{\prime}\right)=\alpha \sqrt{E^{\prime}} \exp \left[-E^{\prime} / \theta(E)\right] \tag{4}
\end{equation*}
$$

where $\theta(E)$ refers to an effective temperature which depends on the incident neutron energy $E$ (see ref. 21 ).

Figs. 7a, b and $c$ show the assumed energetic dependence of $\theta(E)$ for all the reactions here considered.

## CONCLUSIONS

[^0]Thanks are due to Mr. G.C. Panini for many useful graphical and computing codes and to Mr. T. Martinelli for computations.

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TABLE HEADINGS
I) Parameters of the resolved resonances. Symbols are the same as in ENDF/B formats.
II) Parameters of the unresolved resonance region. Numerical values are identified by ENDF/B symbols.
III) Deformed optical model potential.
IV) Discrete levels and level density parameters for ${ }^{241}$ Cm.
V) Discrete levels and level density parameters for ${ }^{242} \mathrm{Cm}$.
VI) Discrete levels and level density parameters for ${ }^{243} \mathrm{Cm}$.
VII) Fission barrier parameters of ${ }^{242} \mathrm{Cm}$ and ${ }^{243} \mathrm{Cm}$ fissioning nuclei.


TABLE II

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## Deformed optical model potential

$$
\begin{aligned}
& V=-(v+i W) \frac{1}{1+\exp \left[\left(r-R_{a}\right) / a\right]}-4 i W_{D} \frac{\exp \left[\left(r-R_{b}\right) / b\right]}{\left\{1+\exp \left[\left(r-R_{b}\right) / b\right]\right\}^{2}} \\
& -V_{S O} \vec{\sigma} \cdot \vec{\ell} \frac{\hbar_{\pi}^{2}}{a r} \frac{\exp \left[\left(r-R_{a}\right) / a\right]}{\left\{1+\exp \left[\left(r-R_{a}\right) / a\right]\right\}^{2}} ; \text { here: } \\
& R_{a, b}=R_{a, b}^{(0)}\left(1+\beta_{2} Y_{2}^{0}\left(\theta^{\prime}\right)+\beta_{4} Y_{4}^{0}\left(\theta^{\prime}\right)\right) \quad \text { ( } \theta^{\prime} \text { refers to the body-fixed system) } \\
& \lambda_{\pi}=\lambda_{\pi} / 2 \pi \quad \text { (reduced pionic Compton wavelength) } \\
& V=47.01-0.267 E_{n}-0.00118 E_{n}^{2}(M e V)\left(E_{n} \quad \text { in } M e V\right) \\
& \mathrm{w}=0 \\
& H_{D}= \begin{cases}3.195 \mathrm{MeV} & \left(E_{n} \leq 2.25 \mathrm{MeV}\right) \\
2.25+0.42 E_{n}(\mathrm{MeV}) & \left(\mathrm{E}_{\mathrm{n}}\right. \text { in MeV)}\end{cases} \\
& \mathrm{V}_{\mathrm{SO}}=7.2 \mathrm{MeV} \\
& \mathrm{R}_{\mathrm{a}}^{(\sigma)}=1.259 \mathrm{fm} ; \quad \mathrm{R}_{\mathrm{b}}^{(0)}=1.237 \mathrm{fm} ; \\
& a \quad=0.66 \mathrm{fm} ; \quad b=0.48 \mathrm{fm} ; \\
& \beta_{2}=0.23 \quad ; \quad \beta_{4}=0.0 \quad .
\end{aligned}
$$

TABLE IV

Discrete levels and level density parameters for ${ }^{241} \mathrm{Cm}$ Neutron channel:

Discrete levels:

| $E(\mathrm{KeV})$ | $J^{I I}$ |
| ---: | :---: |
|  |  |
| 0.0 | $1 / 2^{+}$ |
| 53.0 | $3 / 2^{+}$ |
| 103.0 | $5 / 2^{+}$ |
| 157.0 | $7 / 2^{+}$ |
| 255.0 | $9 / 2^{+}$ |

Continuum:
E $>255$ KeV; level density described by the formula
$\rho(E, J)=\frac{(2 J+1)}{24 \sqrt{2}^{3}} \frac{\exp (2 \sqrt{a(E-\Delta)})}{a^{1 / 4}(E-\Delta+T)^{5 / 4}} \exp \left|-J(J+1) / 2 \sigma^{2}\right|$
where: $\sigma^{2}=k T$
$E-\Delta=a T^{2}-T$
$a=22.9 \mathrm{MeV}^{-1}$
$\Delta=-0.24 \mathrm{MeV}$
$\sigma^{2} / T=100 \mathrm{MeV}^{-1}$

## TABLE V

Discrete levels and level density parameters for ${ }^{242} \mathrm{Cm}$
Neutron channel:
Discrete levels:

| $E(K e V)$ | $J^{\pi}$ |
| ---: | :--- |
| 0.0 | $0^{+}$ |
| 42.1 | $2^{+}$ |
| 139.0 | $4^{+}$ |
| 285.0 | $6^{+}$ |

Continuum:
E)285 KeV; level density formula as in table IV, with parameters:
$a=24.0 \mathrm{MeV}^{-1}$
$\Delta=-0.54 \mathrm{MeV}$
$\sigma^{2} / T=100 \mathrm{MeV}^{-1}$

Fission channel
Transition states at the first barrier peak
described by a level density formula as in
table IV, with parameters:
$a=25.2 \mathrm{MeV}^{-1}$
$\Delta=-0.25 \mathrm{MeV}$
$\sigma^{2} / T=98 \mathrm{MeV}^{-1}$
table VI

Discrete levels and level density parameters for ${ }^{243} \mathrm{Cm}$

Neutron channel:
Discretedevels:

| $E(\mathrm{KeV})$ | $\mathrm{J}^{\pi}$ |
| :--- | :--- |
| 0.0 | $5 / 2^{+}$ |
| 42 | $7 / 2^{+}$ |
| 87 | $1 / 2^{+}$ |
| 93 | $3 / 2^{+}$ |
| 94 | $9 / 2^{+}$ |
| 133 | $7 / 2^{+}$ |
| 153 | $11 / 2^{+}$ |
| 156 | $5 / 2^{+}$calculated, for the $\mathrm{K}^{\pi}=1 / 2^{+}$band |
| 164 | $9 / 2^{+}$ |
| 173 | $7 / 2^{+}$calculated, for the $\mathrm{K}^{\pi}=1 / 2^{+}$band |
| 219 | $: 13 / 2^{+}$ |
| 228 | $11 / 2^{+}$ |
| 260 | $9 / 2^{+}$ |

Continuum: E > $260 \mathrm{KeV}:$ level density formula as in table IV, with
parameters:

$$
\begin{aligned}
\mathrm{a} & =23.0 \mathrm{MeV}^{-1} \\
\Delta & =-0.63 \mathrm{MeV} \\
\sigma^{2} / \mathrm{T} & =100 \mathrm{MeV}^{-1}
\end{aligned}
$$

## Fission channel:

transition states at the first barrier peak described by a level density formula as in table XI , with parameters

$$
\begin{aligned}
\mathrm{a} & =27.2 \mathrm{MeV}^{-1} \\
\Delta & =-1.35 \mathrm{MeV} \\
\sigma^{2} / \mathrm{T} & =98 \mathrm{MeV}^{-1}
\end{aligned}
$$

table VII

Fissioning nucieus ${ }^{242}$ cm

## First peak

Height | $E_{A}(\mathrm{MeV})$ | Curvature $\pi \omega_{A}(\mathrm{MeV})$ |
| :---: | :---: |
| 6.04 | 0.75 |

Fissioning nucleus ${ }^{243}$ Cm

| First peak |  | Second peak |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  | Curvature $\pi \omega_{A}(\mathrm{MeV})$ |  | $E_{B}(\mathrm{MeV})$ | $\pi \omega_{B}(\mathrm{MeV})$ |
| 5.87 | 0.45 |  | 5.0 | 0.55 |

FIGURE CAPTIONS

| Fig. 1a,b,c) | ${ }^{242} \mathrm{Cm}$ neutron cross sections in the resolved resonance region (up to $E_{n}=280 \mathrm{KeV}$ ) for total, radiative capture and elastic scattering reactions, respectively. |
| :---: | :---: |
| Fig. 2) | Average s-wave spacing $\overline{\bar{D}}$ versus visibility threshold of reduced neutron widths, by the method of ref./4/. |
| Fig. 3a,b,c, ${ }^{\text {d }}$ | Neutron angular distributions, deduced from ${ }^{242} \mathrm{Cm}$ elastic and inelastic cross sections, for some typical values of excitation energy. |
| Fig. 4) | Evaluated ${ }^{242} \mathrm{Cm}$ fission cross section, in comparison with a "simulated" one, deduced from experimental fission probabilities (ref. /16,17/). |
| Fig. 5) | ${ }^{242} \mathrm{Cm}$ neutron cross sections in the continuum region. |
| Fig. $6 \mathrm{a}, \mathrm{b}, \mathrm{c}, \mathrm{d}$ ) | ${ }^{242} \mathrm{Cm}$ cross sections in the total range $10^{-5} \mathrm{eV}-15 \mathrm{MeV}$ : <br> a) total; <br> b) capture; <br> c) elastic and <br> d) fission. |
| Fig. 7a,b, c) | Energy spectra of emitted neutrons in a) ( $n, 2 n$ ), <br> b) fission and c) inelastic scattering reactions. |

(SNyUGINOILJコS-X


Fig. la




Fig. 2


Fig. 3a



Fig. 3b


Fig. 3c



Fig. 3d

144! 9542
INELTO ? NO LEVEL E= 5.090

ARBITRARY UNITS

Fig. 3e



Fig. $3 f$


Fig. 4

CROSS SECTIONS IN THE FAST ENERGY RANGE






N, 2 N I.ST NEUTR.


Fig. 7a
N, 2N 2.ND NEUTR.



Fig. 7b


N, N' FISSION


Fig. 7c
inELASTIC CONT.



[^0]:    Experimental information about ${ }^{242} \mathrm{Cm}$ neutron cross sections is very scarce because of the short half-life of this isotope and of the difficulty in producing high purity samples.

    The present work attempts to fill many experimental gaps by means of model calculations. However new, accurate measurements are highly desirable and may lead to substantial improvements and modifications of this evaluation.

