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Calculation and Analysis of Neutron Induced Reaction on ^{185,187}Re and ^{Nat}Re

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Abstract

Based on the relevant experimental data of Re and neighbor nucleus W, and the theoretical model calculations, neutron induced reaction cross sections, the energy spectrum, angular distribution, double differential cross section and γ-production data were calculated for ^{185,187,Nat}Re at incident neutron energies below 20 MeV. The calculated results were compared with experimental data.

Introduction

The cross sections of neutron induced reactions on ^{185,187,Nat}Re are important for nuclear science and technology. Because the experimental data are less, the theoretical calculation is necessary and interesting. The purpose of this work is to calculate all data of n+^{185,187,Nat}Re reactions.

In Sec.1 the theories and parameters used in the calculation are described. The calculated results and analyses are given in Sec.2. Finally, a summary is given in Sec.3.

1 Theories and Parameters

The calculation was made with the semi-classical theory code UNF[1].

First, the code APOM[2], by which the best neutron optical potential parameters can be searched automatically with fit relevant experimental total, nonelastic scattering cross sections and elastic scattering angular distributions, was used to obtain a set of optimum neutron optical potential parameters of ^{185,187,Nat}Re. Because there are no experimental data of elastic scattering angular distributions for Re, so we choose neutron elastic scattering angular distributions of W, which is neighbors nucleus of Re. A set of optimum neutron optical potential parameters of Re are obtained as follows:

$$V = 57.4563+0.1556E-0.02241E^2-24(N-Z)/A$$
$$W_S = \max\{0.0, 8.0057- 0.4181E-12.0(N-Z)/A\}$$
$$W_V = \max\{0.0, 0.06646+0.1891E-0.003214E^2\}$$
$$U_{SO} = 6.2$$
$$r_R = 1.1204, \quad r_S = 1.4095, \quad r_V = 1.6771, \quad r_{SO} = 1.1204$$
$$a_R = 0.4900, \quad a_S = 0.3970, \quad a_V = 0.9298, \quad a_{SO} = 0.4900$$

Using this set of neutron optical potential parameters, adjusting charged particle optical potential parameters and level density parameters, all cross sections of n+^{185,187,nat}Re reactions were calculated by the code UNF[1]. The direct inelastic scattering data were calculated by the code DWUCK4[3]. The exciton model parameter K was taken as 2200 MeV^3. All experimental data were taken from EXFOR library.

2 Calculated Results and Analyses

Fig.1 shows the comparison of neutron total cross section for ^{Nat}Re in energy region 0.001 ~ 20 MeV between the theoretical values (solid line) and experimental data. The calculated results are in good agreement with experimental data for energy $E_n \geq 0.5$ MeV, while for energy $E_n < 0.5$ MeV, the calculated results are in agreement with experimental data taken from Ref.[4]. The comparison for calculated results and experimental data of elastic cross sections of n+^{Nat}Re reaction is given in Fig.2.

The theoretical calculated result is reasonable. The comparison between the theoretical results and experimental data of $^{185}Re(n,\gamma)^{186}Re$, $^{187}Re(n,\gamma)^{188}Re$ and $^{Nat}Re(n,\gamma)$ reaction cross sections are given in Figs.3 to 5, respectively, The calculated values are in good agreement with experimental data for $^{185}Re(n,\gamma)^{186}Re$ and $^{187}Re(n,\gamma)^{188}Re$ reaction cross sections, but for $^{Nat}Re(n,\gamma)$ reaction cross sections, the calculated results are lower than experimental data in energy region 2 ~ 5 MeV. The cross sections of $^{187}Re(n,p)^{187}W$ and $^{187}Re(n,\alpha)^{184}Ta$ reactions are given in Figs.6 and 7, respectively. The calculated cross section values pass through the existent experimental data within error bars, respectively. The comparison of theoretical calculated results and experimental data of $^{185}Re(n,2n)^{184}Re$ and $^{187}Re(n,2n)^{186}Re$ reactions are given in Figs.8 and 9, respectively. The calculated values are in agreement with the experimental data taken from Ref.[5] for $^{185}Re(n,2n)^{184}Re$ reaction cross sections, while for $^{187}Re(n,2n)^{186}Re$ reaction cross sections, the calculated values are higher than previous experimental data, but consistent with resent measured data by Fan Tieshuan[6], the theoretical calculated results are reasonable. Figs.10 and 11 illustrate all reaction cross sections of ^{185}Re and ^{187}Re, respectively. The energy spectrum, angular distribution, double differential cross section and γ-production data were obtained at incident neutron energies below 20 MeV. Because the calculated results for many channels are in pretty agreement with existing experimental data, the predicted cross sections are reasonable.

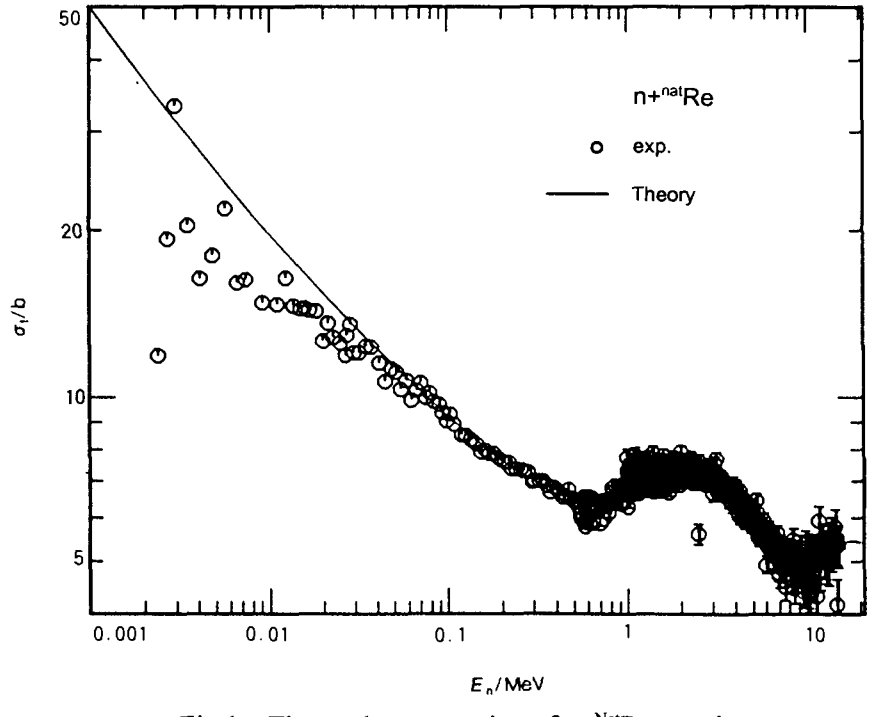

Fig.1 The total cross section of n+^{Nat}Re reaction

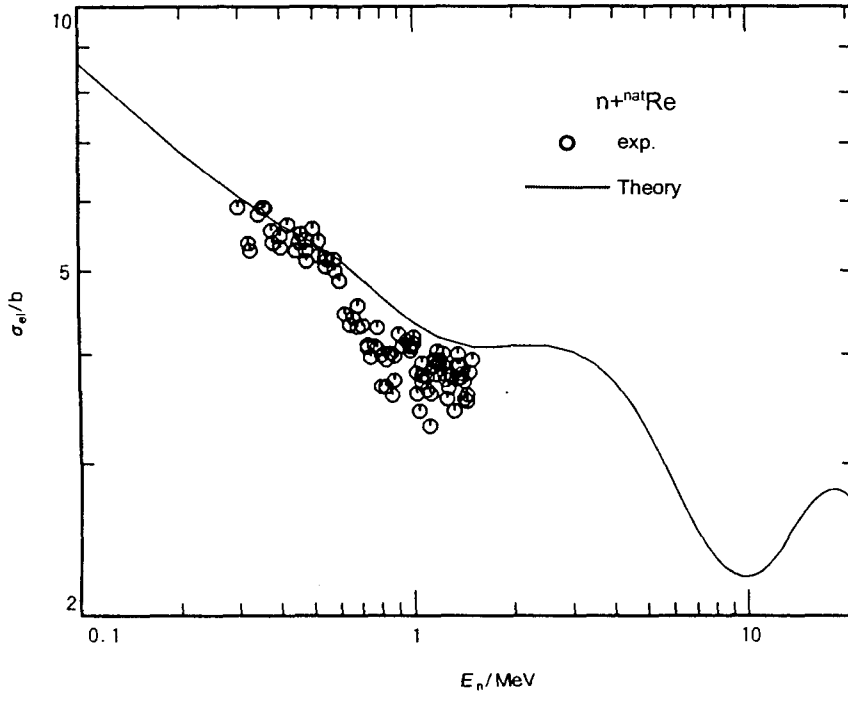

Fig.2 The elastic scattering cross section of n+^{Nat}Re reaction

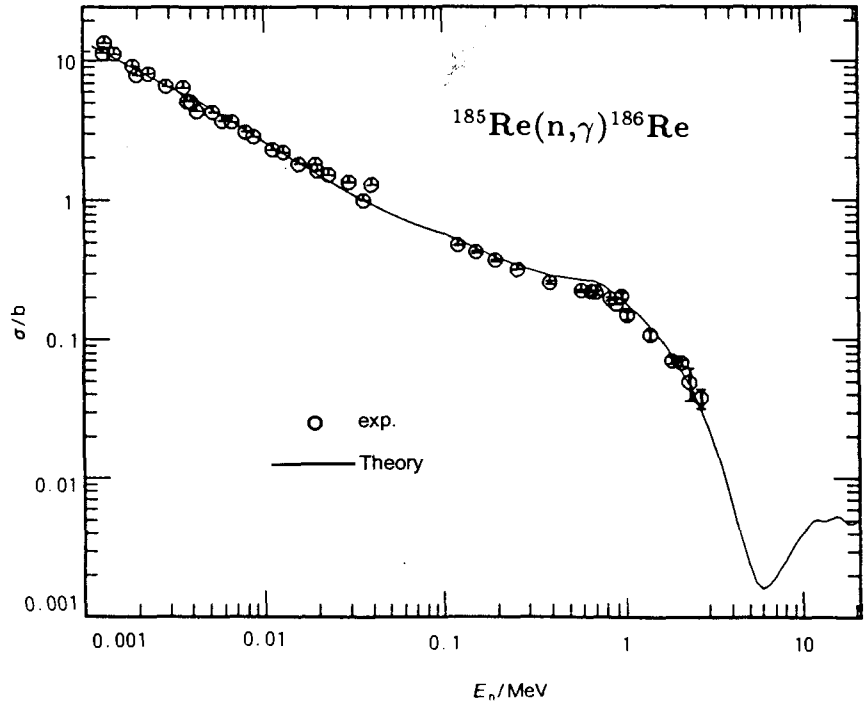

Fig.3 The cross sections of ^{185}Re(n,γ)^{186}Re reaction

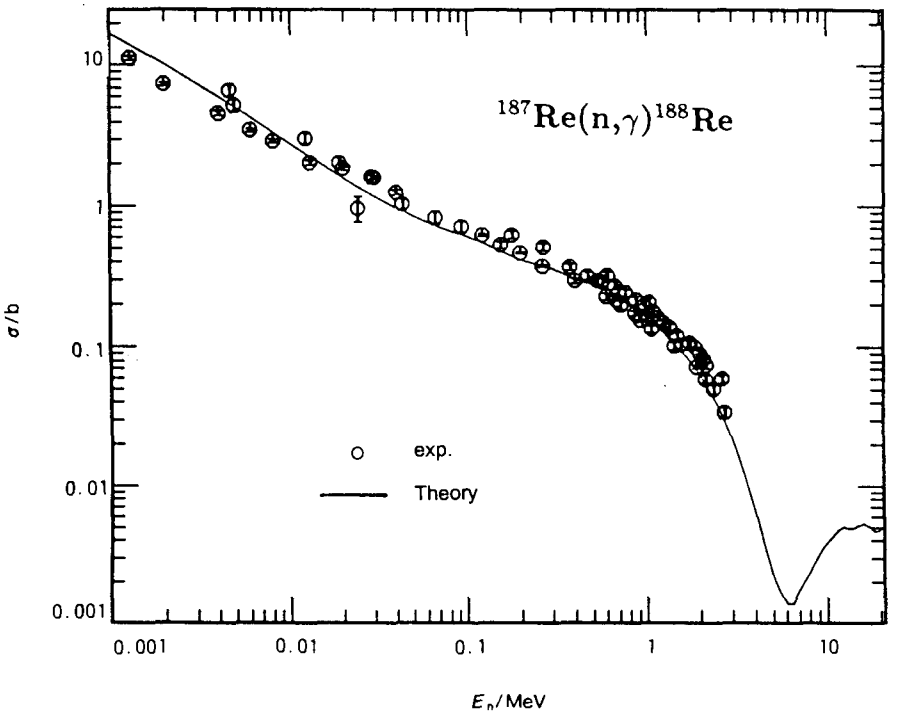

Fig.4 The cross sections of ^{187}Re(n,γ)^{188}Re reaction

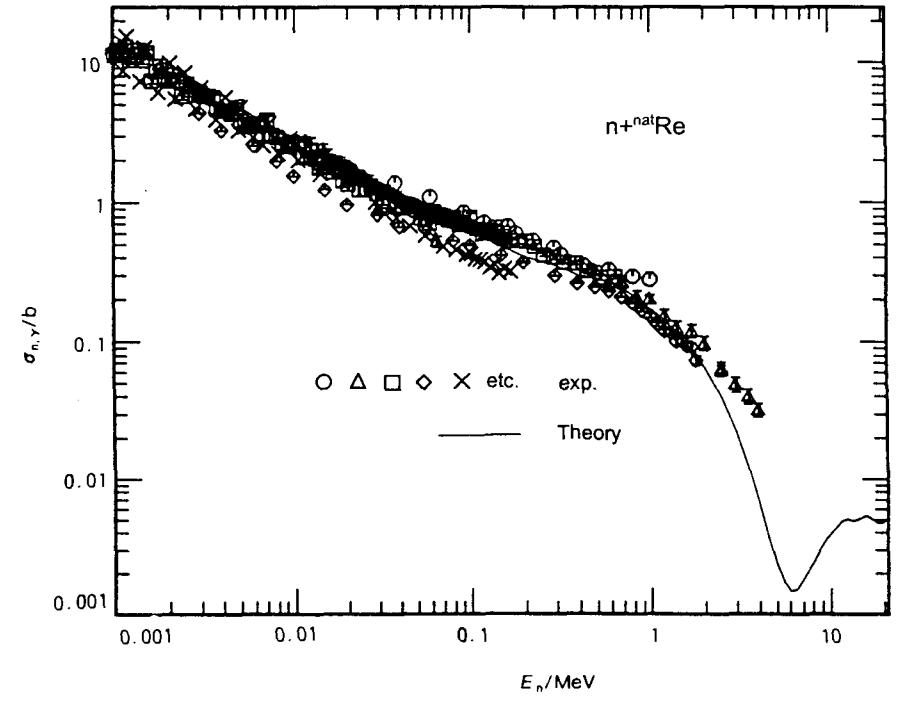

Fig.5 The cross sections of ^{Nat}Re(n,γ) reaction

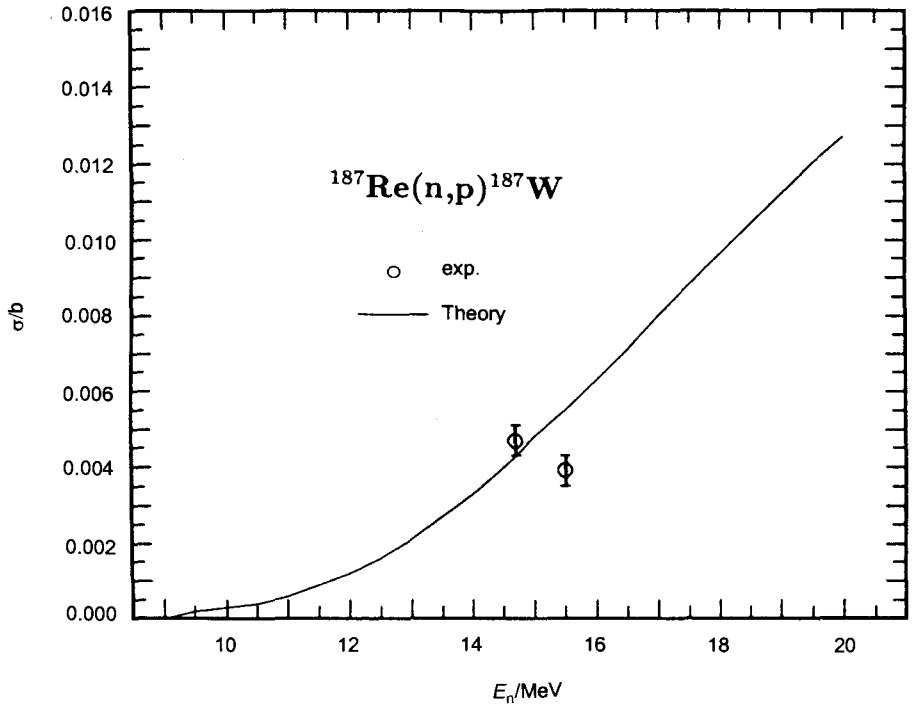

Fig.6 The cross sections of ^{187}Re(n,p)^{187}W reaction

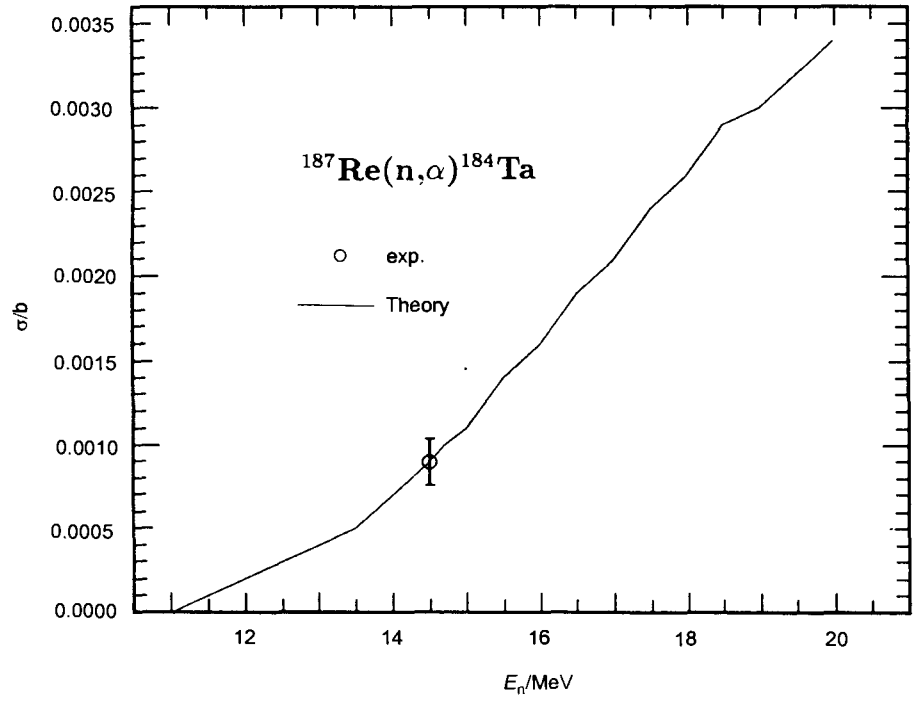

Fig.7 The cross sections of ^{187}Re(n,α)^{184}Ta reaction

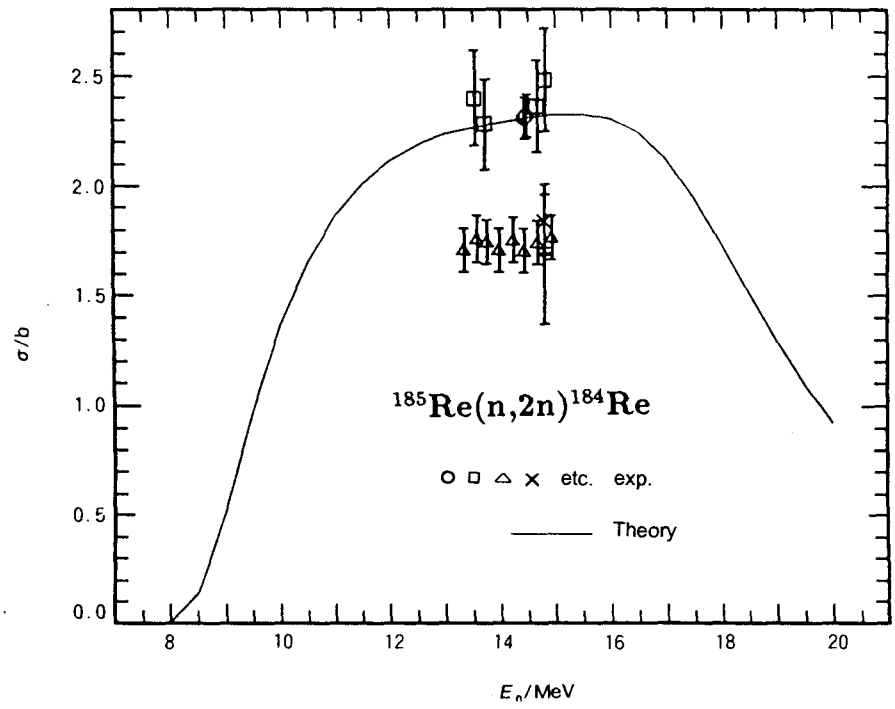

Fig.8 The cross sections of $^{185}Re(n,2n)^{184}Re$ reaction

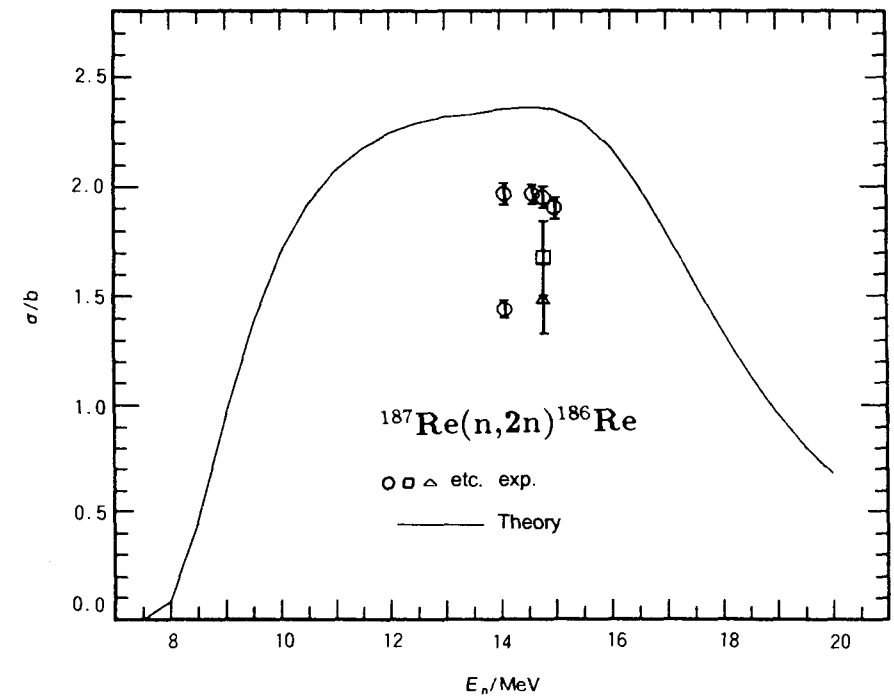

Fig.9 The cross sections of $^{187}Re(n,2n)^{186}Re$ reaction

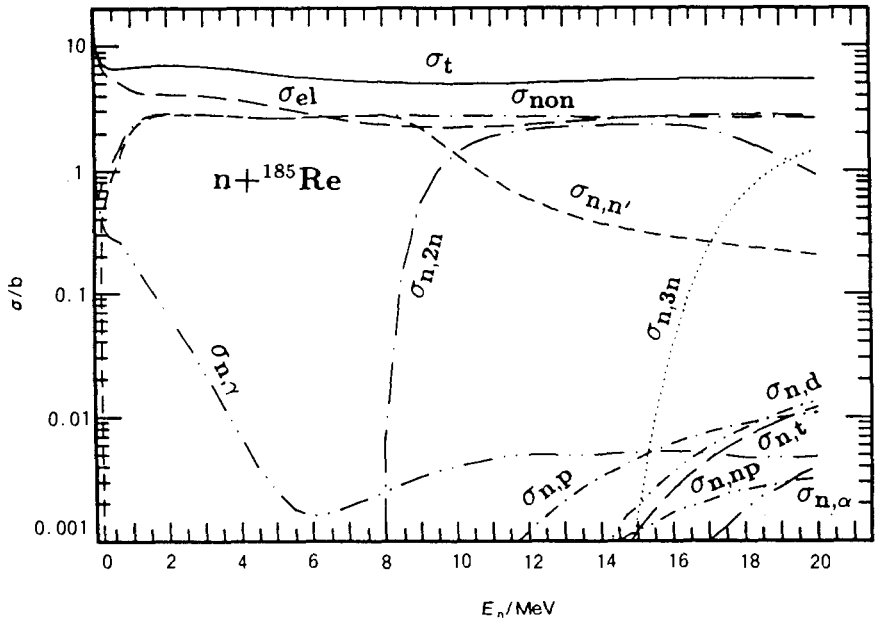

Fig.10 The cross sections of n+^{185}Re reaction

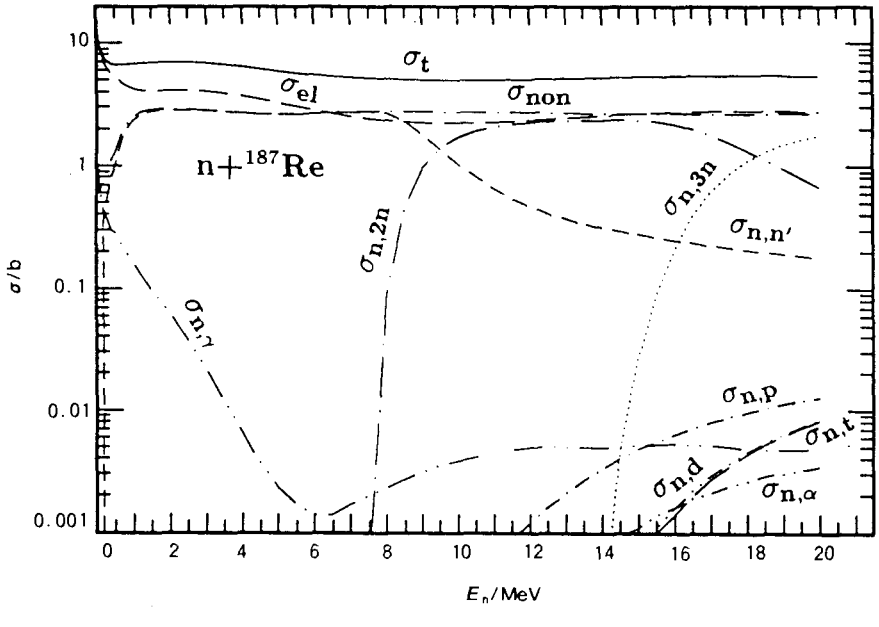

Fig.11 The cross sections of n+^{187}Re reaction

3 Summary

Based on the available experimental data of Re and neighbored nucleus W, we obtained a set of optimum optical potential parameters for $0.001 \leq E_n \leq 20$ MeV. With adjusted proton and alpha particle optical potential parameters, level density and giant dipole resonance parameters as well as K, all the cross sections of neutron induced reaction on ^{185,187,Nat}Re were obtained. Because the calculated results for many channels are in pretty agreement with existing experimental data, the predicted cross sections in energy range where there are no any experimental data are reasonable.

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Calculation of Cross Sections for n+^{63}Cu Reaction

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Abstract

Based on the relevant experimental data, and optical model, evaporation model, $J\pi$-dependent exciton model, and the pick-up mechanism of cluster pre-formation, neutron induced reaction cross sections, the energy spectrum, angular distribution, double differential cross section and γ-production data were calculated for ^{63}Cu at incident neutron energies below 20 MeV. The calculated results were compared with experimental data.