Evaluation Activities at JCPRG

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Abstract

In this report, we briefly introduce some evaluation activities in Japan Charged-Particle Nuclear Reaction Data Group (JCPRG) in 2015. As one important objective in JCPRG, these evaluation of nuclei based on a reliable theoretical approach will bring further understanding and confirming the experimental results and also will help us to predict new data, which are not observed in experiments.

1 Introduction

The JCPRG [1] in Hokkaido University is a member of the International Network of Nuclear Reaction Data Centres (NRDCs) under the auspices of the International Atomic Energy Agency (IAEA). In JCPRG, the main task is to compile the data obtained in Japan on charged-particle and photo-induced nuclear reactions. At the same time, we also perform theoretical calculations to evaluate the experimental reaction data. The evaluation of nuclear reaction data can provide us very useful information for the nuclear reactions and structures and indeed it is becoming one important objective in JCPRG.

Nuclear shape or deformation is one important property for nuclei. By using some theoretical models, to systematic investigation of nuclear deformation in the nuclear chart can provides us with important information for nuclear structures. On the other hand, the nuclear reaction models can provide the estimation of nuclear reaction cross sections, which are very useful for understanding the data obtained from experiments and also can give a prediction if the experimental data are not obtained or difficult to be measured.

In this report, we will introduce some evaluation activities in JCPRG in 2015. First, we will show the study for the quadrupole deformations for axial-symmetric and triaxial deformed nuclei using the Hartree-Fock plus BCS (HF+BCS) method. Then, we will show results on the continuum discretized coupled channel (CDCC) analysis to the integrated elastic and inelastic scattering cross sections for ^{6,7}Li.

2 Systematic investigation of quadrupole deformations for axial-symmetric and triaxial deformed nuclei.

Since the theoretical database for nuclear structure is important for the analysis of nuclear reaction mechanism both as target and projectile, we investigate the ground states of over 1000 even-even

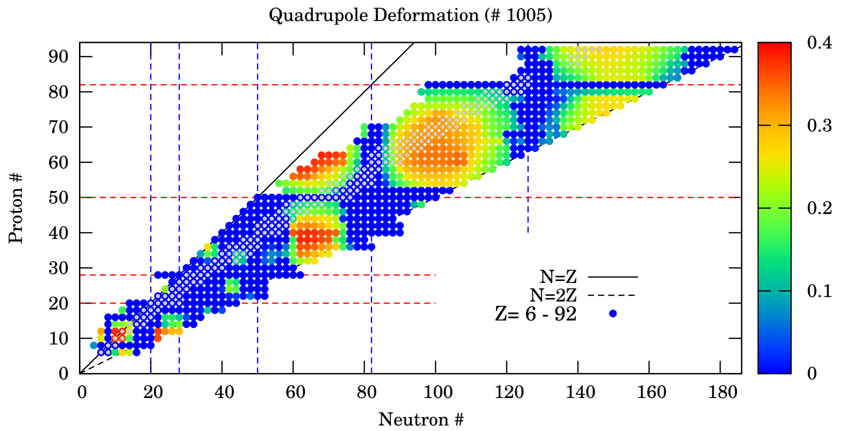

Figure 1: Quadrupole deformation parameter $|\beta_2|$ for whole nuclear mass region.

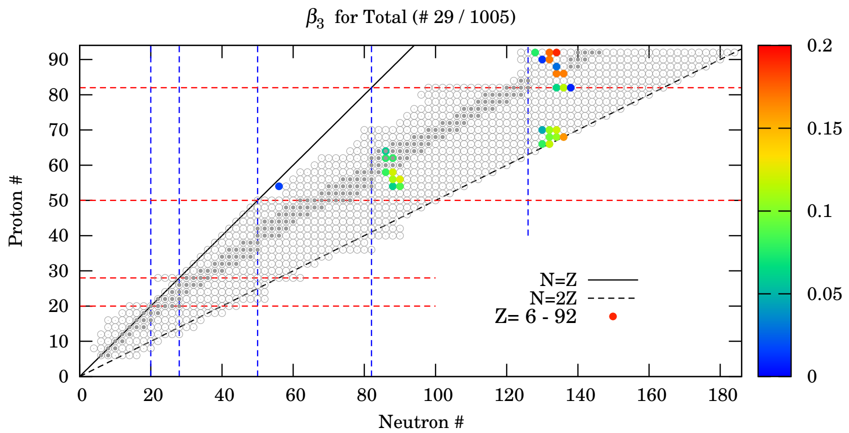

Figure 2: Same as Fig.1, but for octupole deformation parameter $|\beta_3| > 0.05$.

nuclei to understand nuclear deformation. The method for the investigation is the Hartree-Fock plus BCS (HF+BCS) method represented in the three-dimensional coordinate space, which can describe any deformations on the intrinsic frame. The HF+BCS calculations for all nuclei are performed self-consistently, in which a Skyrme effective interaction (SkM*) is used. For the pairing correlation, the constant strength which is desired by the level density of canonical basis, is applied according to same procedure of Ref. [2].

Present systematic investigation can show the distribution of quadrupole deformations for not only axial-symmetric ones (prolate and oblate) but also triaxial deformed nuclei. Figure 1 shows the distribution of absolute value of quadrupole deformation parameter $|\beta_2|$. Large deformed ones are located far from the magic number nuclei. In this work, the numbers of prolate ($|\beta_2| > 0.05$, $|\gamma| < 1.5°$), oblate ($|\beta_2| > 0.05$, $58.5° < |\gamma| < 60°$) and tiaxial ($|\beta_2| > 0.05$, $1.5° < |\gamma| < 58.5°$) nuclei are 375, 70 and 101, respectively. The prolate dominance appears clearly, which consists with previous systematic results [3].

Furthermore, we investigate the octupole deformation whose absolute values $|\beta_3|$ are shown in Fig. 2. The distributions are located at special region which has the difference of angular momentum $\Delta l = 3$ among particle-hole states. The $\Delta l = 3$ correlations in both neutron and proton can be expected as a most important reason to be the octupole deformation in the ground state.

The study will be extended to not only nuclear structure but also nuclear reaction. We have a plan for constructing a new theoretical evaluation database based on these results not only for the ground state properties but also for the reaction processes.

3 Analysis of ^{6,7}Li + n reactions using CDCC

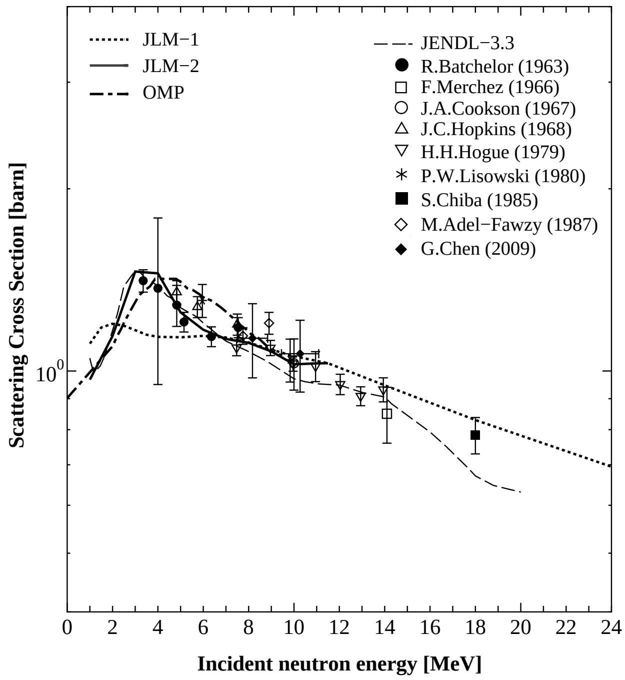

Figure 3: The integrated elastic cross sections of the n + ^{6}Li scattering, in comparison with the evaluated data [4] and experimental data [5–12].

Applying the CDCC [13] framework to the n +^{6}Li(α - d) and n + ^{7}Li (α - t) models, we investigated the integrated neutron elastic and inelastic scattering cross sections for the ^{6}Li and ^{7}Li targets, respectively, at incident neutron energies from 1 MeV to 24 MeV using the cluster-folding of the optical model potentials (OMP) [13, 14] and the complex JLM (J -P Jeukenne, A Lejeune, and C Mahaux) effective nucleon-nucleon interactions [15, 16]. We introduce the normalization factors for real and imaginary parts of these folding potentials comparing with the observed elastic cross sections of the n + ^{6,7}Li scattering. The energy dependent OMP and JLM normalization factors are examined for integrated elastic and inelastic cross sections and angular distributions. For example, we take the normalization factors λ_v= 1.0 and λ_w = 0.2 to reproduce the observed integrated elastic scattering cross sections data from 1 to 24 MeV, where the calculated results are presented by the dotted line (JLM-1) in Fig. 3. Next we try to readjust normalization factors so as to reproduce the low energy data of the measured integrated elastic cross section below 11.5 MeV using the OMP and JLM. The calculated integrated elastic cross sections are shown by the dash-dotted line (OMP) and solid line (JLM-2) in Fig. 3, respectively. These calculations, in which the energy dependent normalization factors are determined so as to reproduce the elastic cross section of the whole energy region from 1 MeV and 24 MeV, show a satisfactorily good agreement with the experimental data of inelastic cross sections and angular distributions.

4 Summary

In summary, we investigate the ground states of over 1000 even-even nuclei to understand nuclear deformation based on the HF+BCS method. For the study of nuclear reactions, by introducing the normalization factors using CDCC, the obtained elastic cross section of the whole energy region from 1 MeV and 24 MeV are very consistent with the experimental data of inelastic cross sections and angular distributions. These theory models are still in developing and they are promising to provide us more useful information for the nuclear structures and reactions in the future.

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