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Search for mixed-symmetry state in even-even $^{130-138}$Ce isotopes within the interacting boson model-2

Ali Mahdi Abdul HUSSAIN, Falih Hussain AL-KHUDAIR, Abdul Ridha Hussain SUBBER*
Department of Physics, College of Education for Pure Sciences, University of Basrah, Basrah, Iraq

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Abstract: The energy levels and reduced transition probabilities B(M1) and B(E2) of the even-even $^{130-138}$Ce isotopes were calculated by using the interacting boson model-2. We have analyzed the F-spin values and produced the symmetry labeling of the states. The calculated results were compared with the available experimental data. It was proved that the proton–neutron interacting boson model is a reasonable model for calculating low-lying spectra in the set of Ce isotopes and the quality of fit presented in this work is acceptable.

Key words: Ce isotopes, interacting boson model-2, mixed symmetry states, B(E2), B(M1)

1. Introduction

The atomic nuclei exhibit a variety of shapes, varying from spherical to gamma and soft to superdeformed and higher orders of deformation. Nuclei near the magic closed shell generally exhibit a spherical shape while nuclei having large numbers of bosons between the closed shells exhibit a deformation in their ground band. The possible shape of the nucleus may be deduced from microscopic calculations of the nuclear properties using a certain nuclear model. The even-even Ce isotopes lie in the transition region from γ-unstable to spherical shape, with the responsible O(6) to U(5) limit of the interaction boson model (IBM-1) [1]. The IBM-2 [2] suggests that the location of states of mixed (proton–neutron) symmetry is one of the most interesting open experimental and theoretical problems in the study of collective features of nuclei. This version shows the difference between proton and neutron boson wave functions and the states produced by IBM-2 contain all symmetry states with mixed-symmetry states, according to the U(6) representation [N-1, 1]. The quantity of proton–neutron symmetry of each state is identified by a new quantum number called F-spin [3]. Such states can be thought of as states in which the proton and neutron oscillate out of phase with respect to one another.

The excitation energies of collective quadrupole excitations in nuclei near the magic closed shell depend on the number of nucleons outside the closed shell. In the even-even cerium isotopes the number of neutron boson N_ν outside the closed shell varies from 5 in ^{130}Ce to 1 for ^{138}Ce, while the number of proton bosons is equal to 4 for all isotopes. The energy ratios $E4_1^+/E2_1^+$ experimentally equal 2.806, 2.640, 2.562, 2.380, and 2.317, respectively. For model limits, the typical values are 2.0, 2.5, and 3.3 for the U(5), O(6), and SU(3) limits, respectively [4].

The one-quadruple phonon states at around 2 MeV have been recognized as a good candidate to be the first mixed-symmetry state $2^+_{1,ms}$ and have been studied systematically as O(6) nuclei [4,5]. These states have

*Correspondence: dabrhs@hotmail.com