Evaluation of Activation Cross Sections for (n,p) and (n,n'p) Reactions on $^{63,65,Nat}Cu$

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Introduction

Copper is a very important structure material in nuclear fusion engineering. The neutron activation cross section are very useful in fusion research and other applications such as radiation safety, environmental, material damage and neutron dosimetry. More efforts are required to identify and resolve the differences and discrepancies in the existing activation cross sections from different laboratories.

The natural copper consists of two stable isotopes, i.e. ^{63}Cu, ^{65}Cu. Their abundances and threshold energys are as in Table 1.

Table 1 Isotopic abundances and their reaction threshold energyies of copper

isotope	(n,p) thresh. / MeV	(n,n'p) thresh. / MeV	abun. / %
63	1.3698	6.2228	69.17
65	0	7.5605	30.83

The cross sections of (n,p) and (n,n'p) for $^{63,65,Nat}Cu$ are recommended based on the recent experimental data and theoretically calculated results[1] from threshold up to 20 MeV. The evaluated cross sections are given in Figs.1 ~ 6 with experimental data and compared with other evaluated data.

1 $^{63}Cu(n,p)^{63}Ni$ Reaction

For (n,p) reaction, the experimental data were measured by Zhao Wenrong (97), Greenwood (89) and Qaim (69)[2-4] in the energy range from 6.0 MeV to 15.0 MeV, respectively. The evaluated data were obtained by fitting experimental data from threshold energy to 15.0 MeV. Above 15.0 MeV, the recommended data were taken from calculated result, and normalized to the fitting experimental datum of 56 mb at 15.0 MeV. The comparison of experimental data with evaluated ones is shown in Fig.1.

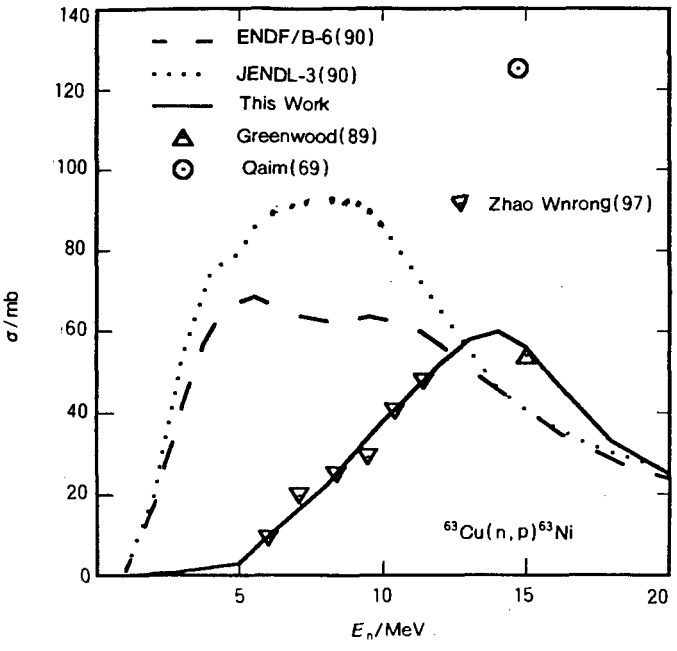

Fig. 1 (n,p) cross section for ^{63}Cu

2 ^{65}Cu (n,p)^{65}Ni Reaction

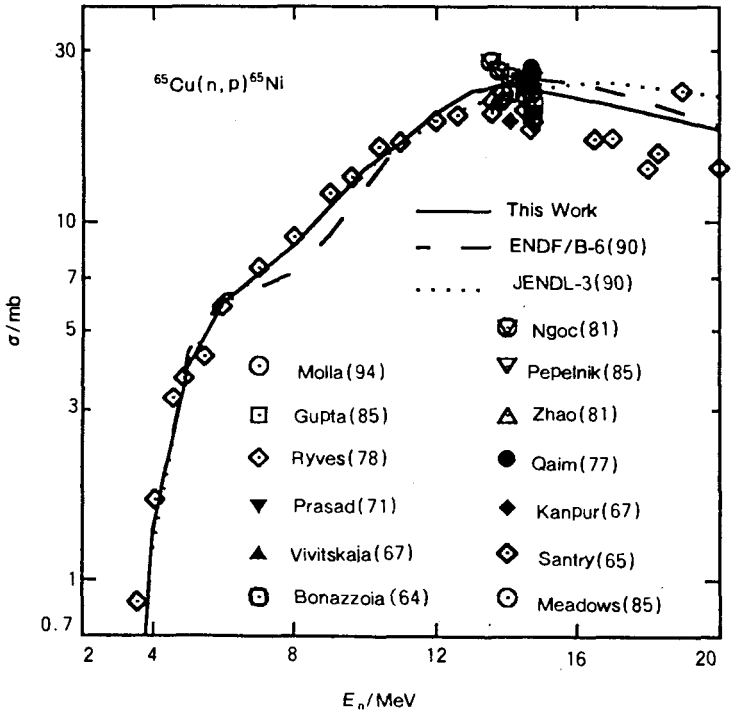

Fig. 2 (n,p) cross section for ^{65}Cu

The experimental data were measured by Molla (94), Meadows (85), Gupta (85), Ngoc (81), Zhao (81), Ryves (78), Qaim (77), Prasad (71), Kanpur (67), Vivitskaja (67), Santry (65) and Bonazzoia (64)[5~15] from 3.5 to 20.0 MeV, respectively. The evaluated data were obtained by fitting experimental data from threshold energy to 20.0 MeV. The comparison of experimental data with evaluated ones is shown in Fig.2.

3 $^{63}Cu(n,n'p)^{62}Ni$ Reaction

For (n,n'p) reaction, the experimental data were measured by Colli (59), Joensson (69) and Allan (57)[16~18] around 14.0 MeV. The recommended data were taken from calculated result, and normalized to the Colli experimental datum of 250 mb at 14.1 MeV, as shown in Fig.3.

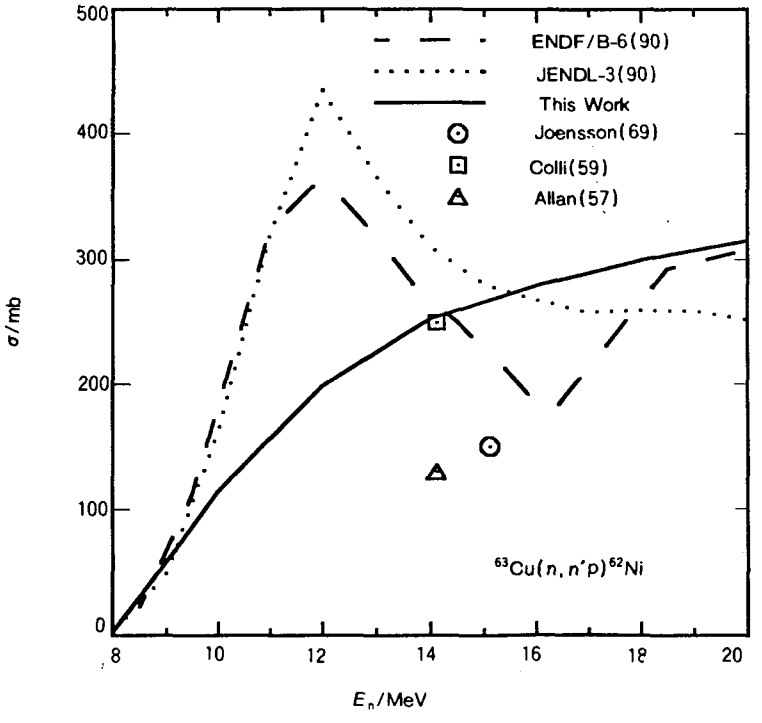

Fig. 3 (n,n'p) cross section for ^{63}Cu

4 ^{65}Cu (n,n'p)^{64}Ni Reaction

The experimental data were measured by Joensson (69) in 15.1 MeV energy point. The recommended data were taken from calculated result, and normalized to the experimental datum of 22 mb at 15.1 MeV as shown in Fig.4.

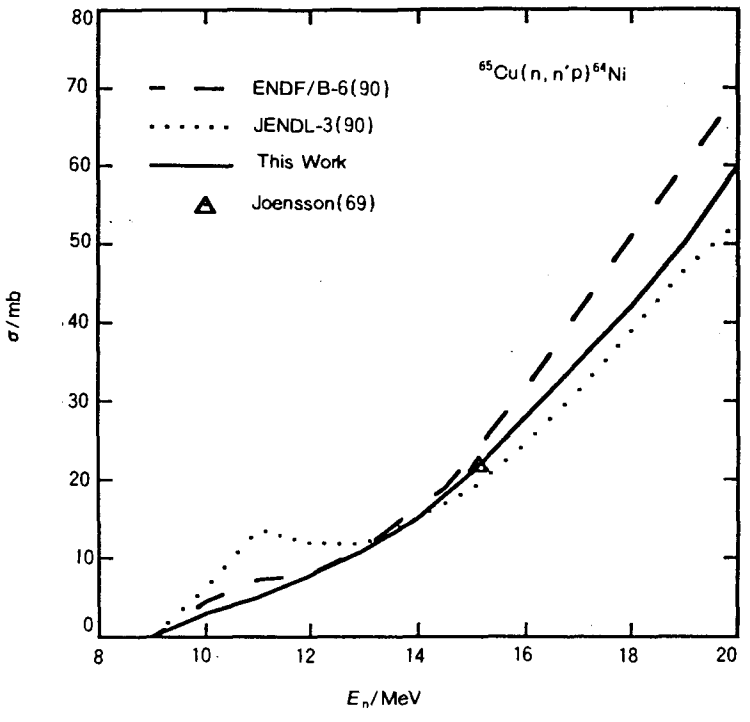

Fig. 4 (n,n'p) cross section for ^{65}Cu

5 The (n,p) and (n,n'p) Reaction for Natural Copper

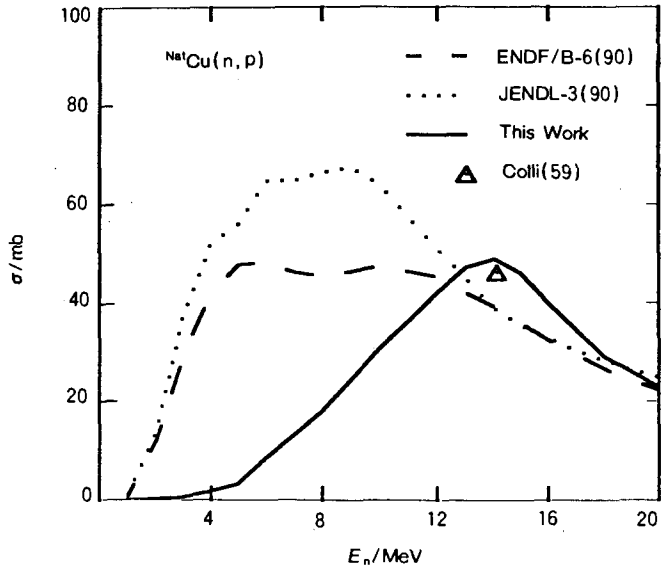

Fig. 5 (n,p) cross section for ^{Nat}Cu

For natural Cu, the experimental datum was measured by Colli (59) at 14.1 MeV energy point. The (n,p) and (n,n'p) cross sections of natural Cu were obtained from summing the isotopic data weighted by the abundance. The comparison of experimental data with evaluated ones is shown in Fig.5 and 6. It is found that the present evaluations are in agreement with the experimental data.

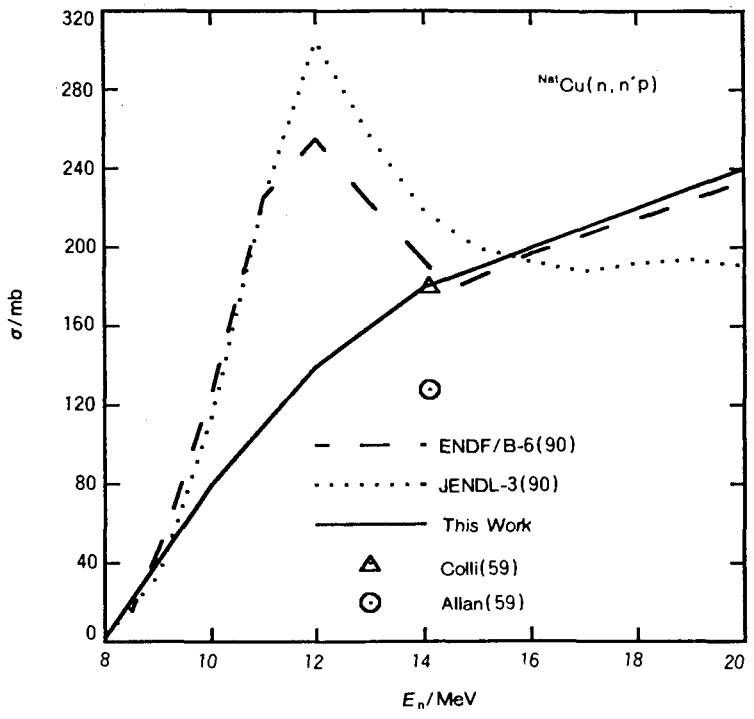

Fig. 6 (n,n'p) cross section for ^{Nat}Cu

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Calculation and Evaluation of the Activation Cross Sections for $^{187}Re(n,2n)^{186m,g}Re$ Reactions

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The activation cross sections for $^{187}Re(n,2n)^{186m,g}Re$ reactions are calculated using UNF code. The calculations are in good agreement with the re-evaluated measured data. Finally the excitation function for $^{187}Re(n,2n)^{186m,g}Re$ reactions are evaluated and recommended based on present calculations and evaluated decay data.

Introduction

Metal rhenium is one of fusion reactor materials. Their cross section for $^{187}Re(n,2n)^{186}Re$ reaction is an important datum for the safety and environmental evaluation of fusion reactor. These cross sections are very scarce and only provided by several laboratories around 14 MeV. Among these measurements there exist large discrepancies for $^{187}Re(n,2n)^{186g}Re$ reaction and large errors for $^{187}Re(n,2n)^{186m}Re$ reaction. Therefore the theoretical calculation is necessary. On the other hand the evaluation of the activation cross sections for $^{187}Re(n,2n)^{186m,g}Re$ reactions should be done so as to meet the nuclear science and technology applications.

1 Decay Data

For the cross section value of isomeric state measured by Lu Hanlin or Y. Ikeda[1] plus ground state by Fan Tieshuan[2] at 14.8 MeV, one can easy find that the