Study on keV-neutron capture cross sections and capture γ-ray spectra of $^{117, 119}$Sn

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The capture cross sections and capture γ-ray spectra of $^{117, 119}$Sn were measured in an incident neutron energy region from 10 to 100 keV and at 570 keV, using a 1.5-ns pulsed neutron source by the ^{7}Li(p,n)^{7}Be reaction and a large anti-Compton NaI(Tl) γ-ray spectrometer. A pulse-height weighting technique was applied to observed capture γ-ray pulse-height spectra to derive capture yields. The capture cross sections of $^{117, 119}$Sn were obtained with the error of about 5% by using the standard capture cross sections of ^{197}Au. The present cross sections were compared with previous experimental data and the evaluated values in JENDL-3.3 and ENDF/B-VI. The capture γ-ray spectra of $^{117, 119}$Sn were derived by unfolding the observed capture γ-ray pulse-height spectra. The calculations of capture cross sections and capture γ-ray spectra of $^{117, 119}$Sn were performed with the EMPIRE-II code. The calculated results were compared with the present experimental ones.

1. Introduction

Recently, a great interest has been taken in the study on the nuclear transmutation of Long–Lived Fission Products (LLFPs: ^{79}Se, ^{93}Zr, ^{99}Tc, ^{107}Pd, ^{126}Sn, ^{129}I, ^{135}Cs) generated in nuclear fission reactors. The neutron capture cross sections of LLFPs are important physical quantities for the study on the transmutation of LLFPs, because performance of transmutation system using neutron capture reaction mainly depends on these quantities. However, there is no experimental data for neutron capture cross section of ^{126}Sn, because the preparation of high-purity sample is difficult and, moreover, γ–ray radiation from a sample causes a serious background.

On the other hand, keV-neutron capture cross sections and capture γ–ray spectra of stable Sn isotopes contain important information useful for the theoretical calculation of the capture cross sections of ^{126}Sn. Thus, we started a systematic measurement of keV-neutron capture cross sections and capture γ-ray spectra of stable Sn isotopes. In the present contribution, the results for $^{117, 119}$Sn are shown.

2. Experimental procedure and data processing

The capture cross sections and capture γ–ray spectra of $^{117, 119}Sn$ were measured in an incident neutron energy region from 10 to 100 keV and at 570 keV, using the 3-MV Pelletron accelerator of the Research Laboratory for Nuclear Reactors at the Tokyo Institute of Technology. Pulsed keV neutrons were produced from the $^{7}Li(p,n)^{7}Be$ reaction by bombarding a Li-evaporated copper disk with a 1.5-ns bunched proton beam from the accelerator. The pulse-repetition rate was 4 MHz. The $^{117, 119}Sn$ samples were highly isotopically enriched metal plates with the net weight of about 1 g. Capture γ rays were detected with a large anti-Compton NaI(Tl) spectrometer[1)] by means of a time-of-flight method.

A pulse-height weighting technique[2)] was applied to the observed capture γ-ray pulse-height spectra to obtain capture yields. The capture cross sections of $^{117, 119}Sn$ were derived using the standard capture cross sections of ^{197}Au[3)]. The capture γ-ray spectra were derived by unfolding the observed capture γ-ray pulse-height spectra.

3. Calculations

The calculation of capture cross sections and capture γ-ray spectra of $^{117, 119}Sn$ were performed with the Empire-II code[4)] in an incident neutron energy region from 10 to 1000 keV using three global optical model parameter sets (Koning–Delaroche, Wilmore-Hodgson, and Moldauer) and three different level densities (Empire-specific, Gilbert-Cameron, and Hartree-Fock-BCS).

4. Results and discussion

The capture cross sections of $^{117, 119}Sn$ were derived with the error of about 5%. The present results of ^{119}Sn are compared in Fig.1 with previous experimental data[5, 6)] and the evaluated values in JENDL-3.3[7)] and ENDF/B-VI[8)].

The capture γ–ray spectrum of ^{119}Sn in incident neutron energy region from 15 to 100 keV is shown in Fig.2. The characteristic primary transitions from the capture states to the ground and first excited states are observed.

The calculated results of capture cross sections of ^{119}Sn are shown Fig.3 and those of capture γ–ray spectrum are shown Fig.4. As seen from Figs.3 and 4, Gilbert-Cameron level density is better than others, but it is not enough to reproduce the present experimental results.

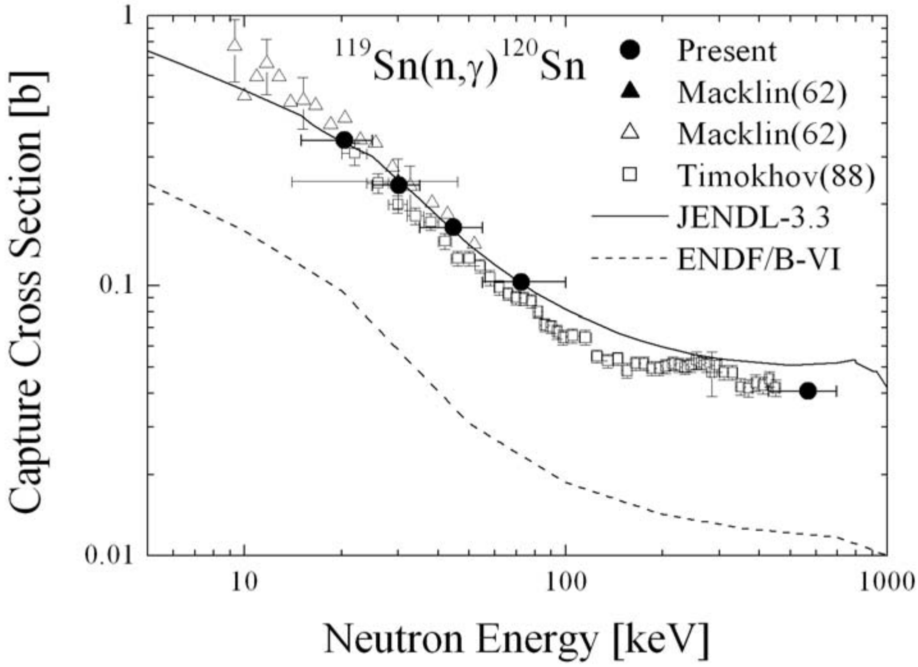

Fig. 1 Neutron capture cross sections of ^{119}Sn
The solid circles show the present results. Other measurements[5, 6] and the evaluations of JENDL-3.3[7] and ENDF/B-VI[8] are compared with the present results.

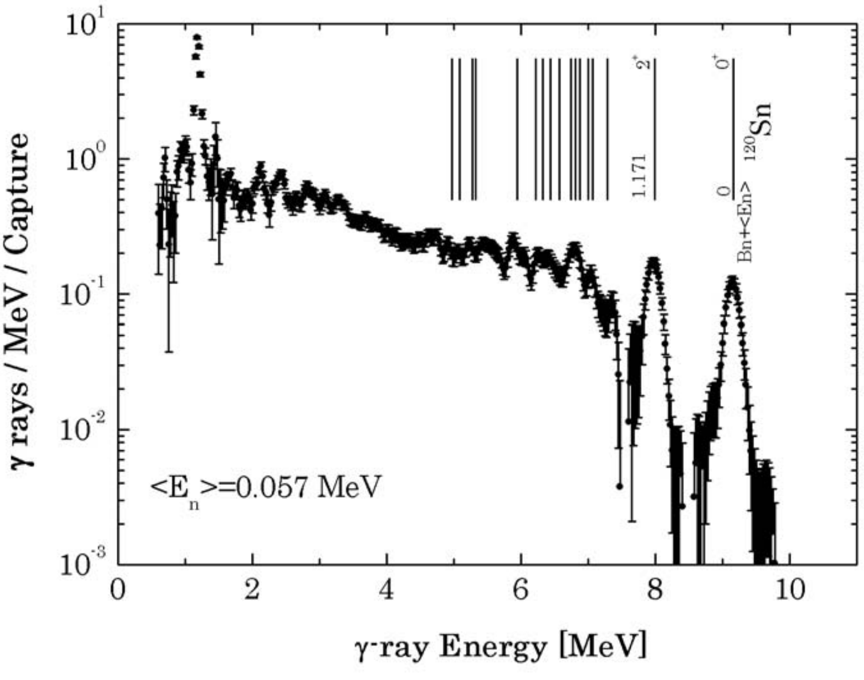

Fig. 2 Neutron capture γ–ray spectrum of ^{119}Sn
The solid circles show the present spectrum. Low lying states of ^{120}Sn are shown in figure, where ground state is placed at 9.17 MeV : the excitation energy of the 57 keV neutron capture states.

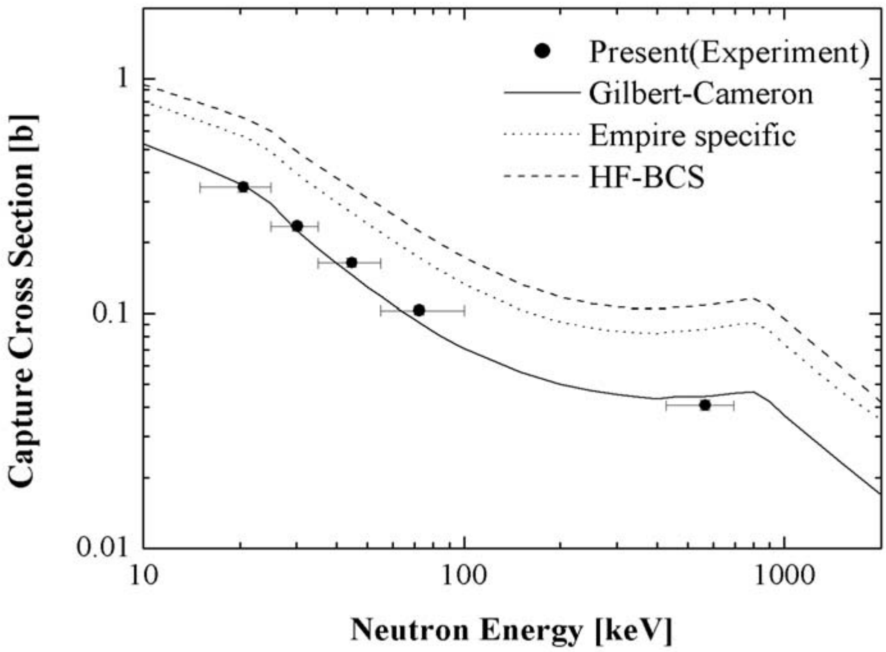

Fig. 3 Neutron capture cross sections calculated with three different level densities.

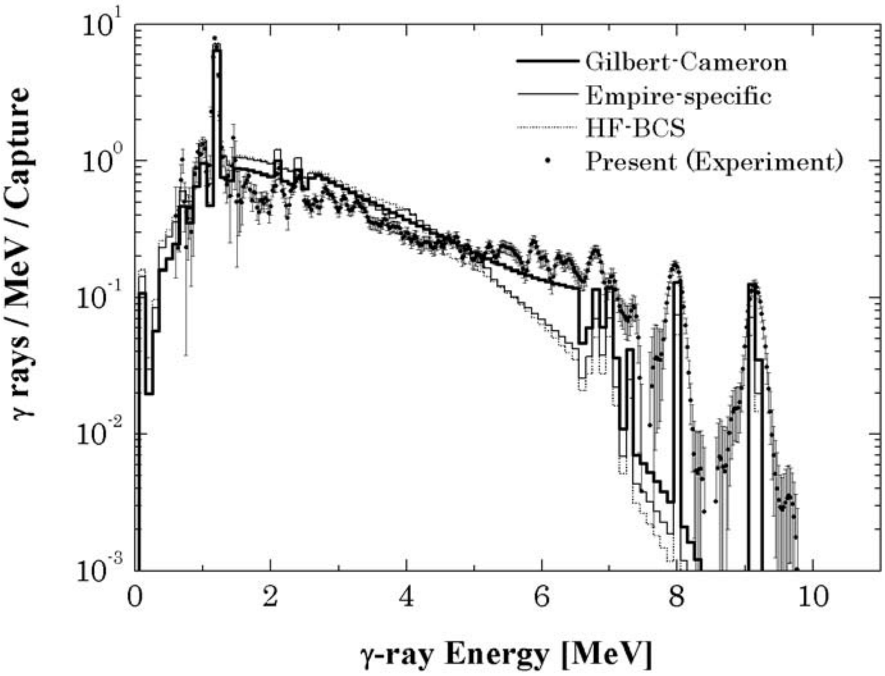

Fig. 4 Neutron capture γ-ray spectra calculated with three different level densities.

5. Conclusions

The capture cross sections and capture γ-ray spectra of $^{117,\,119}Sn$ were measured in the incident neutron energy region from 10 to 100 keV and at 570 keV, using a 1.5-ns pulsed neutron source by the $^{7}Li(p,n)^{7}Be$ reaction and the large anti-Compton NaI(Tl) γ-ray spectrometer. A pulse-height weighting technique was applied to observed capture γ-ray pulse-height spectra to derive capture yields. The capture cross sections of $^{117,\,119}Sn$ were obtained with the error of about 5% by using the standard capture cross sections of ^{197}Au. The present cross sections were compared with previous experimental data and the evaluated values in JENDL-3.3 and ENDF/B-VI. The capture γ-ray spectra of $^{117,\,119}Sn$ were derived by unfolding the observed capture γ-ray pulse-height spectra.

The calculations of capture cross sections and capture γ-ray spectra of $^{117,\,119}Sn$ were performed with the EMPIRE-II code in an incident neutron energy region from 10 to 1000 keV. The calculated results were compared with the present experimental results. In this comparison, Gilbert-Cameron level density was better than others, but it is not enough to reproduce the present experimental results. It is necessary to analyze the present experimental results in more detail.

Acknowledgments

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