Low lying nuclear structure of odd-odd ^{68}Cu using a large basis shell model code with ^{56}Ni core

Shubharthi Maiti, Anirban Goswami, S. Biswas, A. Chakraborty, and B. Mukherjee*
Department of Physics, Siksha-Bhavana, Visva-Bharati, Santiniketan, West Bengal-731235, INDIA

Introduction

Due to the complex interactions between nucleons, an accurate modeling of the mass $\approx$ 70 nuclei remains a challenging task, prompting the development of several nuclear models. The shell model has been found to be quite successful in estimating the level energies, transition strengths, electric and magnetic moments regarding mainly the low-energy states in nuclei near or far from the closed shells. The A = 66-70 mass nuclides (including Fe, Co, Ni, Cu, Zn, Ga, Ge, and Se) lying near the semi-magic neutron number, N = 40 are especially important in the nuclear structure and nuclear astrophysics fields. Many of these nuclides often exhibit shape coexistence, low-lying 2^+ states, and enhanced B(E2) values, with the active orbitals being $2p_{3/2}$, $1f_{5/2}$, $2p_{1/2}$, and $1g_{9/2}$.

This study focuses on the neutron-rich ^{68}Cu isotope (Z = 29, N = 39) that is located just beyond the closed proton shell and close to the N = 40 sub-shell closure. An interesting experimental investigation for the present nucleus was performed by L. Hou *et al.* [1] to measure the lifetimes of the low-energy excited states using $\gamma-\gamma-t$ coincidence method. The measured B($M1$; $2^+ \rightarrow 1^+$) value was found to accord well with the finding obtained from their shell model study with the consideration of a limited configuration space. P. Vingerhoets *et al.* [2] explored the ground-state properties using collinear laser spectroscopy at CERN's ISOLDE, and the outcomes were well described on the basis of shell model with ^{56}Ni as the inert core. In the present work, the energy levels of both positive and negative parities in ^{68}Cu are studied by employing the jun45 [3] and jj44b [4] effective interactions with no model space restrictions. The ^{56}Ni is the concerned inert core. For computations, the NushellX@MSU code [5] is implemented.

Results and Discussion

The energy levels as provided by the jun45 and jj44b effective interactions are compared with the existing experimental data in Figs. 1 & 2. In this analysis, the experimental information with regard to the yrast states corresponding to the spin parities 6^-, 3^-, 4^-, 5^-, 1^+, 2^+ & 3^+ have been taken into account. It is found from our calculations that each of the interactions underpredicts the experimentally known negative-parity levels, and therefore, we do get compressed calculated spectra. The ground state, as predicted by both the interactions, is inconsistent with the experimental finding. The ordering of the experimental states, 1^+ and 2^+ is changed in both of our calculated level schemes. Regarding the positive-parity state of $3\hbar$ spin value, the jun45 interaction is better than jj44b in reproducing the corresponding excitation energy. The mismatch concerning the level energies will be thoroughly explained in the conference. A detailed presentation that includes the study of the electric quadrupole moments, transition strengths and half-lives using two different sets of effective charges will also be presented.

*Electronic address: buddhadev.mukherjee@visva-bharati.ac.in

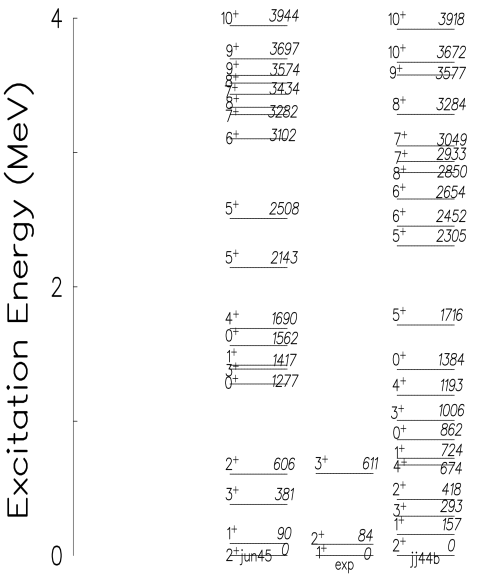

FIG. 1: The calculated and experimental [6] excitation energies for the positive-parity states in ^{68}Cu.

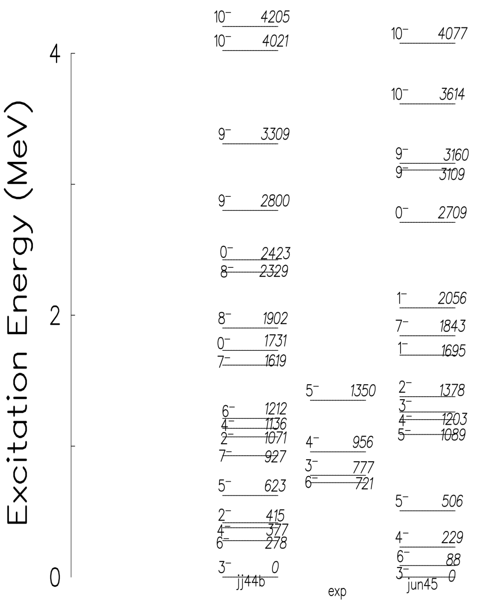

FIG. 2: The calculated and experimental [6] excitation energies for the negative-parity states in ^{68}Cu.

Acknowledgments

The authors acknowledge the financial help received from IUAC, New Delhi (Project No. UFR-67309), UGC-DAE CSR Kolkata Centre (Project No. CRS/2021-22/02/468), and SERB, New Delhi (Project No. CRG/2020/000715).

References

[1] L. Hou, T. Ishii & M. Asai, *Phys. Rev. C* **68**, 054306 (2003).
[2] P. Vingerhoets *et al.*, *Phys. Rev. C* **82**, 064311 (2010).
[3] M. Honma *et al.*, *Phys. Rev. C* **80**, 064323 (2009).
[4] B.A. Brown and A.F. Lisetskiy (unpublished).
[5] A. Brown and W.D.M. Rae, *Nucl. Data Sheets* **120**, 115 (2014).
[6] ENSDF database.