論文 / 著書情報
Article / Book Information

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Title(English)	Construction of a Framework for Systematical Computation of Prompt Fission Observables
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Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

（博士課程）
Doctoral Program

論 文 要 旨

THESIS SUMMARY

系・コース： Department of, Graduate major in	融合理工学　　系 原子核工学　　コース	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of	（工学）
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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

Nuclear fission is the fundamental physics process underlying nuclear applications. The physical quantities obtained from fission reaction, referred to as fission observables in this thesis, play a crucial role in evaluating safety and effectiveness for nuclear applications. However, the experimental fission observable data is limited because experiments for nuclear fission reactions are difficult to conduct due to the radiation and its associated factors. Moreover, since nuclear fission reaction involves multiple physical processes, and each process is rooted in different physical mechanisms, theoretical calculations of the fission observables are also difficult. In this study, a systematical framework for computing fission observables was constructed, and its effectiveness was evaluated, covering the processes after forming a compound nucleus up to prompt decay.

In Chapter 2, a method was developed to calculate the prompt fission observables with Hauser-Feshbach statistical decay model implemented in nuclear reaction code TALYS. It is known that physical quantities also influence prompt decay calculations in addition to the fission fragment yield and the excitation energy, however, the parameter values of several physical quantities that are determined to reproduce the existing prompt fission observables are unknown in TALYS. In this work, the influence of the spin-parity distribution of a fissioning nucleus and fission fragments and the number of continuum states were elucidated by changing parameter values related to them. The investigation was conducted for the ^{235}U(n_{th},f) reaction, which has numerous available experimental results. Although the parameters of the spin-parity distribution affected both neutron and γ-ray multiplicities, the optimal parameter values were found for the spin-parity distribution to reproduce the neutron multiplicity. Additionally, it was elucidated that these optimal values approximately matched the shape of the prompt fission neutron spectrum (PFNS). Regarding the number of continuum states, it was revealed that the impact on neutron multiplicity was minimal, but higher values improved the agreement of γ-ray observables between the calculated results and reported data.

In Chapter 3, a novel method was proposed to improve the accuracy of the fission fragment yield obtained from four-dimensional Langevin model. The Langevin approach successfully has described systematics and anomalies in fission fragment yield and total kinetic energy (TKE) of fission fragments. However, there was room for improvements in the peak positions of the fission fragment yields. In this work, two fission modes corresponding to the Standard I and II modes in Brosa's notation were calculated independently by adjusting the neck parameter and zero-point energy within the four-dimensional Langevin model. The calculated results were then superposed using a superposing ratio. This method successfully described the peak positions and widths of the fission fragment yield for ^{238,240,242}Pu(sf) and ^{239}Pu(n,f) across the incident energy ranges at thermal, 3, and 5 MeV. Not only the fission fragment yield but also the calculated average TKE closely matched with experimental data within 2% in ^{238,240,242}Pu(sf) and within 1% in ^{238,240,242}Pu(n_{th},f). Notably, a systematic trend was found in the superposing ratio of ^{238,240,242}Pu(sf). Assuming the applicability of this systematic to neutron-induced fission, this novel approach allows for accurately calculating fission fragment yield and TKE across a wide range of nuclides undergoing neutron-induced fission. By comparing the calculation results of the conventional four-dimensional Langevin model and the calculation results of this method, it was revealed that the fission fragment yield and TKE accuracy were improved.

In Chapter 4, a method was developed to perform the Hauser-Feshbach statistical decay calculations using the established method in Chapter 2 and the Langevin results obtained

from Chapter 3. The calculation accuracy of prompt fission observables was investigated on the ^{239}Pu(n,f) reaction across the incident energy ranging from thermal to 5 MeV. The charge distribution and excitation energy were calculated using Wahl's Z_p model and energy-dependent R_T model, respectively, for the obtained fission fragment yield and TKE. The parameter values for the spin-parity distribution and the number of continuum states were selected based on the results obtained from Chapter 2. The calculated neutron multiplicity, PFNS, and independent fission product yield were compared with experimental and evaluated data and investigated the present accuracy. The calculated results successfully reproduced known trends and the experimental and evaluated data. In particular, the calculated neutron multiplicity at thermal neutron energy was strongly in good agreement with the evaluated values of ENDF/B-VIII.0 and JENDL-5.

Chapter 5 summarized the results obtained in each of the chapters and concluded. It has succeeded in constructing a theoretical framework for the systematical computation of the prompt fission observables. This study has made it possible to calculate the prompt fission observables, which are important in nuclear engineering.