Comparison of Major Nuclear Data Libraries
– JENDL-3.3, ENDF/B-VI.8, ENDF/B-VIIβ1.2 and JEFF-3.1 –

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Compared are neutron-induced reaction data contained in major general-purpose libraries: major actinides, minor actinides, long-lived fission products, and structural materials in JENDL-3.3, ENDF/B-VI.8, ENDF/B-VIIβ1.2, and JEFF-3.1. It is found from the comparison that there still exist large discrepancies among the cross sections in different libraries.

1. Introduction

Evaluations for JENDL-4 are in progress in order to improve fission product and minor actinide data in JENDL-3.3 [1]. In Europe, the OECD/NEA Data Bank released JEFF-3.1 [2] in 2005. Moreover, the National Nuclear Data Center in BNL, which released ENDF/B-VI.8 [3] in 2001, is now preparing for the release of ENDF/B-VII whose β version [4] is available on Web. It is worthwhile to compare the data in the existing major libraries including the β version ENDF/B-VIIβ1.2 to clarify their differences. Comparisons were made for major actinides ($^{233, 235, 238}$U, $^{239, 240, 241}$Pu, ^{232}Th), minor actinides (^{237}Np, $^{241, 242g, 242m, 243}$Am, $^{242, 244, 245}$Cm), long-lived fission products (^{79}Se, ^{93}Zr, ^{99}Tc, ^{107}Pd, ^{126}Sn, ^{129}I, ^{135}Cs), and structural materials (Cr, Fe, Ni). The following sections describe the results of the comparisons.

2. Major Actinides

The same resolved resonance parameters of ^{235}U [5] were used for all libraries below 2.25 keV, which gives the same thermal behavior of the total, elastic scattering, fission and capture cross sections. In the energy region above 2.25 keV, the difference in the fission cross section of ^{235}U is small, i.e., several %, while the capture cross sections of JENDL-3.3 are about 10% larger than the other libraries in the region from 30 keV to 1 MeV as seen in Fig. 1. At thermal energy, there is little difference (0.02%) in the average number of prompt neutrons emitted in the ^{235}U(n,f) reaction, although several-percent difference can be seen in the case of delayed neutrons. As for ^{238}U, JEFF-3.1 and ENDF/B-VIIβ1.2 adopted the new resolved resonance parameters [6] evaluated in ORNL, which yield somewhat smaller thermal capture cross sections and capture resonance integrals than those of JENDL-3.3 and ENDF/B-VI.8, as seen in Table 1. It is found from Fig. 2 that the ^{238}U(n,n') cross section of ENDF/B-VIIβ1.2 is close to that of JENDL-3.3 below 6 MeV. The ^{233}U data were completely revised for ENDF/B-VIIβ1.2, whereas JEFF-3.1 adopted the ^{233}U data in JENDL-3.3.

The same resolved resonance parameters of ^{239}Pu [7] were adopted for all libraries below 2.5 keV, although background fission cross sections are contained in ENDF around 2 keV. It should be noted that all libraries but JENDL-3.3 adopted the evaluation of Fort et al. [8] for the average number of prompt neutrons emitted in the ^{239}Pu(n,f) reaction, which exhibits fluctuations in the region from 10 to 700 keV. Concerning ^{240}Pu, there is a question why ENDF/B-VIIβ1.2 did not adopt the latest resolved resonance parameters evaluated by Bouland *et al.*[9] Resolved resonance parameters of ^{241}Pu were revised for JEFF-3.1 and ENDF/B-VIIβ1.2 below 20 eV.

As for the fission cross section of ^{232}Th, there is several-percent difference among libraries above 1 MeV.

3. Minor Actinides

Differences can be seen in the fission cross section of ^{237}Np below the sub-threshold between JENDL-3.3, JEFF-3.1 and the two ENDF libraries. Even at thermal energy, there is about 10% difference in the capture cross section of ^{237}Np.

The fission cross section of ^{241}Am in JEFF-3.1 deviates from those of the other libraries considerably below 1 eV. Figure 3 shows the isomeric ratio of the ^{241}Am(n,γ) reactions and it indicates that each evaluator has different views of measurements and nuclear model calculations. The $^{242g,\,242m,\,243}$Am data of JEFF-3.1 were taken from JENDL-3.3, while the $^{242g,\,242m}$Am data of ENDF/B-VIIβ1.2 were partly taken from JENDL-3.3.

Figure 4 shows the fission cross section of ^{242}Cm. In the energy region from 10 keV to 1 MeV, available measurements, which are not shown in the figure, support JENDL-3.3 and JEFF-3.1. The $^{244,\,245}$Cm data of JENDL-3.3 were adopted by ENDF/B-VIIβ1.2, while the ^{245}Cm data of JEFF-3.1 were taken from JENDL-3.3.

4. Long-lived Fission Products

Only the capture cross sections of long-lived fission products (LLFPs) were examined in the present work.

As for ^{79}Se, ENDF/B-VI.8, ENDF/B-VIIβ1.2 and JEFF-3.1 adopted JENDL-3.3 data. There exist no experimental data on ^{79}Se. No resolved resonance parameters are compiled in the libraries. It is strongly recommended that measurements should be performed for this nucleus.

The ^{93}Zr data of ENDF/B-VI.8 contains no resolved resonance parameters, while there is only one resonance level in those of JEFF-3.1. The thermal capture cross section of ^{93}Zr in ENDF/B-VIIβ1.2 is 70% smaller than that of JENDL-3.3, as seen in Fig. 5.

The difference in the capture cross section of ^{99}Tc among the libraries is smaller than that of ^{93}Zr. However, 10-20 % differences can be seen depending on energy region.

As for the capture cross section of ^{107}Pd, a large difference can be seen between JENDL-3.3 and JEFF-3.1 in the resonance region from 10 eV to 1 keV.

There are no experimental data on ^{126}Sn. The data of ENDF/B-VIIβ1.2 were taken from JENDL-3.3, while those of JEFF-3.1 were taken from ENDF/B-VI.8. Measurements are also required for ^{126}Sn to produce reliable evaluated data.

Recently, Noguere *et al*. [10] evaluated the resolved resonance parameters of ^{129}I, and their parameters were adopted by JEFF-3.1. As shown in Fig. 6, there is a marked difference in the low energy tail of the lowest resonance of the $^{129}I(n,\gamma)$ cross section between JEFF-3.1 and JENDL-3.1. Preliminary data of the cross section measured by Kobayashi [11], which are not shown in the figure, seem to support the JEFF-3.1 data.

As for the capture cross section of ^{135}Cs, the resonant cross sections are discrepant among the libraries.

5. Structural Materials

Only the total cross sections of elemental Cr, Fe and Ni were examined in the present work. Maximum 20% differences are seen between JENDL-3.3 and ENDF-VIIβ1.2 in Fig. 7, although the difference is about 2-3 % in the case of Fe and Ni. It is recommended to re-examine the resonance parameters of Cr isotopes for the JENDL-4 evaluation.

6. Conclusions

Major actinide, minor actinide, long-lived fission product and structural material data were compared among the existing major nuclear data libraries JENDL-3.3, ENDF/B-VI.8, ENDF/B-VIIβ1.2 and JEFF-3.1. Even for major actinides, there still remain differences among the libraries. New measurements are required to resolve the differences. Moreover, re-analyses of old measurements are also encouraged with the aid of advanced theoretical techniques.

References

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Table 1 Thermal capture cross sections (σ_c) and capture resonance integrals (I_c)of ^{238}U at 300 K

Library	σ_c (b)	I_c (b)*
JENDL-3.3	2.718	278.1
ENDF/B-VI.8	2.718	278.1
ENDF/B-VIIβ1.2	2.684	275.3
JEFF-3.1	2.684	275.3
Mughabghab 2003 [12]	2.608±0.019	277±3

* Integration was performed from 0.5 eV to 20 MeV.

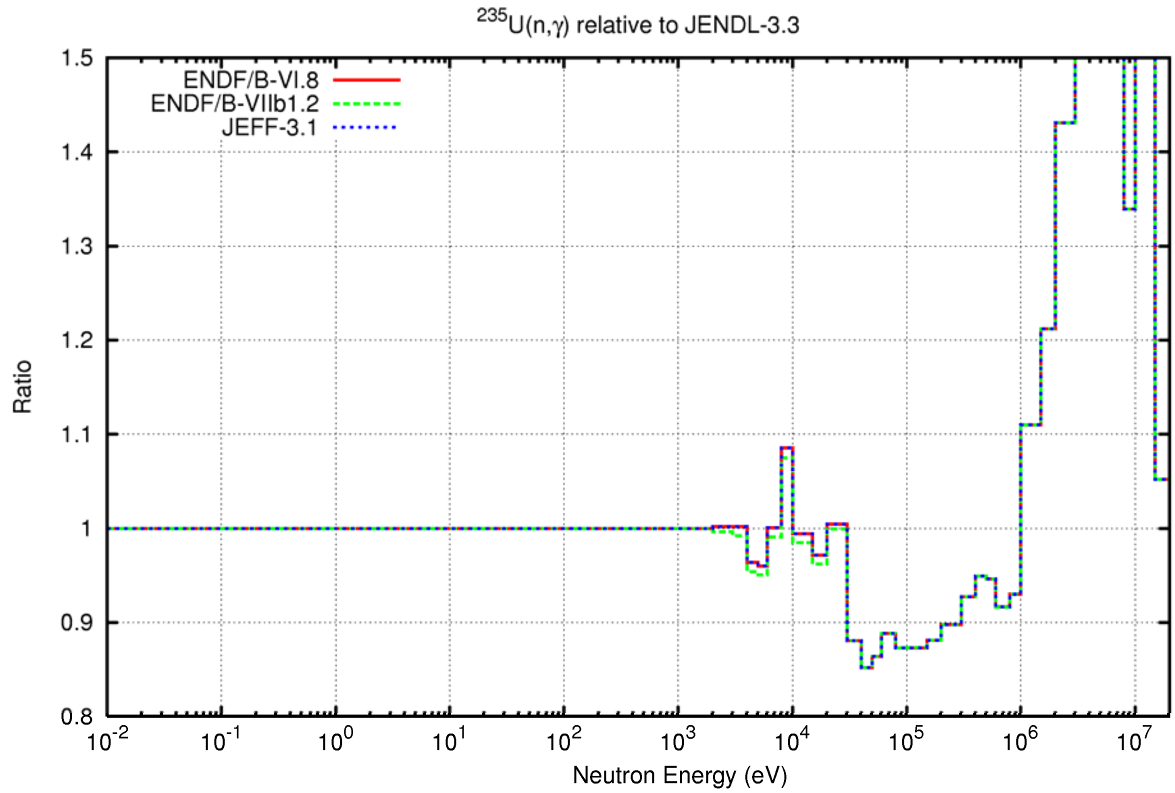

Fig. 1 Capture cross sections of ^{235}U relative to JENDL-3.3

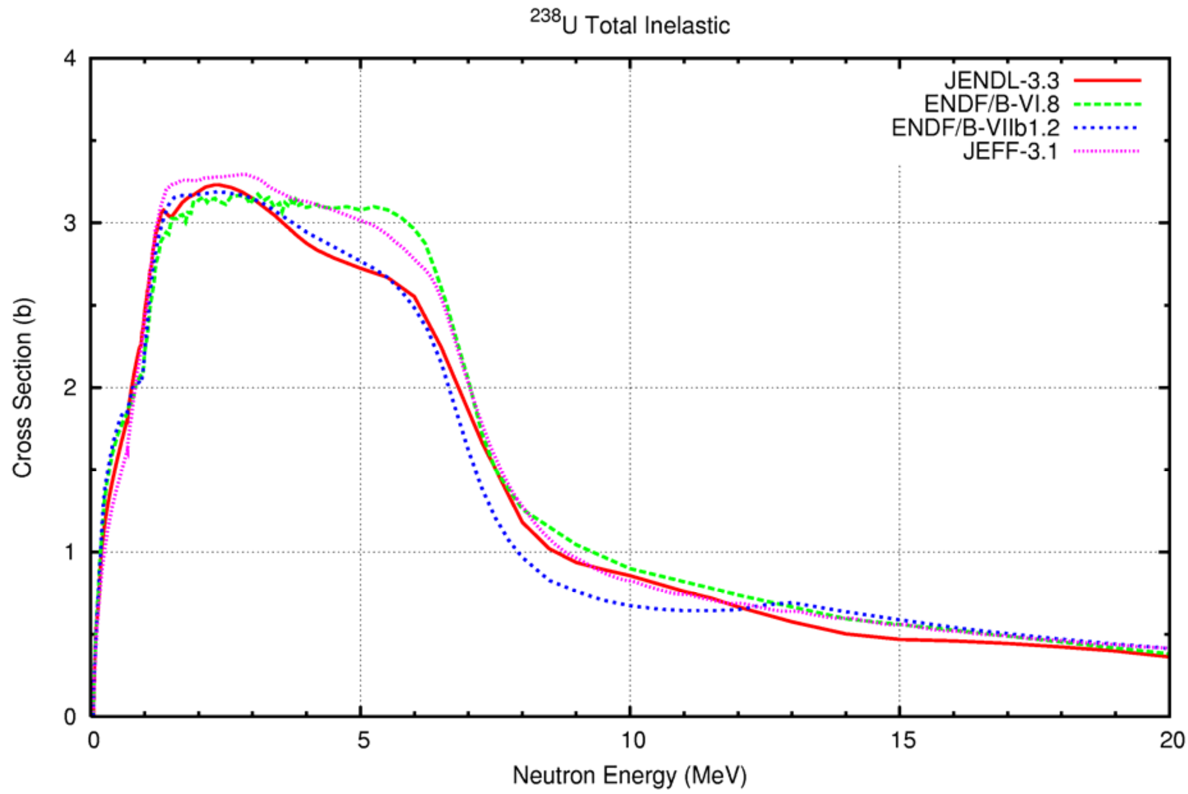

Fig. 2 Inelastic scattering cross sections of ^{238}U

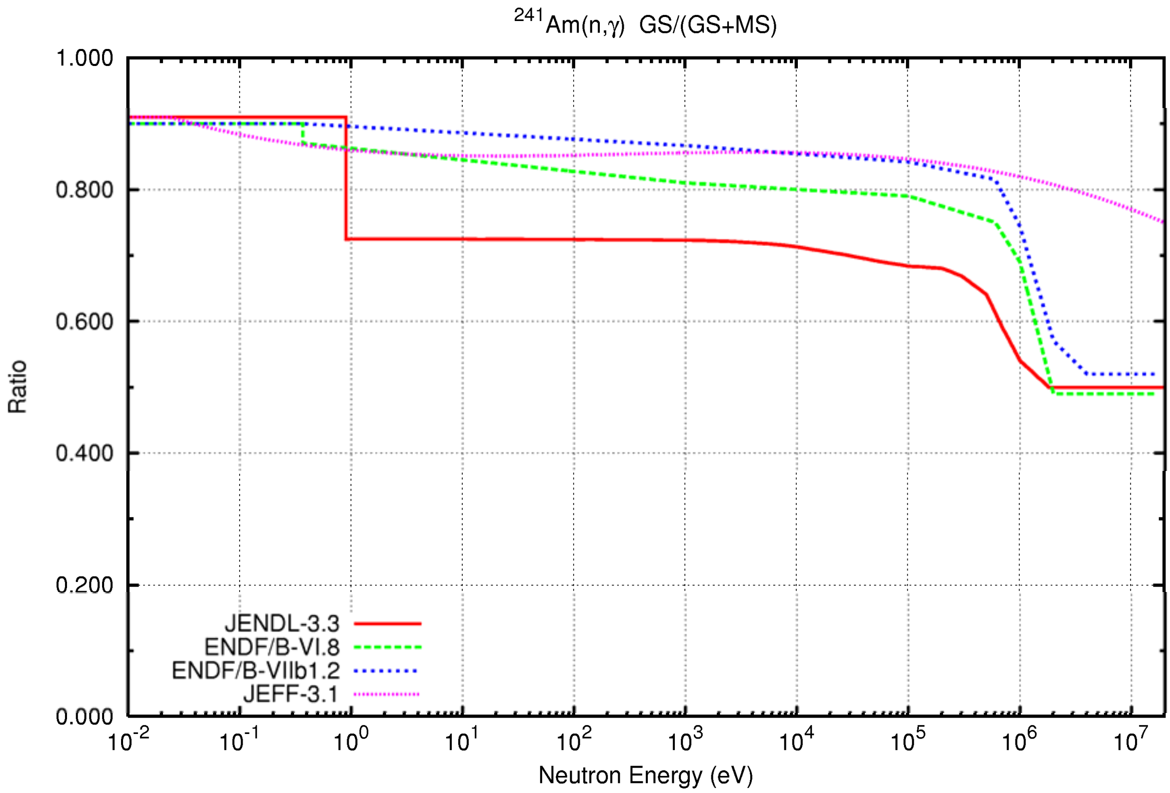

Fig. 3 Isomeric ratio of the ^{241}Am(n,γ) cross section

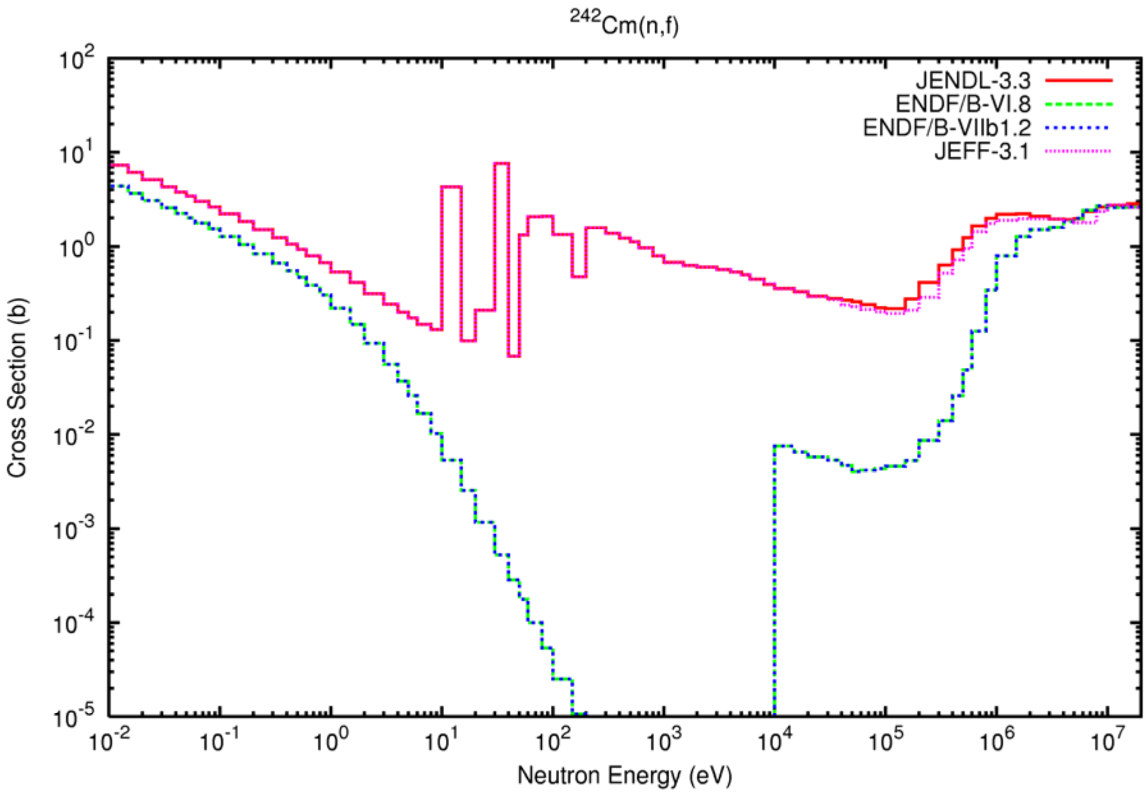

Fig. 4 Fission cross sections of ^{242}Cm

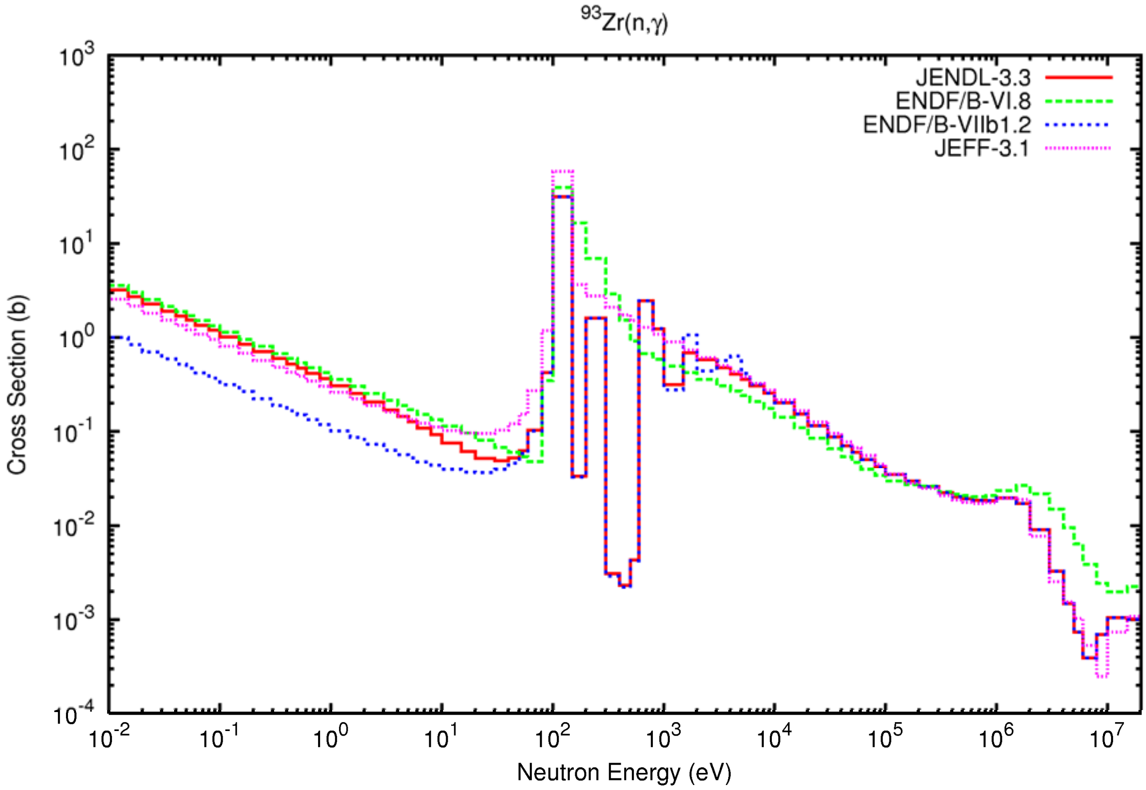

Fig. 5 Capture cross sections of ^{93}Zr

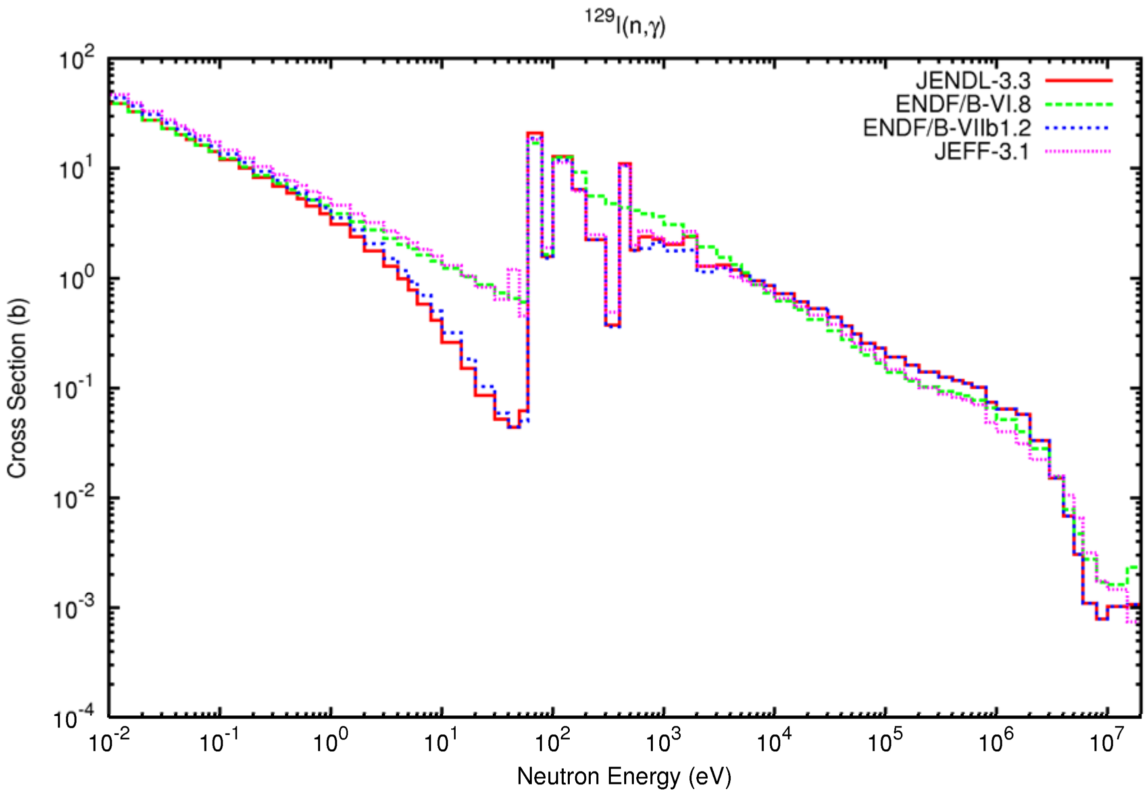

Fig. 6 Capture cross sections of ^{129}I

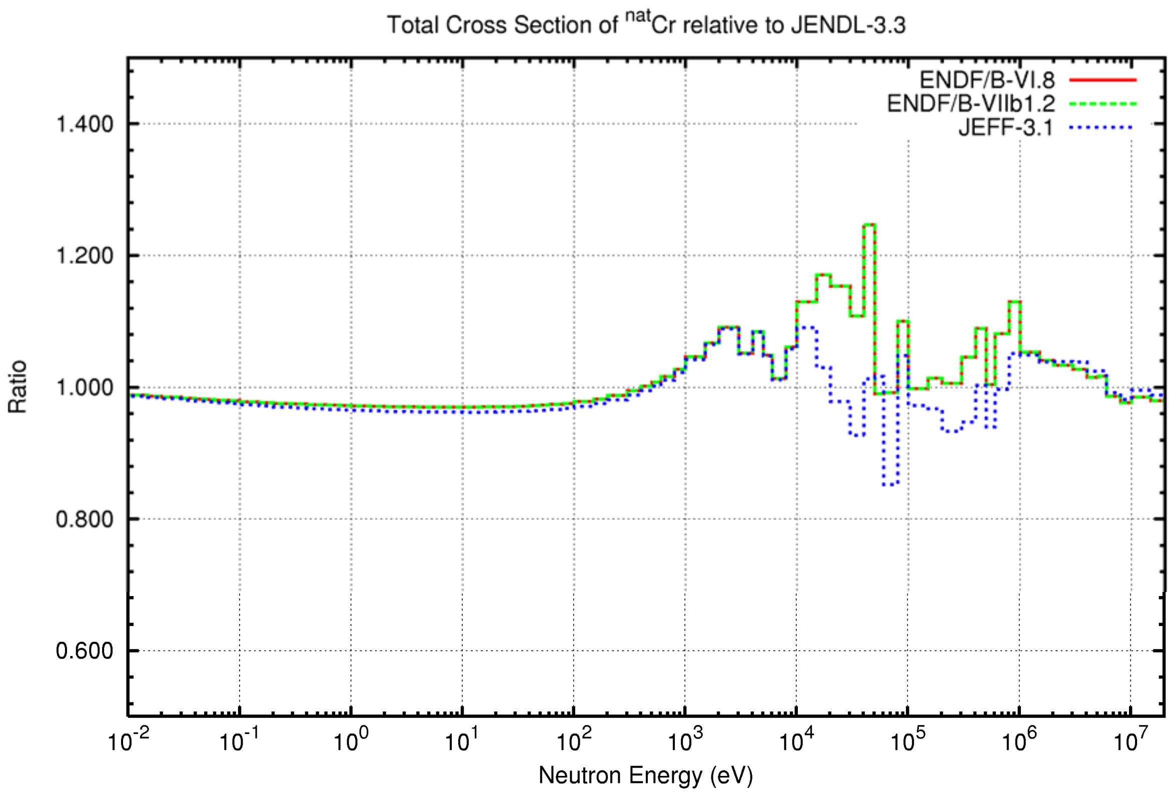

Fig. 7 Total cross sections of elemental Cr relative to JENDL-3.3