Nuclear Structure of Some Even-Even Nuclei in the Mass Region $A \approx 60$

Thesis

Submitted for the degree of Master of Science
As partial fulfillment for requirements of the Master degree of Science
(Physics)

By

Heba Mohamed ELwany

B.Sc. (Special Physics), Ain Shams University (2007)

Physics Department
Faculty of Science
Ain Shams University

2016

APPROVAL SHEET

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This thesis for M.Sc. degree has been approved by:

Prof.Dr. Samir Usha El-kameesy

Physics Department, Faculty of Science, Ain Shams University.

Prof.Dr. Sami Kamal Handawi

Physics Department, Faculty of Science, Ain Shams University.

Dr.Hesham Ibrahim Shahbunder

Physics Department, Faculty of Science, Ain Shams University.

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Student Name: Heba Mohamed Elwany

Degree: Master of Science

Department: Physics - Nuclear Physics

Faculty: Science

University: Ain Shams

Graduation Year: 2007

Registration Year: 2012

Master of Science Thesis

Student Name: Heba Mohamed Elwany

Thesis Title: Nuclear Structure of Some Even-Even Nuclei in the Mass Region A ≈ 60

Degree: Master of Science

Supervising Committee

Prof.Dr. Samir Usha El-kameesy
Prof.Dr. Sami Kamal Handawi
Dr.Hesham Ibrahim Shahbunder

Examining Committee

Prof.Dr.Samir Usha El-kameesy
Prof.Dr. Salwa Mohamed Ahmed El-Mnyawi
Prof.Dr. Nasif Abd El-Azeem Mansour

Graduate Studies
Date of Research: / /
Seal of Approval:
Thesis has been approved on : / / 2016
Faculty Council Approval University Council Approval
/ / 2016 / / 2016

Acknowledgment

*Iam sincerely grateful to my supervisor.***Prof.Dr.Samir Usha El–kameesy***, Physics department, faculty of Science, Ain Shams University for his guiding , his inspiring of this work , his continuous encouragement and his fruitful discussion during all the stages of this investigation. Above all, he provided me a new vision for feeling and embodiment physics in all aspects of life, for him physics is not just a science, Physics is his own life, which is inseparable with him.*

My thanks to **Dr. Hesham Ibrahim Shahbunder,** *Physics Department , faculty of Science, Ain Shams University for his help and his priceless advices.*

All I can say to **Prof. Dr. Sami Kamal Handawi***, Physics Department, faculty of Science,Ain Shams University, may Allah bless your soul.*

Thanks also are due to **Head of the Physics Department** *for his encouragement and facilities he offered.*

Finally, no words can express my thanks to my **Mom***, without you and your encouragement, where I could be?, God keep you for me.*

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Abstract

The present work is based on a theoretical study of nuclear structure properties and the backbending phenomena of even-even isotopes at A≈60 mass region. This study suggests the relative contribution of the rotational and vibrational parts of motion inside the nucleus.

A modification of the dynamic version (IDVM) of the collective model predictions besides the exponential model (IEM) with the inclusion of pairing correlation has been successfully performed. The application of these models to nuclei in the region A≈60 shows the superiority of the latter in describing the forward and down-bending region of the φ -ω^2 plots. Also, the study investigates some nuclear models (the softness model (NS3), the simple model of backbending (SM), showing how far these models coincide with the experimental results.

The transition probabilities B(E2) of the ground state band, the quadrople moment Q , the deformation parameter β and the effective charge of proton e_π and neutron e_ν have been calculated by very accurate theroretical methods .

Summary

Under the light of the present work, the nuclear structure properties and the backbending phenomena of even-even isotopes at A≈60 mass region are analyzed in the frame work of the softness model (NS3), the simple model forbackbending(SM),the dynamic version (DVM) of the collective model and the exponential model(EM).

A simple improved dynamic version (IDVM) of the collective model predictions besides an improved version of exponential model (IEM)with the inclusion of pairing correlation are successfully described thebackbending phenomena in the region of A≈60. From the comparison between the predictions of the two proposed models, a firm conclusion is obtained concerning the superiority of the simple improved version of the exponential model in describing the forward and down-bending region of the ($2\varphi/\hbar^2$ - ($\hbar^2\omega^2$)) plots.

In the present work, some medium light even-even nuclei (Cr, Ge, Se and Kr), have been investigated using the appliedtheoretical models and the predictions of the models are compared with the corresponding experimental results.

Several nuclear parameters such as the transition probabilities B(E2), the quadruple moment Q and the deformation parameter β have been calculated.

The study of the effective charge of proton e_π and neutron e_ν in this mass regionA≈60 is enhanced making use of SU(5) group theory.

Introduction

Lately even- even nuclei at mass region A≈ 60 have recently become important testing ground for most of the recent theories, where the calculated findings may be compared with the corresponding experimental data.

Previous works showed that there is a clear evidence for a major change in the nature of the ground state levels below I = 18 ħ in even-even nuclei in that region [(1)-(8)]. Furthermore, at higher spin values a very regular structure develops. It is simply called the backbending phenomena. These nuclei have several interesting characteristics such as oblate and prolate deformations as well as rapid variations in shape as a function of both spin and mass number. The sudden disappearance of E2 strength at certain spins indicates a shape change that requires the considerations of upper pf configuration[(9)].

Several works have confirmed that backbending could be influenced by the ground state band energy spacing and the pairing gap[(10)-(13)]. Also, the fact that the moment of inertia is almost doubled and is approaching the value of a rigid rotation suggests that the transition is associated with pair correlation[(14)]. A large amount of works have been done in studying the anti-alignment effect of pair correlation on the moment of inertia [(13,15)].

The backbendingphenomena in ^{48}Cr has been studied by Hara *et al.*[5], making use of the projected shell model [16].

The obtained results confirmed that the bakbending in ^{48}Cr is based on band crossing. This result differs from that of Tanaka *et al* calculations based on the Cranked Hartee-Fock- Bogoliubov (CHFB), which claims that the backbending in the area under investigation is not due to level crossing mechanism [17]. Furthermore, the pairing force has been considered to have an important role in backbending phenomena but it is not sufficiently explained [18]. Cranking model analysis of ^{80}Br energy levels reveals the possible existence of neutron alignment at ω= 0.7 MeV [19]. Many attempts have been done to provide theoretical description of the backbending phenomena. The variable moment of inertia (VMI) gives a very good description of the ground state bands of even-even nuclei up to the point where backbendingoccurs[20, 21]. Also, many works took in their consideration the band mixing interpretations to describe backbending[22, 23].

The lack of clear explanation of the backbending phenomena in the A ≈60 mass region led us to reinvestigate the phenomena applying a simple five parameter formula based on a dynamic version of the unified collective model. Additionally, an improved version of the exponential model with pairing attenuation has been also applied in the present work [24].

Zvonov and Mitroshin in 1977[25]have applied a dynamic version of the unified collective model of nuclei as a universal mechanism forming quasirotational bands in spherical, transitional and deformed nuclei. It holds well for the ground state bands in even-even nuclei $40 \leq A \leq 180$.

In the present work, a further improvement of the dynamic version model has been executed. Based on the present originally proposed dynamic version and the previously predicted model given by Anangnostatos[26],the model is modified by adding a new term representing the rotational contribution to the nuclear motion.

Sood and Jain [27] have previously developed an exponential model based on the exponential dependence of the nuclear moment of inertia on pairing correlation.

In the present work, a modified version of the exponential model with pairing attenuation is applied. It is hoped by such work to have a good explanation of the backbending regions besides those of low-lying states.