# Nuclear Reactions and Self-Shielding Effects of Gamma-Ray Database for Nuclear Materials

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A database for transmutation and radioactivity of nuclear materials is required for selection and design of materials used in various nuclear reactors. The database based on the FENDL/A-2.0 on the Internet and the additional data collected from several references has been developed in NRIM site of "Data-Free-Way" on the Internet. Recently, the function predicted self-shielding effect of materials for γ-ray was added to this database.

The user interface for this database has been constructed for retrieval of necessary data and for graphical presentation of the relation between the energy spectrum of neutron and neutron capture cross section. It is demonstrated that the possibility of chemical compositional change and radioactivity in a material caused by nuclear reactions can be easily retrieved using a browser such as Netscape or Explorer.

## 1. Introduction

In the data system for nuclear material design and selection used in various reactors, huge material databases and several kinds of tools for data analysis or simulation code of the phenomena under irradiation [1] are required. Thus, a database on transmutation for nuclear materials had been constructed on PC [2]. The database is converted to a system used on Internet [3-5]. As a database for nuclear material design and selection used in various reactors are developed in NRIM site of “Data-Free-Way”[5-8]. A database storing the data on nuclear reaction is needed to calculate the simulation. Using the database, we can retrieve the data of nuclear reaction for material design on the Internet and understand qualitatively the behavior of nuclear reaction such as the transmutation or decay. The database is required for the friendly user-interface for the retrieval of necessary data. In the paper, features and functions of the developed system are described and especially, examples of the easily accessible search of nuclear reactions are introduced

## 2. Outline of the database on transmutation for nuclear materials

### 2.1 Database system

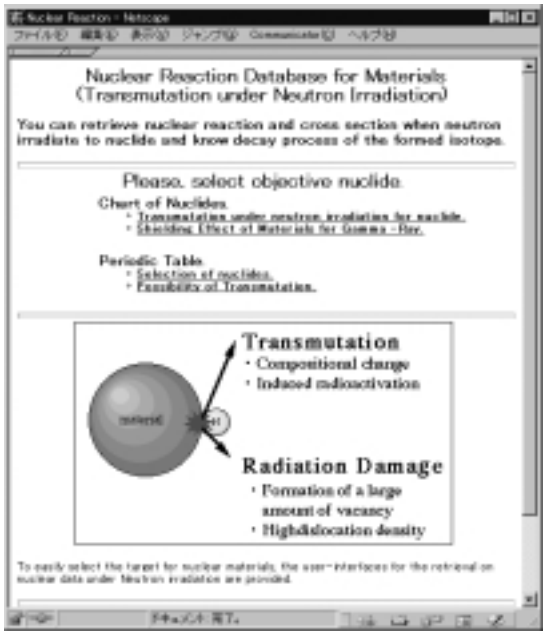


Fig.1 Opening screen of the for transmutation under neutron irradiation.

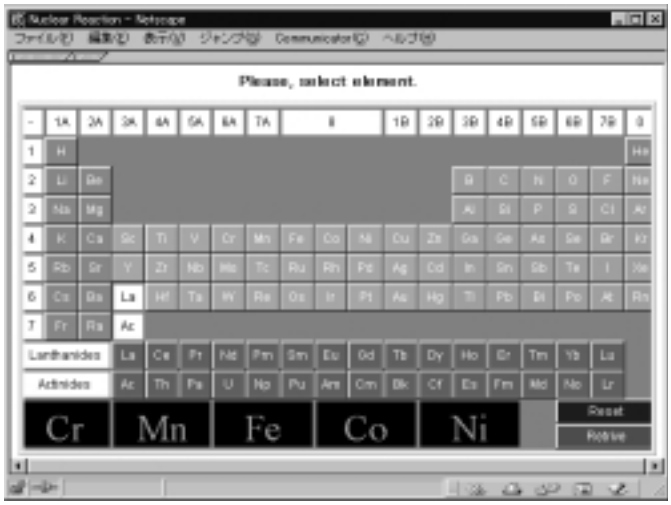


Fig.2 Screen for selection of the nuclide from Periodic table

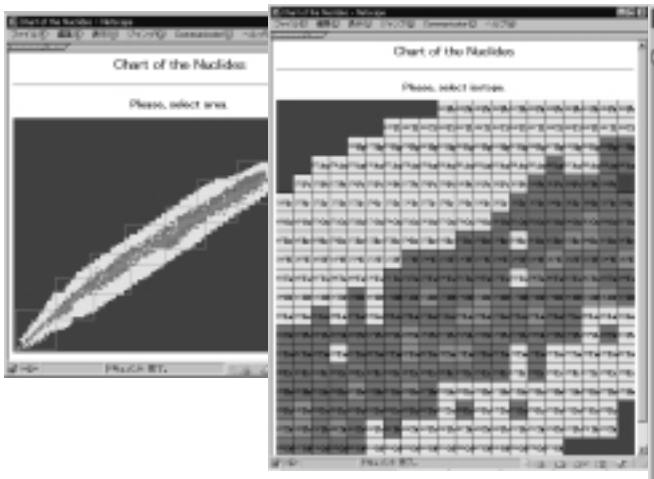


Fig.3 Screen for selection of the nuclide from the chart of the nuclides

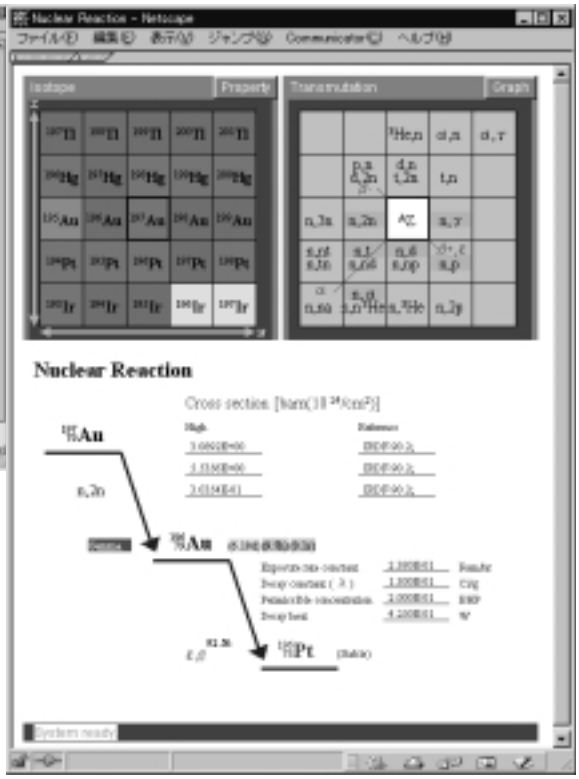


Fig.4 An example of screen to retrieve data on nuclear transmutation of $^{197}$Au to $^{196}$ Au by (n,2n) reaction and decay process of $^{196}$ Au.

In the database of transmutation for nuclear materials, the data of nuclear reaction for

material design is stored and we can understand qualitatively the behavior of nuclear reaction such as the transmutation or decay. The database is managed by ORACLE where RDBMS (relational database management system) is supported on workstation with UNIX OS. As the RDBMS and WWW were connected, users are able to retrieve necessary data using Netscape or Explorer as a user-interface through the Internet.

Fig. 1 shows the opening screen of the for transmutation which users are accessed the database by selecting the term of ”Nuclear Reaction Database” for nuclear materials on transmutation and self-shielding effect of materials for γ-ray under neutron irradiation in the WWW of NRIM site on “Data-Free-Way”. Users are able to select various interface for retrieval and obtain the necessary data. Fig.2 shows the screens to select a desired nuclide from periodic table. Fig.3 shows the other screens to select a nuclide form chart of the nuclides

**2.2 Data structure**

The database consists of five main tables and three supplemental tables. Main tables are element, isotope, spontaneous decay, transmutation and cross section table. The element table has the data such as element name, atomic weight and etc. These data are input values obtained from ordinary periodic table. The data in the isotope table consist of the natural abundance ratio, half-life data, γ-ray or β-ray energy and maximum permissible concentration in air (MPC), which are taken from isotope table. The spontaneous decay table has the data of decay mode and branching ratio. The transmutation table has the data of transmutation process, produced nuclide and etc. The neutron cross-section table stores the data with 42-energy group covering from thermal neutron energy to 15MeV.

**2.3 Stored data**

Various data, which are required for simulation on nuclear reaction, have been collected from reports as follows;

I. Nuclear data such as neutron cross-section are collected from JAERI's CROSSLIB, ENDF/B- 6, JENDL-3 and FENDL/A-2.0. The number of cross section for nuclear reactions which were stored in the database is 3213 in stable nuclides and 5484 in unstable ones.

II. The data on decay process, γ-ray, isotope and element are collected respectively from

a. "Table of Radioactive Isotopes" E. Browne and R. B. Firestone, 1986, LBLU of C, John Wiley & Sons,
b. "Radiation Data Book", edited by Y. Murakami, H. Danno and A. Kobayashi, 1982, Chijin-Shokan.
c. "Chart of the Nuclides" compiled by Y. Yoshizawa and T. Horiguchi and M. Yamada, 1996, JNDC and NDC in JAERI.
d. "Elsevier's Periodic Table of the Elements", collected by P. Lof, 1987, Elsevier.

## 3. Self-shielding effects of materials for γ-ray

### 3.1 Stored Data

Various data, which are required for self-shielding effects have been collected from reports as follows;

Linear Attenuation Coefficient of Materials: Photon Cross-Sections from 1keV to 100MeV for Elements, Nuclear Data Tables A7, (1970) 565.

### 3.2 Calculation Method

Surface dose rate for given nuclear material is calculated for an unstable nuclide by the following equation.

$$D = K\sum c\frac{\mu_a SB}{2\mu_m} \qquad (1)$$

D: Surface dose rate (Sv/h)

K:constant

C:Conversion factor (Sv/Gy)

B:Build up factor

$\mu_a$: Gamma-ray energy absorption coefficient of air ($m^2$/kg)

$\mu_m$: Linear attenuation coefficient of material ($m^2$/kg)

S: Rate of gamma-ray emission (MeV/kg/s)

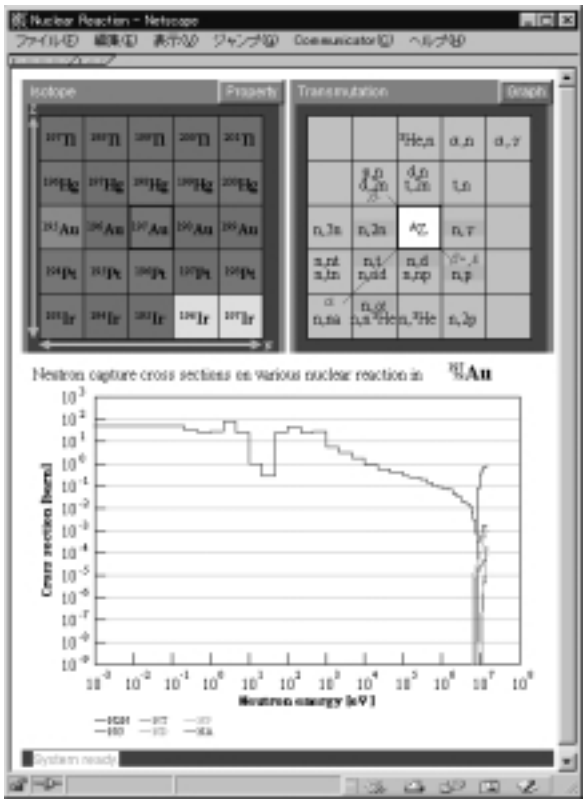


Fig.5 An example of graph of relation between neutron capture cross section for various reaction and neutron energy in $^{197}$Au.

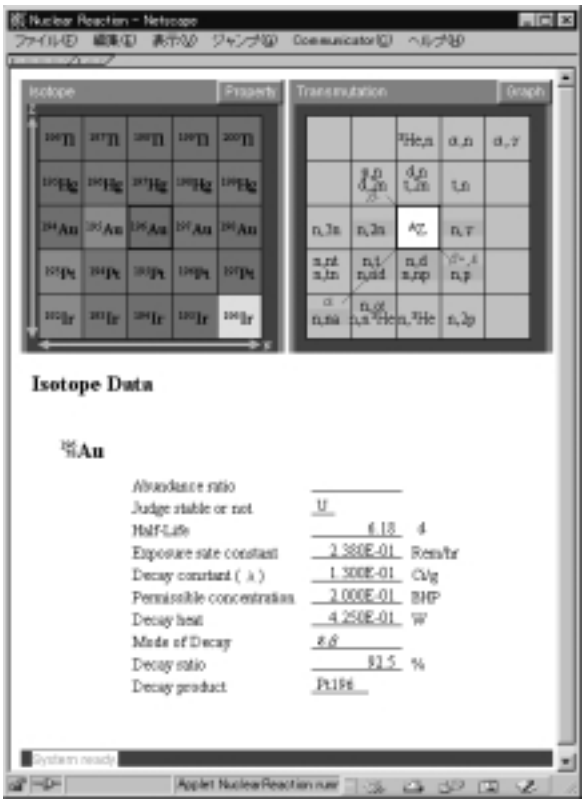


Fig.6 An example of screen to retrieved nuclide data on $^{196}$Au formed by nuclear

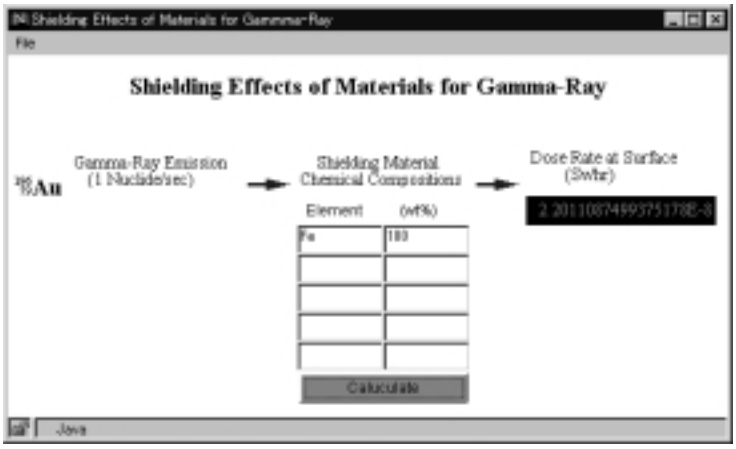


Fig.7 An example of screen of calculator for self-shielding effects of materials for γ-ray from $^{196}$Au.

## 3. Functions and user-interface

### 3.1 Functions

Fig. 1 shows opening main menu screen of the database. This database has four retrieval functions of nuclear reaction process, properties of radioactive isotope, spontaneous decay of each isotope and decay of produced nuclides after nuclear reaction. We can understand qualitatively the behavior of nuclear reaction such as the transmutation or decay. the function predicted self-shielding effect of materials for γ-ray was added to this database.

### 3.2 User-interface for retrieval data

Fig. 2 and Fig. 3 show screens of the selection of the isotope or the nuclide from the periodic table and chart of nuclides, respectively. Fig. 4 shows an example of screen to be retrieved $^{197}$Au on nuclear transmutation of $^{197}$Au to $^{196}$ Au by (n,2n) reaction and decay process of $^{196}$ Au by (n,2n) reaction and decay process of $^{196}$ Au. Fig. 5 shows screen that by selecting the desired nuclear reaction in right folder, user is able to know records on a given transmutation and spontaneous decay in the reaction process. The graph as shown in Fig. 5 appears, if user clicks the graph button in the screen shown Fig. 4 or Fig. 6. The graphs shows the relation between transmutation cross section and neutron energy spectrum on various reactions. The high value of the cross section means that the neutron reaction easily occurs. Fig. 6 shows mass number, the natural abundance ratio, half-life data, to γ-ray or β-ray energy on $^{196}$Au formed by $^{197}$Au(n,2n)$^{196}$Au reaction. Moreover, if user clicks the red button indicated (gamma) in Fig. 4, the screen appears as shown in Fig. 7. In the screen, a self-shielding effect of materials for γ-ray formed $^{196}$ Au is able to calculate. This new function was added to nuclear reaction database for nuclear materials.

## 4. Summary

1) A database on transmutation for nuclear materials with a user-friendly interface was constructed in WWW server on the Internet. (http://inaba.nrim.go.jp//Irra/)

2) The database consists of mainly four tables storing the information of atomic element, isotope, transmutation and cross section for 42 neutron energy groups.
3) The user interface for this database has been constructed for retrieval of necessary data and for graphical presentation of the relation between the energy spectrum of neutron and neutron capture cross section. It is demonstrated that the possibility of chemical compositional change and radioactivity in a material caused by nuclear reactions can be easily retrieved using a browser such as Netscape or Explorer.

**References**


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