Calculate of Electromagnetic Transition for ^{122}Te Isotope

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Abstract

In this research, the properties of energy levels for even-even ^{122}Te isotope and electric quadruple moments $Q2_1^+$ have been studies by using (IBM) Hamiltonian. the experimental data compared with the Previous work. It is found that the ^{122}Te Isotops has value agreement with experimental data. And this nuclei have the properties of U(5) to Su(3) transition region .According to (IBM), ^{122}Te isotope have been shown their membership to the transition region SU(5)-O(6).

Keywords : interacting boson model; energy levels; transition probabilities; rotational limit.

إيجاد أنتقال المغناطيس الكهربائي للنضير ^{122}Te

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الخلاصه:

في هذا البحث، كانت خصائص مستويات الطاقة لـ **(**زوجي-زوجي**)** النظائر **^{122}Te** ولحظات أربعة أضعاف الكهربائية **$Q2_1^+$** دراسات باستخدام (**IBM**) هاملتون. البيانات التجريبية مقارنة مع العمل السابق. وتبين إن نظائر**^{122}Te** لديها اتفاق مع قيمة البيانات التجريبية. وهذه النواة لديها خصائص **U(5)** الى **Su(3)** في المنطقة التي تمر بمرحلة انتقالية. ووفقا لـ (**IBM**)، وقد ثبت النظير**^{122}Te** عضويتهم في المنطقة التي تمر بمرحلة انتقالية **SU(5)-O(6)**.

الكلمات المفتاحيه: تفاعل نموذج بوزون, مستويات الطاقه, الأحتمالية الانتقاليه, حد دوراني.

1.Introduction

The nuclear structure studies in detailed investigation of nuclear shell structure, the shell model descriptions of collective structures, it is useful to employ specific truncation schemes optimized for the description of the phenomena of interest.

the interacting boson model (IBM) represents a kind of a truncated shell model appropriate for the description of quadruple- collectivity. Beside its schematic character the IBM offers very useful insights into the nuclear structure revealing different symmetries of the nuclear wave functions. Since the interacting Boson Model is based on nucleon pairs formed by either tow valence neutrons or tow valence proton, it allows also the study of proton- neutron correlation, albeit of nucleon pairs.

The atomic nucleus with its two different constituents, protons and neutrons, represents a unique finite quantum of many body system. From this studies one knows that proton-neutron correlations in the valence space play an important role in the formation of collective motion.

In principle, the nuclear shell model represents the ideal theoretical microscopic tool to attack the problem of symmetries can help to gain a more detailed understanding of nuclear forces. The isospin symmetry represents one of the fundamental symmetries of nucleonic systems.

2.1 Theoretical study:-

Theory of nuclear structure differs from theory of atomic structure. The atomic electrostatic force holding the atom is central, while that in the nucleus is not.

Arima and Lachello development the interacting boson model (IBM), is a nuclear model for the description of collective structures. It can provide theoretical level energies and transition strengths while including an harmonic it is from residual interactions.

The IBM contain tow basic concepts on which is based. One is that low- lying collective states in even-even nuclei can be described by only the valence nucleons, which form interacting fermion pairs. The other idea is that the fermion pairs couple to form bosons, carrying angular momentum (J) equal to 0 and 2 only, called S and D bosons, respectively.

The energies (εs and εd), and the interactions of s and d bosons, predict the low-lying excitations in the nucleus. There is one available magnetic sub states for the d boson, forming a 6-dimensional space described by the group structure U(6).

3.1 Hamiltonian of the IBM-1

In the form of the IBM, the Hamiltonian of its describes interaction of the s and d bosons in a six- dimensional Hilbert space, and is given by linear combinations of the creation and annihilation operators: s, s†, d , and d†. the most general forms of the IBM-1 Hamiltonian (7,10) as a multipole expansion, grouped into different boson-boson interaction eq (7,10). the low-lying nuclear spectra by assuming that an even-even nucleus, consists of an inert core plus some valence particles (i.e particles outside the major closed shells). Furthermore, the valence particles tend to pair together to form bosons with angular momenta 0 and 2 [10]. Hamiltonian operator function according to IBM-1 is written in terms of creation and annihilation operators as follows [7,10]:

$$\hat{H} = £\,\hat{n}_d + a_0\,\hat{P}^+.\hat{P} + a_1\,\hat{j}.\hat{j} + a_2\,\hat{Q}.\hat{Q} + a_3\,\hat{T}_3.\hat{T}_3 + a_4\,\hat{T}_4.\hat{T}_4$$
----------(1)

Where ε, a_0, a_1, a_2, a_3 and a_4 are parameters used in IBM-1 to determine the Hamiltonian function,

and

$$£ = £_d - £_s$$ ----------(2)

Where £ = Boson's energy.

$£_d$ = d - Boson's energy.

$£_s$ = s – Boson's energy.

$$\hat{n}_d = (\hat{d}^+ \otimes \hat{\tilde{d}}) \equiv d - bosons \quad operator$$
------------------------(3)

$$\hat{P} = \frac{1}{2}(\hat{\tilde{d}} \otimes \hat{\tilde{d}}) - \frac{1}{2}(\hat{\tilde{S}} \otimes \hat{\tilde{S}}) \equiv$$
operator of ------------------------(4)

pairing among bosons

$$\hat{I} = \sqrt{10}\left[\hat{d}^+ \otimes \hat{d}^{\sim}\right]^{(1)} \equiv$$
Angular momentum operator ----------(5)

Another important property that can be deduced and calculated by using the IBM-1 called the reduced electric transition probability B(E2).

The general linear E2 operator of the IBM-1 is the J=2 tensor operator give by.

$$\hat{\mathbf{T}}^{\ell}_{\mathbf{m}} = \alpha_2\delta_{\ell 2}[\hat{\mathbf{d}}^+\times\hat{\tilde{\mathbf{s}}} + \hat{\mathbf{s}}^+\times\hat{\tilde{\mathbf{d}}}]^{2}_{\mathbf{m}} + \beta_{\ell}[\hat{\mathbf{d}}^+\times\hat{\tilde{\mathbf{d}}}]^{\ell}_{\mathbf{m}} + \gamma_o\delta_{\ell o}\delta_{mo}[\hat{\mathbf{s}}^+\times\hat{\tilde{\mathbf{s}}}]^{o}_{o}$$
----------(6)

Where

ℓ=0,1,2,3,4,……   ; m=0,1,2,3,4,……

$$\hat{T}^{E4}_{m} = \beta_4 [\hat{d}^+ \times \tilde{\hat{d}}]^4_m \quad \text{———— (9)}$$

where the first term in eq (6) represented the transition when ℓ = **2** and if ℓ = ***0*** the last term is exist, and the symbol □ is the koroneckar delta function also the multipole transition are is given as:

$$\hat{T}^{E0}_{o} = \beta_0 [\hat{d}^+ \times \tilde{\hat{d}}]^0_0 + \gamma_0 [\hat{s}^+ \times \tilde{\hat{s}}]^0_0 \quad \text{-----------(7)}$$

$$\hat{T}^{E2}_{«} = \alpha_2 [\hat{d}^+ \times \tilde{\hat{s}} + \hat{s}^+ \times \tilde{\hat{d}}]^2_{«} + \beta_2 [\hat{d}^+ \times \tilde{\hat{d}}]^2_{«} \quad \text{------------(8)}$$

4. Results and Discussions

The parameters E2SD and E2DD which are using in this work are dependent on the experimental value with normalization for its where occure in table (1).

Where[18,19] :-

$$\textbf{E2SD} = \alpha_2 \quad , \quad \textbf{E2DD} = \sqrt{5}\ \beta_2 \quad \text{------------------(10)}$$

The theoretical calculations for the probability electric transition taken from refs. [20,21,22] in this work are compare with experimental value shows in table (3).

In this work the nuclei ^{122}Te belong to the transition region U(5) – O(6) about the Hamiltonian parameter in eq (1) are used in this paper and gives a good agreement between theoretical energy levels in this work with the experimental value of energy level taken from ref (15,16,17) as show in table (1). we notice that a very good agreement between our calculation for the g-band in comparison with the experimental data for all nuclei under study.

Values calculated in this study show that the shifts are linked to the levels with the same parity and E2 transitions are predominant.

5. Conclusions

3-In case of quadruple electrical transitions B(E2) for even–even nuclei ,we find that the values of α_2 and β_2 parameters increase whenever the number of bosons increases in one element isotopes.

4-The inter acting boson approximation (IBM-1) show the theoretical results are nearly with experiment.

1-The even-even ^{122}Te isotope have (52) protons and (70) neutrons. The major number for closed shell (66) is called the core for bosons proton and neutrons. Then we calculate the bosons number, for Isotope ^{122}Te, that is have seven bosons.

2-The study of the reduced transition probability $B(E2{:}2_1^+ \rightarrow 0_1^+)$ that it decreases as the mass number increase, and this is a key signature that the nuclei evolve from SU(5) to O(6) limits.

References:

[1]- O S Van Roosmalen, A E L Dieperink and F Iachello, (1982); Chem. Phys. Lett. 85, 32.
[2]- M E Kellman and P R Herrick, (1980); Phys. Rev. A22, 1536.
[3]- Arima A. and Iachello F. (1979); Ann. Phys. ,123,468.
[4]- D. Tonev, A. Dewald, C. Fromsen, J. Jolie, A. Linnemann, A. Lisetskiy, M. N. Mineva, P. Pejovic, P. Petkov, N. Pietralla, and V. Werner, J. (2010);Physics, G, 76, 1321.
[5]- Abdul-Ameer A. (1991); Ph.D thesis "Investigations of nuclear energy levels in ^{82}Kr,^{76}Se and ^{194}Pt" submitted to University of London.
[6]- P Federman and S Pittel, (1977); Phys. Lett. B69, 385.
[7]- C K Nair, A Ansari and L Satpathy, (1977); Phys. Lett. B71, 257.
[8]- Pfeifer W. (2008); "An introduction to interacting boson model of atomic nucleus"; plenum press .
[9]- Norman Cook (2005); "Models of the Atomic Nucleus"; Philadelphia.
[10]- Arima and F. Iachello, (1987); “The Interacting Boson Model.”, Cambridge University Press, Cambridge, UK,.
[11]- Iachello F. and Scholten O. (1979); Phys. Rev. Lett. 43, 679.
[12]- Krane K.(1987); "Introductory Nuclear Physics John Wiely and Sons"; New York. .
[13]- Iachello F. (1980); Phys. Rev, Lett. 44, 772

[14]- A. Arima, and F. Iachello, (1976) ; Ann. Phys. 99, 253.

[15]- O. Scholten, (1979); “Computer Program IBM-1”, University of Groningen,Netherlands,.

[16] - S. -C. Wu, H. Niu, (2003) ; Nuclear Data Sheets 100, 483.

[17]- Balraj Singh and Joel C. Roediger, (2010) ; Nuclear Data Sheets 111, 2081.

[18]- R. F. Casten, P. O. Lipas, D. D. Warner, T. Otsuka, K. Heyde and J. P. Draayer. (1993) ; Algebraic Approaches to Nuclear Structure. Interacting Boson and Fermion Models., Harwood Academic Publishers GmBH, Switzerland,.

[19]- Scholten O. ; Iachello, F. and Arima, A. (1978) ;"Interacting Bosons Model of Collective Nuclear States III. The Transition From SU(5) to SU(3)"; Ann. Phys. 115, (325-366) .

[20]- J. K. Tuli, (2011); National Nuclear Data Center (NDDC), „An Update of B(E2) Evaluation for $0^+_1 \rightarrow 2^+_1$ Transitions in Even-Even Nuclei near N~Z~28, Brookhaven National Laboratory Report BNL-94720-2011-JA http://www.nndc.bnl.gov/be2/.

[21]- B. Singh, R. Firestone (1995); Nuclear Data Sheets; Vol.74 No.383.

[22]- P. Navrátil, B. R. Barrett, and J. Dobeš, (1996) ;Phys. Rev. C 53, 2794.

Table(1): The Hamiltonian Parameters Used in the IBM-Code for ^{122}Te Isotopes

Nucleus	EPS	P.P.	L.L.	Q.Q.	$T_3.T_3$	$T_4.T_4$	CHI	SO6
^{122}Te	0.0005	0.1730	0.0253	0.0000	0.2531	0.0000	0.0000	1.0000

Table(2): The Experimental Values of B(E2) and the Coefficients(E2SD, E2DD) for ^{122}Te Used in the Present Work

Nucleus	$B(E2:2_1^+\rightarrow 0_1^+)e^2b^2$	E2SD	E2DD
^{122}Te	0.1320	0.0931	-0.275

Table (3): The Experimental and Calculated B(E2) Using IBMT-Code and the Quadrupole Moment Q_{21}^+ for ^{122}Te Isotope

i-f	$B(E2)\downarrow e^2b^2$	
	Exp.[18]	IBM-1
$2_1^+ \to 0_1^+$	0.132	0.131
$2_1^+ \to 0_2^+$	----	0.041
$2_2^+ \to 0_1^+$	0.004	0.002
$2_2^+ \to 0_2^+$	----	0.006
$2_2^+ \to 2_1^+$	0.039	0.036
$2_3^+ \to 0_2^+$	----	0.061
$2_3^+ \to 0_3^+$	----	0.001
$2_4^+ \to 0_2^+$	----	0.019
$2_4^+ \to 0_3^+$	----	0.000
$2_1^+ \to 2_2^+$	----	0.191
$4_1^+ \to 2_1^+$	0.196	0.189
$4_1^+ \to 2_3^+$	----	0.001
$4_2^+ \to 2_1^+$	----	0.000
$4_2^+ \to 2_2^+$	----	0.043
$4_2^+ \to 2_3^+$	----	0.004
$Q2_1^+$	0.615	0.614

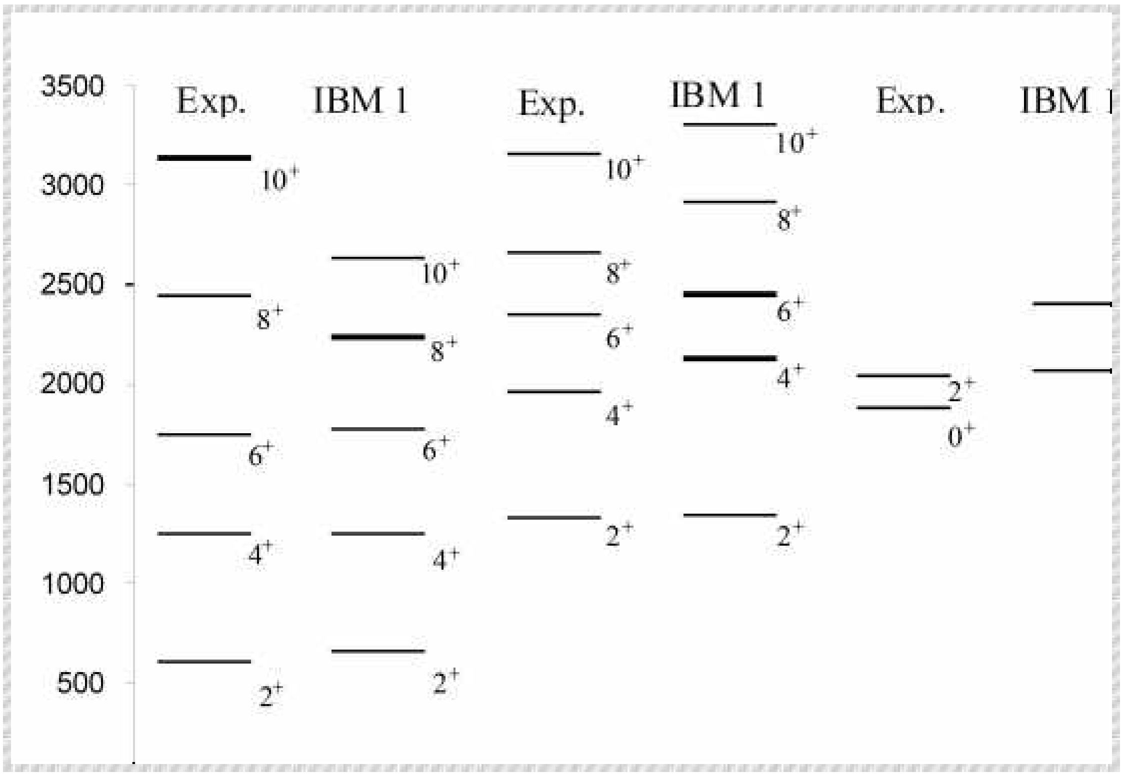

Figure 1: Comparison between Experiment [15, 16, 17] and Calculated Energy Levels for ^{122}Te Isotope.