Update neutron nuclear data evaluation for ^{236,238}Np

Guochang Chen[1], Wentian Cao[2], Jimin Wang[1], Baosheng Yu[1], Guo-you Tang[2]
1. China Nuclear Data Center, China Institute of Atomic Energy, Beijing 102413, China
2. State Key Laboratory of Nuclear Physics and Technology, School of Physics, Peking University, Beijing 100871, China

1. Introduction

The nuclear data with high accuracy for actinides play an important role in nuclear technology applications, including reactor design and operation, fuel cycle, estimation of the amount of minor actinides (MAs) in high burnup reactors and to research to transmute the MAs to short half-lived nuclides or stable ones [1].

The nuclides of ^{236}Np are generated via the α-decay of ^{240}Am or ^{237}Np(n, 2n) and ^{237}Np(d, t) reactions. And the nuclides of ^{238}Np are generated via the α-decay of ^{242}Am or ^{237}Np(n, γ) and ^{237}Np(d, p) reactions. In the present work, according to the systematic trend of the total cross section and elastic cross section etc. of different Np isotopes, and based on the neutron optical model parameters (OMP) of ^{237}Np, a new set of neutron optical model parameters were obtained for ^{236,238}Np. Based on the new set OMP and the systematic trend of the cross sections of different Np isotopes, a full set of ^{236,238}Np neutron nuclear data has been updated and improved by theoretical calculation. The present result has significant improvements over the data in CENDL-3.1 [2].

2. Reevaluation for ^{236,238}Np

After CENDL-3.1 evaluation, there have not new measurements in n+^{236,238}Np and only the data in JENDL-4.0 [3] is new evaluated. In the present evaluation, we analyze and conclude the status of CENDL-3.1 and the the systematic trend of reaction cross section of different Np isotopes, modify and update the OMP, direct reaction contribution, inelastic scattering cross section and fission cross section. Other data file is directly adopted from CENDL-3.1.

2.1 Update OMP

The optical model parameters are the base of theoretical calculation, which will influence the total cross section, elastic scattering, inelastic scattering and their differential cross sections. In the present work, according to the systematic trend of the total cross section and elastic cross section etc. of different Np isotopes, and based on the neutron optical model parameters of ^{237}Np, a new set of neutron optical model parameters were obtained for ^{236,238}Np. The OMP of n+^{237}Np reaction is listed in **Table 1**, which are included proton, alpha, deuterium, tritium emission OMP.

The comparison between present results and other evaluation data in ^{238}Np(n, tot) and (n, el) reactions is shown in **Fig. 1.** The present result is similar as JENDL-4.0, however the evaluated data of JEFF-3.1 is quite different with other evaluations.

2.2 Inelastic Scattering Cross Section

35 discrete levels of ^{238}Np are taken into account in model calculation for inelastic scattering cross section, and the first collective band of ^{238}Np are taken into account in direct inelastic scattering calculation using ECIS code [4]. The spin of ground state of is 6^-, and the first excited state is only given the spin information as 1. According to the theoretical calculation results using DWBA method, we assume the parity of the first excited state is "+". Up to the fourth

excited states were taken into account in direct inelastic scattering calculation using DWBA method. The calculated results of inelastic scattering cross section of ^{236,238}Np are shown in **Fig. 2**.

Table 1 Optical model parameters of n+^{237}Np

Parameter	OMP of different emission particals				
	neutron	proton	alpha	deuterium	tritium
AR	0.595	0.500	0.520	0.810	0.750
AS	0.592	0.510	0.490	0.680	0.750
AVV	0.591	0.510	0.490	0.680	0.750
ASO	0.565	0.500	0.510	0.810	0.750
XR	1.279	1.250	1.350	1.150	1.200
XS	1.022	1.250	1.350	1.340	1.200
XV	1.222	1.250	1.350	1.340	1.200
XSO	1.279	1.250	1.350	1.150	1.200
XC	1.250	1.250	1.350	1.150	1.300
UO	0.135	-2.700	0.000	0.000	0.000
U1	0.293	0.220	0.000	0.000	0.000
U2	-0.009	0.000	0.000	0.000	0.000
VO	49.145	54.000	151.900	81.000	165.000
V1	-0.040	-0.320	-0.170	-0.220	-0.170
V2	-0.015	0.000	0.000	0.000	0.000
V3	-24.000	24.000	50.000	0.000	-6.400
V4	0.000	0.400	0.000	2.000	0.000
VSO	6.200	6.200	2.500	7.000	2.500
WO	9.206	11.800	41.700	14.400	46.000
W1	0.037	-0.250	-0.330	0.240	-0.330
W2	-12.000	12.000	44.000	0.000	0.000
A2S	0.700				
A2V	0.700				

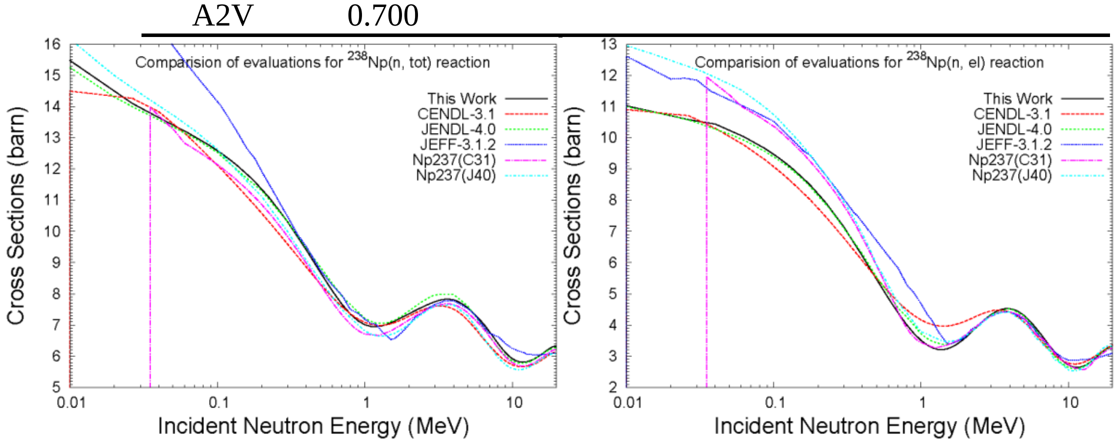


Fig. 1 Comparison of evaluated data for (n, tot) and (n, el) reaction of ^{238}Np

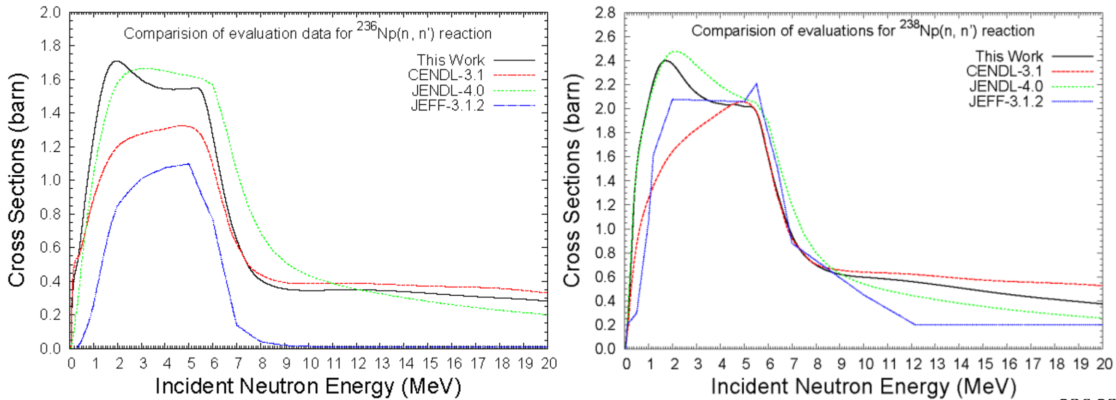


Fig. 2 Comparison of evaluated data for inelastic scattering cross section of $^{236,238}Np$

2.3 Fission Cross Section

$^{236,238}Np$ fission cross section is no reaction threshold, so the first fission reaction contribution is decrease with the incident neutron energy. The calculation results of $^{236,238}Np$ fission cross section is shown in **Fig. 3**. The present evaluated results agree well with the simulated (n, f) cross sections for exotic actinide nucleithe of H.C.Britt and J.B.Wilhelmy [5].

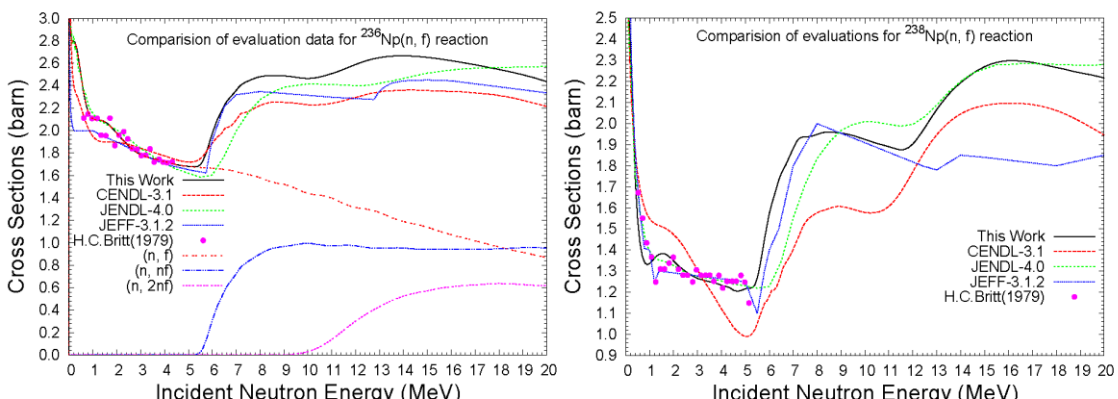


Fig. 3 Comparison of evaluated data for (n, f) reaction of $^{236,238}Np$

2.4 Differential Cross Section

Based on the new set of OMP and other theoretical calculated parameters, the differential cross sections for $^{236,238}Np$ are obtained using FUNF code [6]. The comparison between present results and other evaluated data in elastic scattering angular distribution at 14 MeV is shown in **Fig. 4**. At forward angle, the evaluated data agree well with each other in shape and amplitude. At backward angle, there are exist discrepancy each other in shape and amplitude. The Madland-Nix method is applied to calculate fission spectra. The comparison of fission spectra with different incident neutron energy is shown in **Fig. 5**. The shape of fission spectra with different incident neutron energy is reasonable.

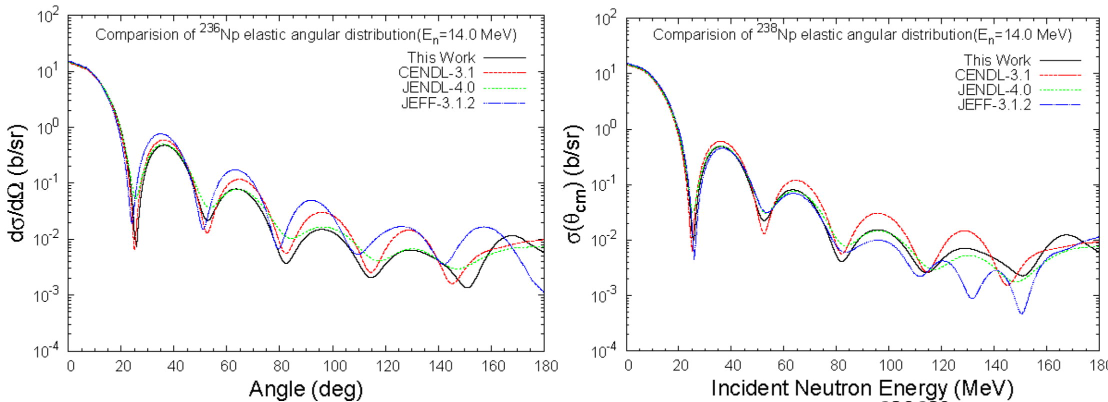
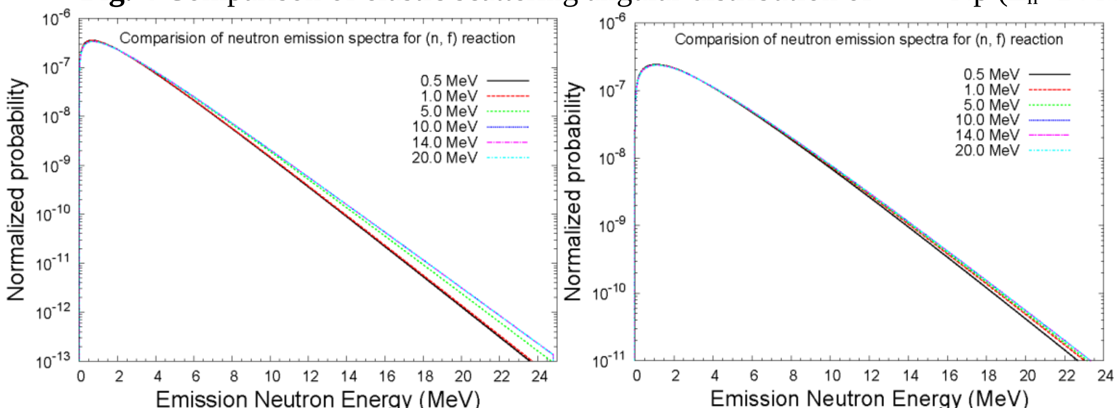


Fig. 4 Comparison of elastic scattering angular distribution of ^{236,238}Np (E_n=14 MeV)



(a) ^{236}Np fission spectra (b) ^{238}Np fission spectra

Fig. 5 Comparison of fission spectra of ^{236,238}Np

3. Conclusion

According to the systematic trend of the total cross section and elastic cross section etc. of different Np isotopes, and based on the neutron optical model parameters of ^{237}Np, a new set of neutron optical model parameters were obtained for ^{236,238}Np. Based on the new set OMP and the systematic trend of the cross sections of different Np isotopes, a full set of ^{236,238}Np neutron nuclear data has been updated and improved by theoretical calculation. The present result has significant improvements over the data in CENDL-3.1 in inelastic scattering cross section, fission cross section, (n, 2n) etc. The present results are more reasonable than the data in CENDL-3.1.

References

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