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Evaluation of Activation Cross Sections for (n,2n) Reactions on Some Nuclei

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Abstract

The evaluations of activation cross sections of (n,2n) reaction for ^{58}Ni, ^{87}Rb, ^{89}Y, ^{90}Zr, ^{140}Ce and ^{169}Tm were performed in order to update the previous evaluated data. The cross sections are recommended based on the recent experimental data, especially the new measured results in CIAE. The present evaluated data are compared with other evaluated data.

The activation cross sections are very useful in fusion research and other applications such as radiation safety, environmental, neutron dosimetry and material damage. More efforts are required to identify and resolve the differences and discrepancies in the existing activation cross sections from different laboratories. The main characteristics of the evaluated activation cross sections in this work are as follows :

1 Most of the activation cross sections mentioned above have been measured

in CIAE. A project of activation cross sections measurements and evaluation have been under–way in CIAE for a long period. The new measured data could contribute to this evaluated work and modify the recommended data.

2 The activation cross section in the so–called 'gap' energy region 5～12 MeV are being researched using the activation method with quasi–energetic neutron produced by the $^{1}H(^{11}B,n)^{11}C$ reaction at JAERI and by D(d,n) reaction using D–D gas target at variable energy compact Cyclotron CV 28 FRG (Julich, Federal Republic of Germany). These newly measured data could supplement the scarce data in this energy region, and modify the previous evaluation.

3 In order to eliminate the discrepancies in the existing activation cross sections, the background neutron yield from both "gas–out" effect and D–D breakup needs to be accurately determined and abstracted. It was noted that both effects increase with the neutron energy and strongly depend on the threshold of the specific reaction. Recently, the accurate experimental data have been obtained in many laboratories.

(1) ^{58}Ni

The cross sections for $^{58}Ni(n,2n)^{57}Ni$ reaction above 15 MeV were measured mainly by Paulsen[1], Bayhurst[2], Zhao Wenrong[3] and Pavlik[4]. there are large discrepancy among these measured data sets.

Paulsen[1] measured the data early, Pavlik[4] measured in 1982 and revised in 1985. Meanwhile, the new data of Pavlik[4] span a wide energy region from threshold to 19 MeV.

The half–life of residual nuclei ^{57}Ni are known very well (36 h), the characteristic gamma ray 1378 keV has a branching ratio 0.779, which are adopted in the world after 1982. The corrections for the characters of gamma ray of ^{57}Ni are negligible.

The recommended data above 15 MeV were determined based on measured data by Pavlik[4]. The evaluated data are shown in Fig. 1.

(2) ^{87}Rb

For $^{87}Rb(n,2n)$ cross section, the experimental data are scarce. At present, the cross section was evaluated based on the experimental data and theoretically calculated data. The evaluated data are compared with those from

ENDF / B–6. Both evaluated data are consistence with each other in their tend. However, the discrepancies exist in the energy region from 13 to 15 MeV. Present evaluated data shown in Fig. 2 are consistent with the existing measured data given by R. Pepelinik[5] and Yuan Xialin[6].

(3) ^{89}Y

For ^{89}Y(n,2n)^{88}Y reaction there exist lots of measured data. The measured data by Zhao Wenrong[3] cover the energy region from 13 to 18 MeV and consist with the new measured data. At present work, the cross section was evaluated based on new experimental data, especially the measured data in CIAE from 13 to 18 MeV. The previous evaluation is modified and the data are shown in Fig. 3.

(4) ^{90}Zr

For this nuclide, there are many new experimental data. The evaluated data (Fig. 4) were based on these new measured data by Csicki[7], Ikeda[8], Kobayushi[9], Palvik[10] around threshold and above 18 MeV energy region. The evaluated data are compared with other evaluated data from ENDF / B–6, JENDL–3, BRON–2 (Fig. 5).

(5) ^{140}Ce

The experimental data[2] exist only from 12 to 20 MeV. The cross section was evaluated based on these measured data (mainly from CIAE) and systematic (below 12 MeV). The evaluated data are shown in Fig. 6.

(6) ^{169}Tm

The cross section was evaluated based on experimental data. The existing experimental data from 8 to 13 MeV were measured by Frehaurst[11] with liquid tank method. The cross sections were measured relatively to the known cross sections of ^{238}U(n,f) reaction. In the measurements, the different ^{238}U(n,f) standard cross sections were used. Now, the cross sections, especially from 11 to 12 MeV energy region, were renormalized by using the new ^{238}U(n,f) cross section from ENDF / B–6. The new corrected values supersede the earlier data. The previous evaluated data are modified and the evaluated data are shown in Fig. 7.

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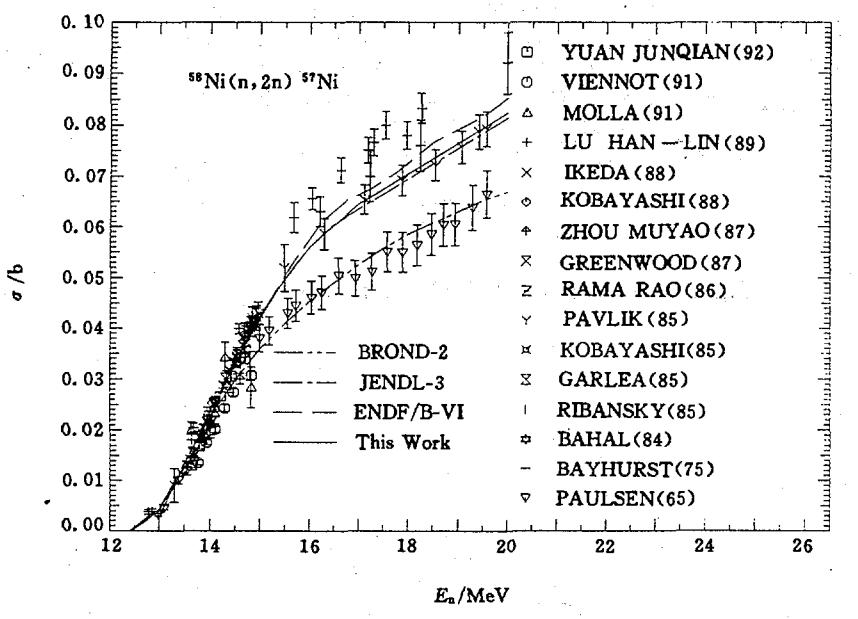

Fig. 1 The evaluated ^{58}Ni(n,2n) cross section

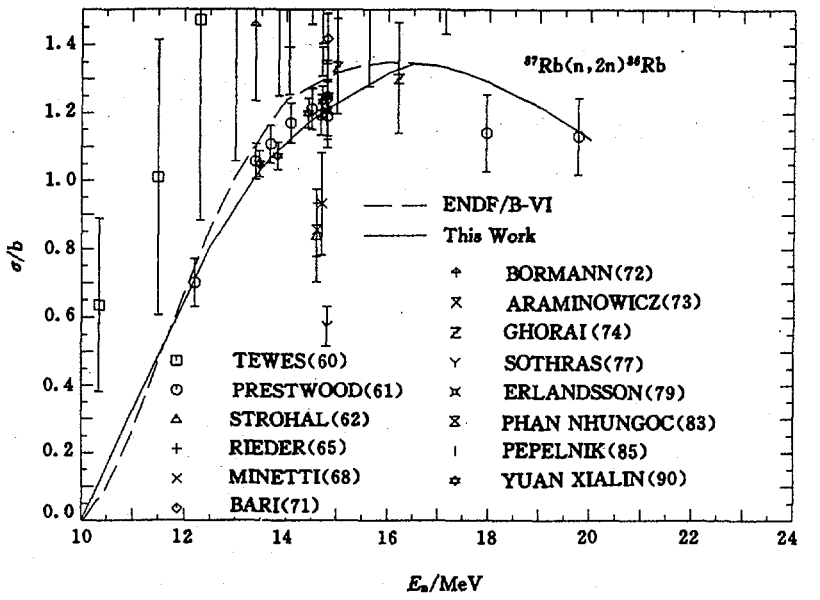

Fig. 2 The evaluated ^{87}Rb(n,2n) cross section

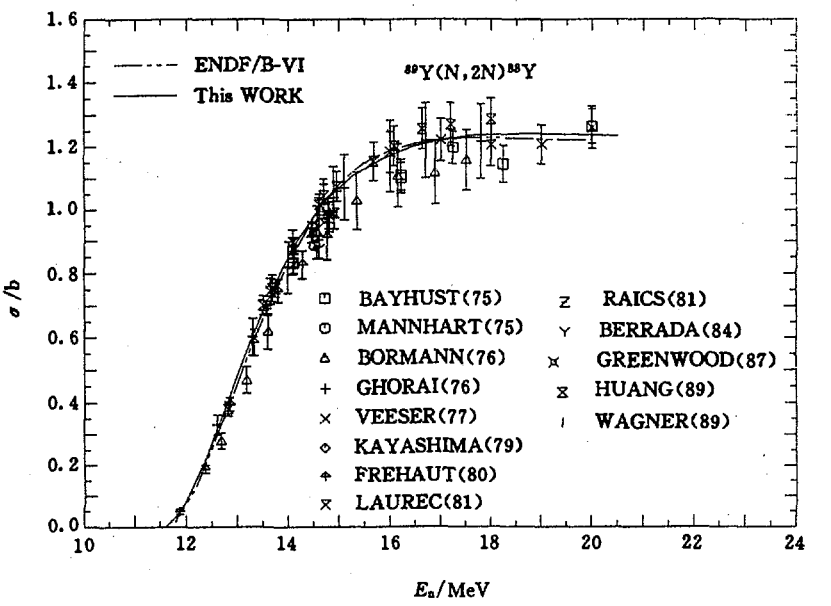

Fig. 3 The evaluated ^{89}Y(n,2n) cross section

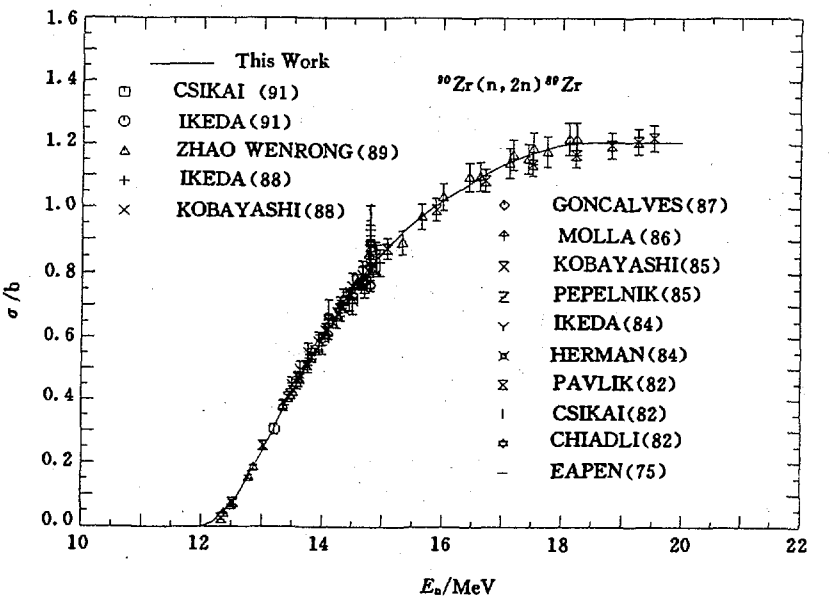

Fig. 4 The evaluated ^{90}Zr(n,2n) cross section

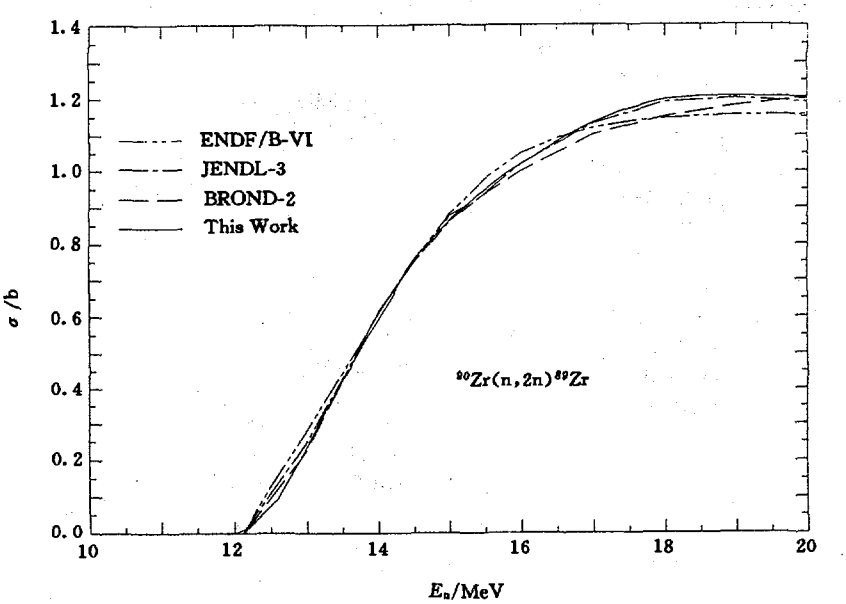

Fig. 5 Comparison between the evaluated data for ^{90}Zr(n,2n) reaction

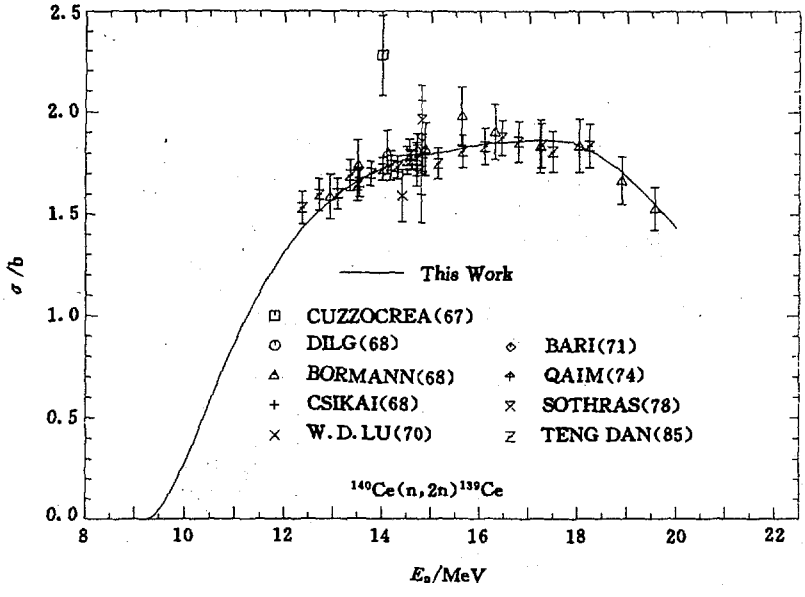

Fig. 6 The evaluated ^{140}Ce(n,2n) cross section

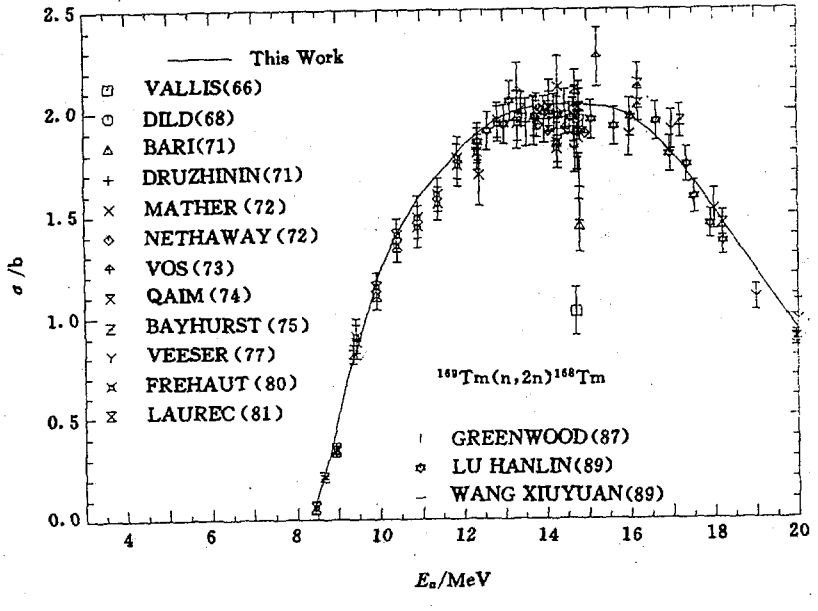

Fig. 7 The evaluated ^{169}Tm(n,2n) cross section

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Sensitivity of *Logft* on ε Branching to Ground State of ^{197}Au in Decay of ^{197}Hg

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The decay scheme of ^{197}Hg (64.14 h) is fairly established[1], as shown in Fig. 1. In the decay scheme adopted in the Table of Isotopes (7th edition) [2] there is no electron capture branching to the ground state of ^{197}Au and ε transition proceeds by 99% and 1% to the 77.35 and 268.71 keV states respectively. The later evaluation of decay data for $A = 197$[1] attributed about 5.6% feeding to the ground state of ^{197}Au. The evaluated value is estimated from the assumption that the β–transition rate logft of ^{197}Hg (ground state) → ^{197}Au (ground state) is equal to β^-–transition rate logft of ^{197}Pt (ground state)→ ^{197}Au (ground state) ($logft = 7.33 \pm 0.12$ is known[1]). Its I_ε value is obtained from Fig. 2 where *logft*–values are calculated by using LOGFT code[3].

Recently the ε branching is estimated directly from the accurate measurement[4] of K x–ray and γ–ray intensity in the decay of ^{197}Hg (64.14 h)