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# BISERM Version 2

## Nuclear Data Library for Evaluation of Radiation Effects in Materials induced by Neutrons of Intermediate energy

by

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Abstract: This document describes the cross-section data library for studies of radiation effects induced by intermediate energy neutrons. The library contains hydrogen, helium-3 and helium-4 production cross-sections as well as nonelastic and total displacement cross-sections for neutrons in the energy range from threshold to 1 Ge V. The cross-sections are given for 259 isotopes from 27 Al to 2~i. All this information is given in 18 compressed files plus one file with the catalogue of the data. The library was composed at the Institute of Nuclear Power Engineering in Obninsk, Russia. It is available on one PC diskette from the IAEA Nuclear Data Section cost free upon request. It requires 4 Mb of diskspace after decompression.

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The file was revised to conform with ENDF/B format standards.. The merged file was corrected for format errors and processed through the code CHECKR to ensure, as far as possible, format compatibility.

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RUSSIAN FEDERATION

**BISERM v .2**

# NUCLEAR DATA LIBRARY FOR EVALUATION OF RADIATION EFFECTS IN MATERIALS INDUCED BY NEUTRONS OF INTERMEDIATE ENERGIES

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# BISERM v .2

## NUCLEAR DATA LIBRARY FOR EVALUATION OF RADIATION EFFECTS IN MATERIALS INDUCED BY NEUTRONS OF INTERMEDIATE ENERGIES

New version of cross section data library BISERM[1] to study radiation effects induced by intermediate energy neutrons is presented. The library contains neutron displacement cross sections, hydrogen and helium production cross sections for 259 stable nuclei from $^{27}$Al to $^{2O9}$Bi. Hydrogen and helium production cross sections are presented at the energy from the threshold of (n,p), (n,a) and (n,$^{3}$He) reactions up to 1 GeV. Displacement cross sections are given from 10
MeV to 1 GeV.

The previous version of BISERM is described in Refs.[1-6].

## 1. BRIEF DESCRIPTION OF CROSS SECTION EVALUATION METHOD

The basic principles of the cross section evaluation are discussed in Refs. [3,4].
The Robinson function [7] has been used for displacement cross section calculations.

Neutron displacement cross sections for elastic scattering ($\sigma_{del}$) were calculated up to the energy of 40 MeV using the optical model with the potential from Ref.[8]. In the energy range from 40 to 150 MeV, the $\sigma_{del}$ values were calculated using the optical potential from Ref.[9], and the results were adjusted to the $\sigma_{del}$ obtained at the energies below 40 MeV. At the energies above 150 MeV, the approximate approach [10] was used to obtain elastic displacement cross sections for neutrons. For $^{52}$*Cr,* $^{56}$Fe, and $^{58}$*Ni,* the $\sigma_{del}$ values were calculated using the potential from Ref.[ll] in the energy range 10-100 MeV.

Displacement cross sections for nonelastic interactions ( $\sigma_{dnon}$ ) were obtained with the help of the modified intranuclear cascade evaporation model [ 12] using the DISCA code.

The calculation of hydrogen ($\sigma_H$) and helium ($\sigma_{He}$) production cross sections at the energies up to 100 MeV has been performed on the basis of the geometry dependent hybrid exciton and evaporation models [13]. The precompound α-particle spectra were obtained using the coalescence pick-up model [14,15].

To obtain $\sigma_H$ and $\sigma_{He}$ values at the energies up to 1 GeV, the intranuclear cascade evaporation model has been used. The non-equilibrium α-particle production was taken into account using the approach from Ref. [ 16] .

**[1]"BISERM" means BIblioteka SEchenij dlja Radiatsionnogo Materialovedenija translated as Cross section Library for Radiation Technology**

**BISERM data library**

The α-particle production cross sections obtained using two different approaches at the energies below 100 MeV (hybrid exciton evaporation and intranuclear cascade evaporation models) are in better agreement than in the Ref. [4]. By this reason the "medium " energy range 50 -160 MeV, where only the approximate evaluation of $\sigma_{He}$ has been performed in Ref. [ 4] , has not been introduced in the present work.

To obtain $\sigma_H$ and $\sigma_{He}$ values, in agreement with experimental data below 20 MeV the correction of the calculated (n,p) and (n,a.) cross sections has been performed using the EXFOR data and the systematics predictions [17] at 14.5 MeV.

For some nuclei the (n,p) and (n,a.) cross sections were taken from ADL-3 [18] and MENDL-l [19] libraries at the energies below the maximum of excitation functions. Calculated cross sections for the reaction (n,$^3$He) were corrected on available evaluated experimental data [20].

**The Figure shows the example of data presented in the BISERM files.**

**2. DATA FORMAT**

BISERM data are written in the ENDF-6 format.

The cross sections are presented in MF=3 file. Neutron induced proton, α-particle, and $^3$He production cross sections are given in the standard MT=203, MT=207, and MT=206 sections, respectively.

Neutron total displacement cross sections (sum: $\sigma_{del}+\sigma_{dnon}$) and nonelastic displacement cross sections are written using new assigned MT=90l and MT=903 sections of MF=3. Instead of standard QM and QI values the effective displacement threshold energy $E_d$ [3] is given for these MT -sections.

## 3. CATALOGUE

Each line of the BISERM catalogue includes the following infonnation .

- **Z-Name-A** for the target nucleus
- **Type of cross section**. Five type of cross sections are presented: proton production, α-particle production, $^3$He production, nonelastic displacement and total displacement
- **Reaction energy (Q-value) or effective threshold displacement energy ($E_d$)**. The Q-value is given for proton-, α-particle and $^3$He production cross sections. The $E_d$ value is presented for displacement cross sections
- **Cross section values at 14.5 and 800 MeV** given in barns
- **The brief comments** pointing out the method of the cross section correction or data adoption.

For example,

"Corr: expr,syst < 20 MeV" means that the cross sections included in the BISERM file have been corrected using the available experimental data and the systematics predictions in the energy range below 20 Me V" ,

***Catalogue -***

"MENDL < 20 MeV" means that the cross sections below the maximum of the excitation function located below 20 Me V were taken from the MEND L-l library .

## 4.DISTRIBUTION OF THE LIBRARY

BISERM data files are free distributed and available after request.

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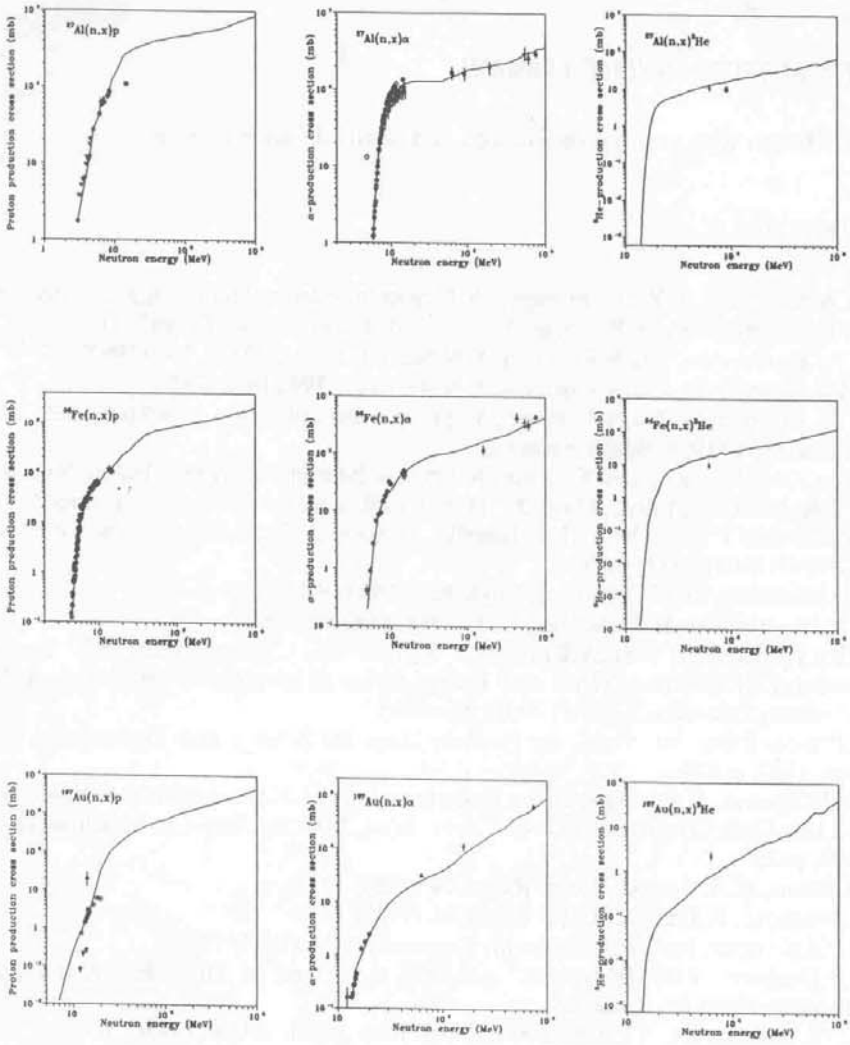


Figure. Example of the proton, α-particle, and $^{3}$He production cross sections from the BISERM data files (solid line). Experimental cross sections for (n,p) and (n,α) reactions are taken from the EXFOR library at the energy below 20 MeV. At the energies above 50 MeV the proton induced p- and α-production cross sections are shown (see the references in [4]).

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