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IBM-2 Calculations for Even-Even Cadmium Isotopes

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Abstract

The structure of some even-even Cd isotopes has been studied using the neutron-proton interacting boson model(IBM-2). Theoretical calculations of the energy levels were fitted, the transition probabilities and the multipole mixing ratios for some selected transitions were obtained and compared with the experimental results. The set of model parameters used in this work suggest that most of the Cadmium isotopes are vibrational. The behaviors of the set of parameters in the Hamiltonian were studied as a function of neutron number across the transitional region, notably χ_ν, κ which indicated manifestly the change of shape of these isotopes from vibrational to almost rotational. The present results are in a good agreement with the experimental work.

Key words: IBM-2, Energy levels, Reduced Transition probability, Effective charges, Mixing Ratios δ ,

Introduction

The elements in the Z=50 region are particularly favorable for comprehensive nuclear structure studies, because their many stable isotopes allow systematic studies to be done.
The neutron-proton interaction is also known to play a dominant role in quadrupole correlations in nuclei. As a consequence, the excitation energies of collective quadrupole excitations in nuclei near a closed shell Z=48 are strongly dependent on the number of neutrons outside the closed shell.
The low-lying energy level and their properties in the isotopes of $^{110-116}$Cd (Z=48), with neutron number varies from 62 to 68 were a matter of many experimental and theoretical investigations during the last decades [1-5]. The interacting boson approximation has been quite successful at describing the collective properties of several medium nuclei. This model (IBM) presented by Arima and Iachello [6–9] and Casten [10]as become widely accepted as a tractable theoretical scheme of correlating, describing and predicting low-energy collective properties of complex nuclei. In this model, the low-energy states of even–even nuclei are described in terms of interactions between s (J=0) and d (J=2) bosons. The corresponding Hamiltonian is diagonalized in this boson space by employing somewhat powerful and effective group theory methods.

IBM-2 Model

For a given nucleus, the boson numbers N_ν and N_π are found by counting neutrons and protons from the nearest closed shells. The vector space of IBM-2 is then just the product of all possible states $(s, d)^{N\nu}$ with those of $(s, d)^{N\pi}$, where in each factor the set of states is the same as in IBM-1 [11]. In this analysis we have used the following Hamiltonian [9],[12]:

$$H = \varepsilon(\tilde{n}_{d_\nu} + \tilde{n}_{d_\pi}) + \kappa . Q_\nu . Q_\pi + \tilde{\kappa}(Q_\nu . Q_\nu + Q_\pi . Q_\pi) + V_{\nu\nu} + V_{\pi\pi} + M_{\nu\pi} \quad \ldots . \ (1)$$