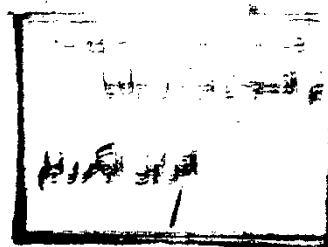


Ain Shams University
Faculty of Girls for Art.
Science and Education
Physics Department



THEORETICAL STUDY OF BACKBENDING IN STRONGLY AND WEAKLY EVEN - EVEN DEFORMED NUCLEI

Thesis Submitted in Partial Fulfillment
of the Requirement for M.Sc. Degree in Physics

Presented by

Manal Mahmoud Ahmed Sirag

Supervisory Committee

Prof. Dr. Aly Mohamed El-Naim
Prof. of Theoretical Nuclear Physics

1993

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

«فَاللَّهُ سُبْحَانَهُ لَا إِلَهَ إِلَّا هُوَ الْحَيُّ الْقَيُّومُ لَا يَأْخُذُهُ سِنَةٌ وَلَا نَوْمٌ لَهُ مَا فِي السَّمَاوَاتِ وَمَا فِي الْأَرْضِ مَنْ ذَا الَّذِي يَشْفَعُ عِنْدَهُ إِلَّا بِإِذْنِهِ يَعْلَمُ الْغُيُوبَ وَأَنْتَ أَعْلَمُ الْغُيُوبَ لَا يُحِيطُ بِشَيْءٍ إِلَّا بِمَا شَاءَ وَسِعَ كُرْسِيُّهُ السَّمَاوَاتِ وَالْأَرْضَ وَلَا يَئُودُهُ حِفْظُهُمَا وَهُوَ الْعَلِيُّ الْعَظِيمُ»

صَدَقَ اللَّهُ الْعَظِيمُ



Name of student: Manal Mahmoud Ahmed Sirag
Title of thesis: Theoretical Study of Backbending
in Strongly and Weakly Even-Even
Deformed Nuclei.
Scientific Degree: B.Sc.
Department: Physics.
Name of Faculty: Faculty of Girls.
University: Ain Shams.
B.sc. Graduation date: May, 1987.
M.Sc. Graduation date:

CONTENTS

	Page
Acknowledgement.....	
List of figures	
list of tables	
Abstract	1
Summary	2
Introduction	6
 Chapter (I): Some characteristics of deformed nuclei...	10
I.1 Classification of nuclei according to energy ratio.....	11
I.2 Moment of inertia.	15
I.2.1 Classical moment of inertia	16
I.2.2 Rotation of a nucleus and a cranking model	20
I.2.3 Moment of inertia and angular velocity	26
 Chapter (II): Ground state band models.	29
II.1 Rotation energy relation for symmetric nuclei...	30
II.2 Models of energy states of GSB in e-e nuclei...	33
II.2.1 The variable moment of inertia (VMI).....	34
II.2.2 The Generalized variable moment of inertia model (GVMI).....	37

II.2.3 The Vibrational anharmonic variable model (VAVM).....	41
II.2.4 The VMI-in terms of nuclear softness model (VMINS).....	42
Chapter (III): Backbending phenomenon.....	46
III.1 The Yrast line.....	46
III.2 The structure of the yrast line.....	46
III.3 Backbending and its representation.....	49
III.4 Yrast energy and interaction strength.....	51
III.5 Factors affecting backbending.....	53
III.6 Causes of backbending.....	54
III.7 Previous models for backbending.....	55
III.8 Present models for backbending.....	58
III.8.1 The present exponential form of the dependence of moment of inertia on the pairing correlation.....	58
III.8.2 Superband energy.....	61
III.8.3 Interaction potential.....	61
Chapter (IV): Results and discussion.....	67
IV.1 The R(4) and r-ratio classification.....	67
IV.2 Experimental plot of backbending shape.....	68
IV.3 Experimental extraction of backbending parameters.....	70
IV.3.1 Alignment angular momentum.....	70

IV.3.2 The critical parameters.....	71
IV.3.3 Interaction strength.....	73
IV.4 Results for different models.....	74
IV.4.1 The effect of superband.....	74
IV.4.2 The effect of interaction potential.....	75
IV.4.3 Results of weakly deformed nuclei.....	76
IV.4.4 Results of strongly deformed nuclei.....	81
IV.4.5 Results using the exponential model.....	84
IV.4.6 Proposed interaction and superband forms.....	85
IV.5 Conclusion.....	86
Figures and Tables.....	88
References.....	135
Arabic summary.....	138

Acknowledgement

Acknowledgement

I would like to thank and express my feelings of appreciation and gratitude to:

1) Thesis Supervisor:

Dr. Aly M. El-Naim,
Professor of Theoretical Nuclear Physics,
Ain Shams University.

2) Institution:

Head and staff members of Department of Physics,
Faculty of Girls,
Ain Shams University.

List of Figures

Fig. no.		Page
Fig. (1):	The relation between r-ratio and R(exp.) for even-even nuclei.....	88
Fig. (2):	The structure of the yrast band.....	89
Fig. (3):	The crossing of two bands.....	90
Fig. (4):	The relation between J and W.....	90
Fig. (5):	Classification of (A) against R(4).....	91
Fig. (6):	The r-ratio vs (I) for ^{78}Kr and ^{80}Kr as vibrational nuclei.....	92
Fig. (7):	The r-ratio vs (I) for ^{104}Pd and ^{106}Pd as vibrational nuclei.....	92
Fig. (8):	The r-ratio vs (I) for ^{154}Dy and ^{156}Er as vibrational nuclei.....	93
Fig. (9):	The r-ratio vs (I) for Ce isotopes as δ - unstable nuclei.....	93
Fig. (10):	The r-ratio vs (I) for ^{162}Er as rotational nuclei.....	94
Fig. (11):	The r-ratio vs (I) for Hf isotopes as rotational nuclei.....	94
Fig. (12):	The r-ratio vs (I) for Os isotopes as rotational nuclei.....	95
Fig. (13):	Plots of angular momentum and aligned angular momentum vs rotational frequency for the yrast band.....	96

Fig. (14): Relation between J_{eff} and w^2	97
Fig. (15): The effect of superband variation for vibrational ^{106}Pd nucleus using GVMI- model.....	98
Fig. (16): The effect of superband variation for vibrational ^{106}Pd nucleus using VAVM- model.....	98
Fig. (17): The effect of superband variation for γ - unstable ^{130}Ce nucleus using GVMI- model.....	99
Fig. (18): The effect of superband variation for vibrational ^{130}Ce nucleus using VAVM- model.....	99
Fig. (19): The effect of superband variation for rotational ^{182}Os nucleus using GVMI- model.....	100
Fig. (20): The effect of superband variation for rotational ^{182}Os nucleus using VAVM- model.....	100
Fig. (21): The effect of different interaction forms on the backbending plot of ^{80}Kr using VAVM-model.....	101
Fig. (22): The effect of different interaction forms on the backbending plot of ^{106}Pd using VMINS-model.....	101

Fig. (23): The effect of different interaction forms on the backbending plot of ^{130}Ce using GVMi-model.....	102
Fig. (24): The effect of different interaction forms on the backbending plot of ^{182}Os using VMI-model.....	102
Fig. (25): The backbending plot of ^{78}Kr as a weakly deformed nucleus using different models...	103
Fig. (26): The backbending plot of ^{80}Kr as a weakly deformed nucleus using different models...	103
Fig. (27): The backbending plot of ^{104}Pd as a weakly deformed nucleus using different models...	104
Fig. (28): The backbending plot of ^{106}Pd as a weakly deformed nucleus using different models...	104
Fig. (29): The backbending plot of ^{128}Ce as a weakly deformed nucleus using different models...	105
Fig. (30): The backbending plot of ^{130}Ce as a weakly deformed nucleus using different models...	105
Fig. (31): The backbending plot of ^{132}Ce as a weakly deformed nucleus using different models...	106
Fig. (32): The backbending plot of ^{134}Ce as a weakly deformed nucleus using different models...	106
Fig. (33): The backbending plot of ^{154}Dy as a weakly deformed nucleus using different models...	107
Fig. (34): The backbending plot of ^{156}Er as a weakly deformed nucleus using different models...	107

Fig. (35): The backbending plot of ^{156}Er as a weakly deformed nucleus using different models....	108
Fig. (36): The alignment values for ^{78}Kr nucleus.....	109
Fig. (37): The alignment values for ^{80}Kr nucleus.....	109
Fig. (38): The oscillatory behaviour for the X as a function of A for Ce-isotopes.....	110
Fig. (39): The alignment values for ^{130}Ce nucleus.....	111
Fig. (40): The alignment values for ^{132}Ce nucleus.....	111
Fig. (41): The alignment values for ^{134}Ce nucleus.....	112
Fig. (42): The alignment values for ^{154}Dy nucleus.....	112
Fig. (43): The alignment values for ^{156}Er nucleus.....	113
Fig. (44): The alignment values for ^{158}Er nucleus.....	113
Fig. (45): The backbending plot of ^{158}Dy as a strongly deformed nucleus using different models.....	114
Fig. (46): The backbending plot of ^{162}Er as a strongly deformed nucleus using different models.....	114
Fig. (47): The backbending plot of ^{160}Hf as a strongly deformed nucleus using different models.....	115
Fig. (48): The backbending plot of ^{174}Hf as a strongly deformed nucleus using different models.....	115

Fig. (49): The backbending plot of ^{178}Os as a strongly deformed nucleus using different models.....	116
Fig. (50): The backbending plot of ^{180}Os as a strongly deformed nucleus using different models.....	116
Fig. (51): The backbending plot of ^{182}Os as a strongly deformed nucleus using different models.....	117
Fig. (52): The backbending plot of ^{184}Os as a strongly deformed nucleus using different models.....	117
Fig. (53): The alignment values for ^{158}Dy nucleus.....	118
Fig. (54): The alignment values for ^{162}Er nucleus.....	118
Fig. (55): The alignment value for ^{178}Os nucleus.....	119
Fig. (56): The alignment value for ^{180}Os nucleus.....	119
Fig. (57): The alignment values for ^{182}Os nucleus.....	120
Fig. (58): The alignment value for ^{184}Os nucleus.....	120
Fig. (59): The oscillatory behaviour for the X as a function of A for Os-isotopes.....	121
Fig. (60): The exponential dependence of J on pairing energy gap with different powers for ^{132}Ce	122
Fig. (61): The exponential dependence of J on pairing energy gap with different powers for ^{134}Ce	122

Fig. (62): The exponential dependence of J on pairing energy gap with different powers for ^{158}Dy	123
Fig. (63): The exponential dependence of J on pairing energy gap with different powers for ^{168}Hf	123
Fig. (64): The exponential dependence of J on pairing energy gap with different powers for ^{174}Hf	124
Fig. (65): The exponential dependence of J on pairing energy gap with different powers for ^{180}Os	124
Fig. (66): The exponential dependence of J on pairing energy gap with different powers for ^{182}Os	125
Fig. (67): The backbending plot of ^{158}Dy using two different potential forms.....	126
Fig. (68): The backbending plot of ^{174}Hf using two different potential forms.....	126
Fig. (69): The backbending plot for ^{134}Ce using VMI- for the superband.....	127