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Nucleon- Nucleon Realistic Interactions of Some Light Nuclei

A research

Submitted to the Council of the College of Education for Pure Sciences of University of Babylon in Partial Fulfillment of the Requirements for the Degree of Higher Diploma Education/ Physics of Materials and its Applications.

By

Wadah Mohmmed Morad Farhan

B.Sc. in Physics

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Supervised by

Prof. Dr. Khalid Salih Jassim

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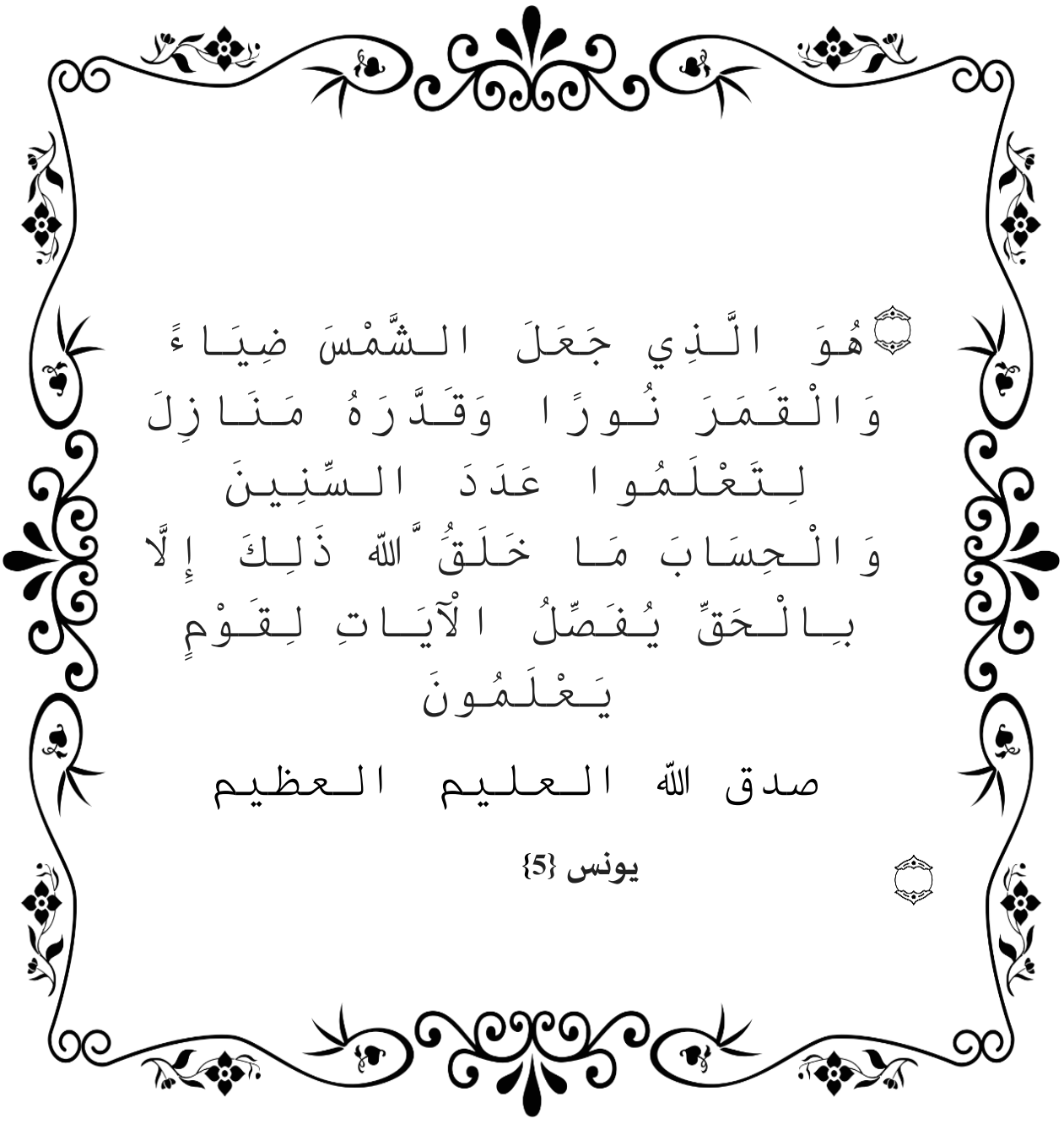

﴿هُوَ الَّذِي جَعَلَ الشَّمْسَ ضِيَاءً وَالْقَمَرَ نُورًا وَقَدَّرَهُ مَنَازِلَ لِتَعْلَمُوا عَدَدَ السِّنِينَ وَالْحِسَابَ مَا خَلَقَ اللّه ذَلِكَ إِلَّا بِالْحَقِّ يُفَصِّلُ الْآيَاتِ لِقَوْمٍ يَعْلَمُونَ﴾

صدق الله العليم العظيم

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Signature:

Name:Fatima Mohammed Hussain

Title:Assistant Professor

Address Physics Department

Date: / /2021

Scientific Supervisor's Certification

This is certify that I have read this thesis, entitled **Nucleon Nucleon Realistic Interactions of some light Nuclei** and I found that this thesis is qualified for debate.

Signature:

Name:Shrooq Abd AL Abbas

Title:Assistant Professor

Address:Physics Department

Date: / /2021

Supervisor Certification

I certify that this research entitled ***Nucleon Nucleon Realistic Interactions of Some light Nuclei***, is prepared by the student (**Wadah Mohammed Morad Farhan**), under my supervision at the College of Education for Pure Sciences, University of Babylon, as partial fulfillment of the requirements for the Degree of Higher Diploma Education/ Physics of Materials and it's Applications.

Signature:

Supervisor: **Khalid Salih Jassim**

Title: **Professor**

Address: Physics Department

Date: / / 2021

Certification of the Head of the Department

In view of the available recommendation, I forward this thesis for debate by the examination committee.

Signature:

Name: **Khalid H. Abbas**

Title: **Professor**

Address: Head of Physics Department

Date: / / 2021

Committee Certification

We members of Examining Committee, certify that after reading this research entitled **Nucleon Nucleon Realistic Interactions of Some light Nuclei** ' submitted by (***Wadah Mohammed Morad Farhan***) , and examining the student in its contents, in our opinion it is adequate for the partial fulfillment of the requirement for the Degree of Higher Diploma Education/ Physics of Materials and its Applications.

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Name:Mohammed Abd AL Hamsa
Title:Professor
Date: / /2021

Member

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Name:Mohanad Hussain Oleiwi
Title:Assistant Professor
Date: / /2021

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Signature:
Name:Mohsen Kadim Abd
Title:teacher
Date://2021

Supervisor

Signature:
Name:Khalid Salih Jassim
Title:Professor
Date: / /2021

Approved by the Dean of the college of Education for Pure

Signature:
Name:Bahaa H . Rabee
Title:Professor
Date: / /2021

Dedication

To My Dear…

Father

Mother

Sisters and Brother

Acknowledgements

At the beginning, thanks Allah for what I have now…

I would like to express my special thanks to **Prof. Dr. Khalid Salih Jassim** for his supervision. Without his endless support and help this work could not be achieved. I cannot forget my beloved friends; their encouragement was my motivation. I also would like to thank my College. I apologize for whom I miss to mentioning. I wish success to all.

Wadah

Abstract

Nucleon-nucleon realistic interaction of some light nuclei: ^{6}Li, ^{7}Li, ^{9}Be, ^{10}B and ^{12}C nuclei have been calculated using Michigan three Yukawa's (M3Y).

The wave functions of radial single-particle matrix elements have been calculated with harmonic-oscillator.

In this research, we used the M3Y- code which is written in Fortran 90 language.

The two-body Michigan three Yukawa's (M3Y) interactions were given in LS-coupling. A transformation between LS and jj must performed to get the relation between the two-body shell model matrix elements and the relative and center of mass coordinates, using the harmonic oscillator radial wave functions with Talmi-Moshinsky transformation. In these calculations, we calculate the values of M3Y matrix elements and then plotted with the total angular momentum to show the distributions according to J.

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INTRODUCTION AND LITERATURE REVIEW

The first idea about the nature of the nucleon-nucleon interaction came from Japanese scientist Yukawa in 1935 [1]. He assumed that the strong interaction between the nucleons is carried out by an exchange of a particle of a medium heavy mass of about 200 MeV [2], called meson A meson is an elementary particle with a positive,negative or neutral charge .the meson agree that they have a mass of 2oo MeV the same as the mass of an electron and have a spin moment equal to1,and mesons are unstable particles,and in the least fraction of a second immediately after their formation ,they begin to disintegrate into lighter particles .Mesons may carry negative or positive charges or be neutral . It is called π -meson which has found to be the carrier of the strong nuclear force.there are many types of meson such as Pseudoscalar,Pseudovector,Vector meson and Scalar meson. But during the fifties it was discovered other mesons which contributed to the nucleon-nucleon interaction. One of the high points of this development was the suggestion of Gregory Briet in 1958 [3] that the short range repulsion should be due to a

vector, isoscalar meson, the omega meson with a mass of about 800 MeV. It

was a big success of the meson exchange theory of the nucleon-nucleon interaction when this meson was found also experimentally [2]. The Michigan three-range Yukawa M3Y interaction will be pliable in various models and M3Y interaction gave matrix elements similar to some dependable shell-model interactions, the M3Y-type interactions has been obtained from the realistic N-N interaction by fitting the Yukawa functions to the G-matrix given by the sum of the Yukawa functions .M3Y-type interactions have successfully been used for nuclear reactions , involved electron scattering. A kind of the M3Y-type interactions can be used to the electron scattering form factor calculations.

K. Jassim (2008) had been used microscopic theory which allows particle-hole excitation from the 1s and 1p shells core-orbits and also from the 2s1d-shell orbits to the higher allowed orbits with excitations about $6\hbar\omega$ were included core-polarization effects. The two-body Michigan three Yukawa M3Y interactions are used CP matrix elements and also the two-body wildenthal interaction is used for the sd-shell model space to calculate the longitudinal electron scattering form factors in even-even sd-shell nuclei :^{18}O , ^{20}Ne , ^{24}Mg and ^{28}Si the CP effects on the coulomb form factors was essential for the transition strengths (B(C2)) and the q and noticed matching in the form factor in the lower value of momentum transition, from another side there is no matching (deviation) in higher values in momentum transition.

Inelastic electron scattering form factors in some odd-A sd-shell nuclei: ^{17}O, ^{27}Al and ^{39}K were calculated by K. Jassim (2013) using the two-body wildenthal interaction as a model space effective interaction. The M3Y interactions are used for CP calculation. The wave functions of radial single-particle matrix elements have been calculated with HO

potential. The model space calculations fails to describe the form factor in all momentum transfers region, while the calculations using CP effect give an excellent agreement.

K. Jassim et al. (2014) have been calculated the nuclear structure of: ^{23}Na, ^{25}Mg, ^{27}Al, and ^{41}Ca nuclei using shell-model calculations. Two shell-model codes, CPM3Y and NUSHELL for Windows, have been used to calculate these results. The wave functions of radial single-particle matrix elements have been calculated with HO and WS potentials. A set of two-body interactions are used in this work ,Wildenthal interaction A in the proton-neutron formalism for sd, universal sd-shell interaction B and GXFP1 interaction for the fp shell. Michigan three-range Yukawa M3Y was used as a two body interaction for CP calculations .Very good agreements are obtained for all nuclei in this study after comparing the measured results with the experimental data. Results from electron scattering form factor calculations have shown that the core-polarization effects are necessary to get a reasonable description of the data without adjustable any parameter.

Khalid S. Jassim and et. al have been studied the nuclear structure (energy levels, elastic and inelastic electron-nucleus scattering, and transition probability) of ^{23}Na, ^{25}Mg, ^{27}Al, and ^{41}Ca nuclei have been studied using shell-model calculations with M3Y interaction. A set of two-body interactions are used in this paper. The universal s d of the Wildenthal interaction in the proton-neutron formalism, universal s d-shell interaction A, universal s d-shell interaction B, and GXFP1 interaction for the f p shell is used with the nucleon-nucleon realistic interaction Michigan three-range Yakawas as a two-body interaction for

core-polarization calculations. Two shell-model codes, CPM3Y and nushell for Windows, have been used to calculate the results. The wave

functions of radial single-particle matrix elements have been calculated with harmonic-oscillator and Woods-Saxon potentials. The level schemes are compared with the experimental data up to 5.776, 5.251, and 4.51 MeV for ^{23}Na, Mg, respectively. Very good agreements are obtained for all nuclei in this study. Results from electron scattering form-factor calculations have shown that the core-polarization effects are essential to obtain a reasonable description of the data with no adjustable parameters.

KS Jassim, AA Al-Sammarrae, FI Sharrad, HA Kassim, Elastic and inelastic electron-nucleus scattering form factors of some light nuclei: Na 23, Physical Review C 89 (1), 014304, 2014.

Khalid S. Jassim and et. al. were studied the longitudinal form factors for electron scattering have been calculated for p-shell nuclei using enlarged model space includes all orbits in 1p and 2s-1d shells The two-body Cohen-Kurath interaction is used for the p-shell orbits while Preedam-Wildenthal for the sd-shell orbits The two body Milliner-Kurath interactions are used for the psd orbits The two-body Kuo-normalized G-matnx between the p-shell orbits and the sd-shell orbits are adopted Core-polarization effects are taken into consideration through excitations of nucleons from the 1 s core orbits and also from the valence 1p and 2s-1 d orbits into higher shells, with Shco excitations The two-body Michigan three Yakawa (M3Y) interaction is used for the core-

polarization matrix elements Core polanzation effects improve the agreement with the experimental data remarkably well and play an essential role for electromagnetic transitions and electron scattering form factors.

RA Radhi, AK Hamoudi, KS Jassim, "Calculations of longitudinal form factors of p-shell nuclei, using enlarged model space including core-polarization effects with realistic two-body effective interaction", Indian Journal of Physics, 81, 683-695, 2007.

Khalid s. Jassim and et. al. have been studied the Longitudinal and transverse electron scattering form factors and transition probabilities have been calculated for different states in ^{10}B, ^{32}Sc and ^{48}Ca nuclei, where a microscopic theory is employed to include the effect of high configuration outside the model space, which is called the core-polarization (CP) effect. The Cohen–Kurath interaction for p-shell, the universal sd of Wildenthal interaction for sd-shell and the GXFP1 interaction for fp-shell are used with the Michigan three-range Yakawa (M3Y) effective NN interaction and modified surface delta interaction as a residual interaction for the CP calculations. The calculation is performed using the shell model codes CPM3Y and NuShell. The radial wave function for the single-particle matrix elements have been calculated with the Skyrme–Hartree Fock, harmonic oscillator potential and Wood Saxson potential to calculate the single-particle wave function. The inclusion of CP effects modifies the form factors markedly and describes the experimental data very well in the momentum transfer dependence.

Khalid S. Jassim, The electron scattering form factor of ^{10}B, ^{32}S and ^{48}Ca nuclei,

Physica Scripta 86 (3), 035202, 2012.

Chapter Two

Michigan Three Yakawa (M3Y) Potential

2.1 Relative and center of mass transformation coefficient

For a two-particle system in a harmonic-oscillator potential, we shall characterize the two-particles by their coordinates and quantum numbers . For the purpose of our discussion, two systems of coordinates are introduced:

1.Laboratory frame, where the two particles are described by their coordinates with respect to the center of the potential well, $\vec{r}_1$ and $\vec{r}_2$, and corresponding radial quantum numbers, n_1, n_2 and l_1, l_2, respectively.

2.Center of mass frame, where the system is characterized by the relative coordinate $\vec{r}$ and the coordinate $\vec{R}$ of the center of mass of the two-particles, defined as [4]:

$$\vec{r}=\frac{1}{\sqrt{2}}(\vec{r_1}-\vec{r_2}),\ \vec{R}=\frac{1}{\sqrt{2}}(\vec{r_1}+\vec{r_2}) \qquad (2\text{-}1)$$

The wave functions in the two coordinate systems may be written as follows

- Laboratory frame:

$$\psi^{Ho}_{\lambda\mu}\{l_1,l_2\}=\left[\phi^{Ho}_{n_1l_1}(r_1)\times\phi^{Ho}_{n_2l_2}(r_2)\right]_{\lambda\mu}$$

$$=\sum_{m_1m_2}\left\langle l_1m_1l_2m_2\,|\lambda\mu\right\rangle\,\phi_{n_1l_1}(r_1)\phi_{n_2l_2}(r_2) \qquad (2\text{-}2)$$

The notation $n_1l_1(1),n_2l_2(2)$ means particle number 1 is in the state n_1l_1 and particle number 2 is in the n_2l_2 orbit, $\phi^{Ho}_{n_1l_1}$ and $\phi^{Ho}_{n_2l_2}$ are the wave functions for particle 1 and 2, respectively.

- Center of mass:

$$\psi^{Ho}_{\lambda\mu}\{lL\}=\left[\phi^{Ho}_{nl}(r)\times\phi^{Ho}_{NL}(R)\right]_{\lambda\mu}=\sum_{mM}\left\langle lmLM\,|\lambda\mu\right\rangle\,\phi_{nl}(r)\phi_{NL}(R) \qquad (2\text{-}3)$$

where $\phi_{nl}^{Ho}, \phi_{NL}^{Ho}$ are the wave functions for the particle 1 and 2 in term of relative and center of mass, respectively. The principal and the radial quantum numbers n, ℓ are corresponding to the relative motion, and N, L to that of the center of mass motion.

The transformation brackets (Moshinisky brackets) are then the coefficients which arise on expanding the wave function in equation (2-2) in terms of wave function in equation (2-3).

$$\left[\phi_{n_1l_1}^{Ho}(r_1)\times\phi_{n_2l_2}^{Ho}(r_2)\right]_{\lambda\mu} = \sum_{nlNL} M_\lambda \left\langle nlNL \middle| n_1l_1n_2l_2 \right\rangle \left[\phi_{nl}^{Ho}(r)\times\phi_{NL}^{Ho}(R)\right]_{\lambda\mu} \quad (2\text{-}4)$$

The coefficients $M_\lambda \left\langle nlNL \middle| n_1l_1n_2l_2 \right\rangle$ that appear in equation (2-4) are called Brody-Moshinisky brackets.

The square of M_λ gives the propability that the two particle systems will be found in a state of relative motion characterized by the oscillator function $R_{nl}(r)Y_{lm}(\theta,\phi)$ and center of mass motion $R_{NL}(R)Y_{LM}(\Theta,\Phi)$

It may be shown that this transformation is independent of the magnetic number μ. The transformation braket vanishes for all combinations of its parametres which do not satisfy the total angular momentum

$$\vec{\lambda} = \vec{l_1} + \vec{l_2} = \vec{l} + \vec{L}$$

and the degenerated eigen value (energy) in this case is [5]:

$$E(n_1l_1, n_2l_2) = (2n_1 + l_1 + \frac{3}{2})\hbar\omega + (2n_2 + l_2 + \frac{3}{2})\hbar\omega$$

$$E(nl, NL) = (2n + l + \frac{3}{2})\hbar\omega + (2N + L + \frac{3}{2})\hbar\omega \qquad (2\text{-}5)$$

where $E(n_1l_1, n_2l_2) = E(nl, NL)$

it follows from the conservation law of energy that [5]:

$$2n_1 + l_1 + 2n_2 + l_2 = 2n + l + 2N + L \qquad (2\text{-}6)$$

Therefore, the transformation of Moshinsky bracket vanishes for all combinations of its parameters which do not satisfy the energy condition of equation (2-6), and any summations over λ will be restricted to [4,5]

$$|l_1 - l_2| \le \lambda \le l_1 + l_2$$

$$|l - L| \le \lambda \le l + L \qquad (2\text{-}7)$$

The wave functions $\phi_{nl}(\vec{r})$ describe states with energy $(2n + l + \frac{3}{2})\hbar\omega$ and have the form

$$\phi_{nl}(\vec{r}) = R_{nl}(\alpha r) Y_{lm}(\theta, \varphi) \qquad (2\text{-}8)$$

where

$$R_{nl}(\alpha r) = \left[\frac{2^{l-n+2}(2l+2n+1)!!\,\alpha^{2l+3}}{\sqrt{\pi}\left[(2l+1)!!\right]^2} \right]^{1/2} \left[\exp\left(-\frac{\alpha^2}{2} r^2 \right) \right] r^l$$

$$\times \sum_{k=0}^{n} \frac{(-1)^k 2^k n!(2l+1)!!(\alpha^2 r^2)^k}{k!(n-k)!(2l+2k+1)!!}$$

$Y_{l'm'}(\theta', \varphi')$ is the angular wave function and $\alpha^2 = \frac{m\omega}{\hbar}$.

Thus the (nlNL) sum in equation (2-4) is finite.

2.2 Some properties of Brody-Moshinisky coefficient

The Brody-Moshinisky transformation coefficient has a symmetry properties in a certain calculation, we reviewd them as [5]:

1- $M_\lambda(nlNL; n_1 l_1 n_2 l_2) = (1)^{L-\lambda} M_\lambda(nlNL; n_2 l_2 n_1 l_1)$ (2-9)

2- $M_\lambda(nlNL; n_1 l_1 n_2 l_2) = (1)^{l_1-\lambda} M_\lambda(NLnl; n_1 l_1 n_2 l_2)$ (2-10)

3- $M_\lambda(nlNL; n_1 l_1 n_2 l_2) = (1)^{L-l_2} M_\lambda(NLnl; n_2 l_2 n_1 l_1)$ (2-11)

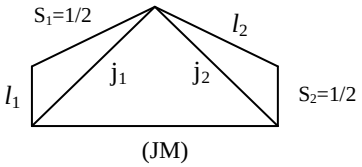
The Moshinisky transformation coefficients are real and independent of μ.

2.3 Energy matrix element with oscillator function

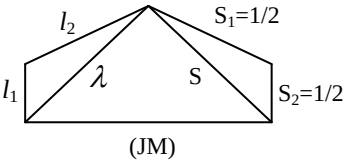
The oscillator is the only potential that can be separated into relative and center of mass coordinate system, this property also important in order to get the matrix element of the residual interaction as it is a function of relative coordinate ($\vec{r}$)

In order to make the two body wave functions compatable with the LS-term of the residual interaction , because of the strong two-body spin-orbit force in nuclei, which leads to the required shell structure, and the orginal two body wave function is represented with jj schem, it is necessary to transform the two body wave function from jj schem to LS schem as follows [5]:

$$[\phi_{j_1 l_1} \times \phi_{j_2 l_2}]_{JM} =$$



$$= \sum_{\lambda S} \sqrt{(2j_1+1)(2j_2+1)(2\lambda+1)(2S+1)} \begin{Bmatrix} l_1 & 1/2 & j_1 \\ l_2 & 1/2 & j_2 \\ \lambda & S & J \end{Bmatrix}$$



(2-12)

Thus

$$\Phi_{JM}\{j_1 n_1 l_1(1), j_2 n_2 l_2(2)\} = [\phi_{j_1 l_1}(1) \times \phi_{j_2 l_2}(2)]_{JM}$$

$$= \sum_{\lambda s} \gamma_{\lambda s}^{(J)}(j_1 l_1; j_2 l_2) \times [\psi_\lambda \{n_1 l_1(1), n_2 l_2(2)\} \times \chi_s(1,2)]_{JM} \qquad (2\text{-}13)$$

where

$$\chi_{SM'}(1,2) = \sum_{\upsilon\upsilon'} (\frac{1}{2}\upsilon \frac{1}{2}\upsilon' | SM') \chi_\upsilon(1) \chi_{\upsilon'}(2) \qquad (2\text{-}14)$$

And $\psi_{\lambda\mu}$ is the spatial part of the two particle orbital wave function given by equation (2-13).

The coefficient $\gamma_{\lambda s}^{(I)}(j_1 l_1; j_2 l_2)$ is the j-j to L-S transformation coefficient.

$$\gamma_{\lambda S}^{(I)}(j_1 l_1; j_2 l_2) = \sqrt{(2j_1+1)(2j_2+1)(2\lambda+1)(2S+1)} \begin{Bmatrix} l_1 & 1/2 & j_1 \\ l_2 & 1/2 & j_2 \\ \lambda & S & J \end{Bmatrix} \qquad (2\text{-}15)$$

and when squared it gives the probability that the state $[\psi_\lambda \times \chi_S]_{JM}$ will be realized in the original j-j coupled eigenfunction.

However, the T=1 interaction energies must be calculated using space-spin antysmmetric states and those for T=0 by use of space-spin symmetric wave function. Thus instead of equation (2-13), we use [١١]:

$$\Phi_{JM}(j_1 n_1 l_1, j_2 n_2 l_2; T) = \frac{\mathbf{1}}{\sqrt{\mathbf{2}(\mathbf{1}+\delta_{j_1 j_2}\delta_{l_1 l_2}\delta_{n_1 n_2})}} \sum_{\lambda S} \gamma_{\lambda S}^{(J)}(j_1 l_1, j_2 l_2)$$
$$\times([\psi_\lambda\{n_1 l_1(\mathbf{1}), n_2 l_2(\mathbf{2})\} \times \chi_s(\mathbf{1},\mathbf{2})]_{JM}$$
$$+(-\mathbf{1})^T[\psi_\lambda\{n_1 l_1(\mathbf{1}), n_2 l_2(\mathbf{2})\} \times \chi_s(\mathbf{2},\mathbf{1})]_{JM}) \qquad (2\text{-}16)$$

As a consequence of the defining equation (2-14)

$$\chi_{SM'}(2,1) = (-1)^{1+s}\chi_{SM'}(1,2) \qquad (2\text{-}17)$$

and from equation it follows that [5]

$$\psi_{\lambda\mu}\{n_1 l_1(2), n_2 l_2(1)\} = (-1)^{l_1+l_2-\lambda}\psi_{\lambda\mu}\{n_1 l_1(1), n_2 l_2(2)\} \qquad (2\text{-}18)$$

Furthermore, from the properties of the Moshinisky coefficient [5]:

$$M_\lambda(nlNL; n_1 l_1 n_2 l_2) = (-1)^{L+\lambda} M_\lambda(nlNL; n_2 l_2 n_1 l_1)$$

If we combine these results together with the fact that [6] $(-1)^{l_1+l_2-L} = (-1)^l$, which follows from equation we see that Φ_{JM} can be written as:

$$\Phi_{JM}(j_1 n_1 l_1, j_2 n_2 l_2; T) = \frac{1}{\sqrt{(2(1+\delta_{j_1 j_4}\delta_{l_1 l_2}\delta_{n_1 n_2})}}$$
$$\times \sum_{\lambda S} \sum_{nlNL} \gamma_{\lambda S}^{(J)}(j_1 l_1, j_2 l_2)\{1-(-1)^{S+T+l}\} \times M_\lambda(nlNL; n_1 l_1 n_2 l_2)$$
$$\times([\psi_\lambda\{n_1 l_1(1), n_2 l_2(2)\} \times \chi_s(1,2)]_{JM} \qquad (2\text{-}19)$$

In this equation, the terms involving the phase factors show that, even l wave function, which are symmetric under the interchange of the two particles, must go with S=1,T=0 and S=0,T=1, where as antisymmetric spatial states (l odd) are associated with S=1,T=1 and S=0,T=0. Thus if we merely replace $\gamma_{\lambda S}^{(J)}$ by

$$\gamma'^{(J)}_{\lambda S}(j_1 l_1, j_2 l_2) = \frac{\{1-(-1)^{S+T+l}\}}{\sqrt{(2(1+\delta_{j_1 j_4}\delta_{l_1 l_2}\delta_{n_1 n_2})}}\gamma^{(J)}_{\lambda S}(j_1 l_1; j_2 l_2) \qquad (2\text{-}20)$$

Matrix elements of general energy operators V between basis states given by equation (2-19) have the form [5]:

$$\begin{aligned}
&\left\langle \Phi_{JM}\left(j_1 n_1 l_1, j_2 l_2 n_2; T\right)\middle|V\middle|\Phi_{JM}\left(j_3 n_3 l_3, j_4 l_4 n_4; T\right)\right\rangle \\
&\quad = \sum_{n'l'N'L'}\sum_{nlNL}\sum_{\lambda' S'}\sum_{\lambda S}\gamma'^{(J)}_{\lambda S}(j_1 l_1, j_2 l_2)\gamma'^{(J)}_{\lambda S}(j_3 l_3, j_4 l_4) \\
&\quad \times M_{\lambda'}(n'l'N'L'; n_1 l_1 n_2 l_2) M_{\lambda}(nlNL; n_3 l_3 n_4 l_4) \\
&\times \left\langle [[\phi_{n'l'}(r)\times\phi_{N'L'}(R)]\times\chi_{S'}]_{JM}\middle|V\middle|[[\phi_{n'l'}(r)\times\phi_{N'L'}(R)]\times\chi_{S'}]_{JM}\right\rangle \qquad (2\text{-}21)
\end{aligned}$$

One can abbreviate the two-body matrix element of a general operator as:

$$\left\langle \Phi_{JM}\left(j_1 n_1 l_1, j_2 l_2 n_2; T\right)\middle|V\middle|\Phi_{JM}\left(j_3 n_3 l_3, j_4 l_4 n_4; T\right)\right\rangle = \left\langle j_1 j_2\middle|V\middle|j_3 j_4\right\rangle_{\Gamma}$$

2.4 The realistic M3Y effective Nucleon-Nucleon interactions

The two-body matrix elements which are used in the present work to calculate the core-polarization effect are not obtained from a fit to spectroscopic data such as modified surface delta interaction (MSDI), but they are calculated from free nucleon-nucleon interaction. It can be reasonably well-understood in terms of the meson-exchange models, so that the usual procedure is to start with theoretical forms of the NN interaction, based on varying degrees of meson-exchange theory, such as Paris, Born and Ried potentials [7]. Basically, one wants analytical form of the NN potential, which is, in general, obtained by fitting some set of potential parameters, i.e.,

strength and ranges to the ground state (g.s) properties of deuteron and the low-energy NN scattering phase-shift (up to $\approx$300 MeV), so that one can then extrapolate to the off-energy shell behavior required by many-body systems. For higher energies, description in terms of a potential loses its meaning due to meson exchange.

Potentials derived from the description of free nucleon-nucleon scattering are customarily referred to as a realistic NN effective interaction. One of the interactions of this type, which is frequently used in shell-model calculations, is the one obtained by Hamada-Johnston [8]. In another approach one-derived two-body matrix elements in a particular single-particle basis directly from the scattering phase-shift. In this case, interaction of the explicit form of the realistic interaction is avoided by Elliott et al [9].

The direct application of a realistic interaction in a shell-model calculation dose not lead to an acceptable agreement with spectroscopic data. This is due to the fact that a shell-model calculation is necessarily restricted to a finite, truncated model space. For a reasonably complete description in terms of a realistic interaction, one should take into account the scattering of nucleons into many more single-particle states. In particular, also the presence of the core assumed to be inert in the model calculation has a strong modifying influence of the interaction between the nucleons outside the core. This means that for a model calculation one needs the so-called (effective interaction). For a given configuration space this effective interaction can, in principle, be constructed from the nucleon-nucleon interaction when all processes that take place outside the chosen configuration space are accounted for in terms of perturbation theory.

The realistic M3Y effective NN interaction, which is used in electron scattering ($V_{res} = v_{12}$) is expressed as a sum of the central potential part $v_{12}^{(C)}$, spin-orbit potential part $v_{12}^{(LS)}$, and long range tensor part $v_{12}^{(TN)}$, as follows [7]:

$$v_{12} = v_{12}^{(c)} + v_{12}^{(LS)} + v_{12}^{(TN)} \quad \text{……. ……(2-22)}$$

The three potentials are expressed as: [7]

$$v_{12}^{(c)} = \sum_n (t_n^{(SE)} P_{SE} + t_n^{TE} P_{TE} + t_n^{(SO)} P_{SO} + t_n^{(TO)} P_{TO}) f_n^{(C)}(r_{12})$$

$$v_{12}^{(LS)} = \sum_n (t_n^{(LSE)} P_{TE} + t_n^{(LSO)} P_{TO}) f_n^{(LS)}(r_{12}) L_{12}.(\vec{s}_1 + \vec{s}_2)$$

$$v_{12}^{(TN)} = \sum_n (t_n^{(TNE)} P_{TE} + t_n^{(TNO)} P_{TO}) f_n^{(TN)}(r_{12}) r_{12}^2 S_{12}$$

……..(2-23)

The relative coordinate is denoted by $\vec{r}_{12} = \vec{r}_1 - \vec{r}_2$ and $|\vec{r}_{12}| = r_{12}$ Correspo - ndingly, the relative momentum is defined by $\vec{P}_{12} = \frac{(\vec{P}_1 - \vec{P}_2)}{2}$, $\vec{L}_{12}$ is the relative orbital angular momentum, $\vec{L}_{12} = \vec{r}_{12} \times \vec{P}_{12}$, $\vec{s}_1$ and $\vec{s}_2$ are the nucleon spin operators, and S_{12} is the tensor operator which is defined as[7,5]:,

$$S_{12} = 4[3(\vec{S}_1 \bullet \vec{r}_1)(\vec{S}_2 \bullet \vec{r}_2) - \vec{S}_1 \bullet \vec{S}_2] \quad \text{……(2-24)}$$

$$f_n(r_{12}) = \frac{e^{-\mu_{12} r_{12}}}{\mu_n r_{12}} \quad \text{……(2-25)}$$

where $t_n^{(SE)}$, $t_n^{(SO)}$, $t_n^{(TO)}$, $t_n^{(TE)}$ are the strength parameter in central part for (singlet-even), (singlet-odd), (triplet-odd) and (triplet-even), and $t_n^{(LSE)}$, $t_n^{(LSO)}$ are the strength parameter in the spin –orbit part for (singlet-even), (singlet-odd) and $t_n^{(TNE)}$, $t_n^{(TNO)}$ are the strength parameter in tensor part for (tensor even), (tensor-odd) respectively and (μ_n) are the range parameter of the nucleon-nucleon interaction, (μ_n=1/Rn). These parameter values are given in table (2-1).

The two-body matrix elements of the realistic M3Y effective NN interaction consist of three parts, one is the central matrix element, the spin-orbit matrix element and the tensor matrix element.

$$\langle j_1 j_2 | V_{res} | j_3 j_4 \rangle_\Gamma = \langle j_1 j_2 | V_C | j_3 j_4 \rangle_\Gamma + \langle j_1 j_2 | V_{s.l} | j_3 j_4 \rangle_\Gamma + \langle j_1 j_2 | V_{ten} | j_3 j_4 \rangle_\Gamma \quad (2\text{-}26)$$

where

$\langle j_1 j_2 | V_C | j_3 j_4 \rangle_\Gamma$ are the two-body matrix element of the centeral potential.

$\langle j_1 j_2 | V_{s.l} | j_3 j_4 \rangle_\Gamma$ are the two-body matrix element of the spin-orbit potential.

$\langle j_1 j_2 | V_{ten} | j_3 j_4 \rangle_\Gamma$ are the two-body matrix element of the tensor potential.

The two-body matrix elements of the centeral potential are given as [4,5]:

$$\langle j_1 j_2 | V_C | j_3 j_4 \rangle_\Gamma = \sum_{n'nlNL} \sum_{\lambda S} \gamma'^{(J)}_{\lambda S}(j_1 l_1, j_2 l_2) \gamma'^{(J)}_{\lambda S}(j_3 l_3, j_4 l_4)$$

$$\times M_{\lambda'}(n'l'N'L'; n_1 l_1 n_2 l_2) \times M_{\lambda}(nlNL; n_3 l_3 n_4 l_4) \left\langle R_{n'l'}(\vec{r}) \middle| V_S(\sqrt{2}\beta r) \middle| R_{nl}(\vec{r}) \right\rangle \quad (2\text{-}27)$$

The matrix elements of spin-orbit potential are given as[208,209]:

$$\langle j_1 j_2 | V_{s.l} | j_3 j_4 \rangle_\Gamma = \sum_{n'nlNL} \sum_{\lambda\lambda'} (-\mathbf{1})^{l+L+J} \sqrt{\mathbf{6}l(l+\mathbf{1})(\mathbf{2}l+\mathbf{1})(\mathbf{2}\lambda+\mathbf{1})(\mathbf{2}\lambda'+\mathbf{1})}$$

$$\times \gamma'^{(J)}_{\lambda S}(j_1 l_1, j_2 l_2) \gamma'^{(J)}_{\lambda S}(j_3 l_3, j_4 l_4) M_{\lambda'}(n'l'N'L'; n_1 l_1 n_2 l_2)$$

$$\times M_{\lambda}(nlNL; n_3 l_3 n_4 l_4)\ W(ll\lambda\lambda'; 1L)\ W(\lambda\lambda'; 1J)$$

$$\times \left\langle R_{n'l'}(\vec{r}) \middle| V_S(\sqrt{2}\beta r) \middle| R_{nl}(\vec{r}) \right\rangle \quad (2\text{-}28)$$

where, $W(....;..)$ is the Racah coefficient.

Finally, the matrix elements of the tensor potnetial are given as [4,5]

$$\langle j_1 j_2 | V_{ten} | j_3 j_4 \rangle_\Gamma = 2\sqrt{30} \sum_{n\ln'l'} \sum_{NL} \sum_{\lambda\lambda'} (-1)^{l-L+1-J} \sqrt{\{(2l+1)(2l+1)(2\lambda+1)(2\lambda'+1)\}}$$

$$\times M_{\lambda}(nlNL; n_3 l_3 n_4 l_4) W(\lambda\lambda' 11; 2J) W(ll'\lambda\lambda'; 2L)$$

$$\times \gamma'^{(J)}_{\lambda S}(j_1 l_1, j_2 l_2)\gamma'^{(J)}_{\lambda S}(j_3 l_3, j_4 l_4)\langle l200|l'0\rangle M_{\lambda'}(n'l'N'L'; n_1 l_1 n_2 l_2)$$

$$\times \left\langle R_{n'l}(\vec{r})\middle|V_{ten}(\sqrt{2}\beta r)\middle|R_{nl}(\vec{r})\right\rangle \qquad (2\text{-}29)$$

The radial integrals in equations (2-27), (2-28), and (2-29) may be calculated analytically and numerically using the fitting of the oscillator matrix elements of Elliott [10].

According to this fitting, the radial integral is:

$$\left\langle R_{n'l}(\vec{r})\middle|V(\sqrt{2}\beta r)\middle|R_{nl}(\vec{r})\right\rangle = \sum_{i=1}^{3}\frac{V_i}{\sqrt{2}\beta_i r}\int_0^\infty R_{n'l}(r)R_{nl}(r)e^{-\sqrt{2}\beta_i r}r^2 dr$$

$$= \frac{V_1}{\sqrt{2}\beta_1}Rad(n'l,nl,\beta_1) + \frac{V_2}{\sqrt{2}\beta_2}Rad(n'l,nl,\beta_2) + \frac{V_3}{\sqrt{2}\beta_3}Rad(n'l,nl,\beta_3) \quad ...(2\text{-}30)$$

where

$Rad(n'l,nl,\beta_1)$ is the radial part at β_1

$Rad(n'l,nl,\beta_2)$ is the radial part at β_2

$Rad(n'l,nl,\beta_3)$ is the radial part at β_3

Where: $\beta = \mu$ =1/R, and R is the range parameter of the nucleon-nucleon interaction

The first range parameters of the interaction (R_1) between two nucleons in centeral and spin-orbit force is 0.25 fm, the second range (R_2) is 0.4 fm, and the longest range (R_3) is 1.41fm. But the longest range of the interaction (R_3=0.7 fm) is only used in $r^2Y(x)$ fit to the tensor force.

There are four different ways in which pairs of protons and/or neutrons can be combined, and the nuclear force is different in each case.

- The "even" part of NN interaction is the part of interaction that is applies when the relative wave function is even (symmetric) under exchange of two particles. Notice that it is attractive as described above with a short range repulsion.

The label TE is the Triplet-Even (S=1, T=0) case that applied to the neutron and proton with parallel spins. Two neutrons cannot be in this configuration becuse it would violate the Pauli exclusion principle for identical particles. The label SE is the Singlet-Even (S=0, T=1) case applied to the di-neutron or di-proton with anti-parallel spins.

- The "odd" part of the NN interaction is applied when the relative wave function is odd (anty-symmetric) under exchange of the radial wave function. Notice that it basically consists of only the short-range repulsion.

The SO shows the Singlet-Odd (S=0, T=0) part applied to an L=1 (p state) of the n-p system with anti-parallel spins. The TO shows the Triplet-Odd (S=1, T=1) part that applied to nn and pp states with parallel spin.

The values of the best fit to the potential parameters ($t_n^{(SE)}, t_n^{(SO)}, t_n^{(TO)}, t_n^{(TE)}, t_n^{(LSE)}, t_n^{(LSO)}, t_n^{(TNE)}, t_n^{(TNO)}$) are shown in table (2-1) [11].

Table (٢.1). Shows the values of the best fit to the potential parameters [11].

	R_1=0.25 fm	R_2=0.40 fm	*R_3=1.414 fm
Oscillator matrix elements (Channel)	t_1	t_2	t_3
Centeral Singlet-Even (SE)	9958	-3105	-10.463
Central Triplet-Even (TE)	11849	-3761	-10.463
Central Singlet-Odd (SO)	26941	-2777	31.389
Central Triplet-Odd (TO)	0.0	0.0	3.488
Tensor-Even (TNE)	0.0	-171.7	-78.03
Tensor-Odd (TNO)	0.0	283.0	13.62
Spin-Orbit Even (LSE)	0.0	-813.0	0.0
Spin-Orbit Odd (LSO)	-2672	-620.0	0.0

** R_3 =1.414 fm, with the exception of TN unstarred, where R_{max} = 0.7 fm.*

Chapter Three

Results and discussions

3.1 Introduction:

To study the nucleus properties and explain the concepts of nuclear structure, we can use the electron scattering theory by the nucleon-nucleon interaction that in turn needs to many of issues we need to know in order to make calculations are possible and fast. These issues are mathematics, nuclear shell model theories, formulas and quantum mechanical theories, so you must connect and integrate, and programming of these issues and theories in a computer program we use in the computer so we can solve the big issues.

In the present study, a computer program, POT was used to calculate the Mechigan Three Yakaw (M3Y) potential which is used as a residual interaction in electron scattering form factors calculations.

The p-shells have been adopted in a study that addressed the coupling and distribution the nucleus within the specified model space. In the extended psd shell considered the ^{4}He as inert core and $1p_{1/2}$,$1p_{3/2}$ orbits represented by the quantum numbers nlj are valence orbital, where ^{4}He consists of two protons and two neutrons and to be inert in $1s_{1/2}$, Whilst the residual (A-4) nucleons are distributed over every feasible combinations. The nucleus which used in this study are: ^{6}Li, ^{7}Li, ^{9}Be, ^{10}B,^{12}C.

3.2 ^{6}Li nucleus

The ^{6}Li and ^{7}Li nuclei are especially interesting nuclei because both are the lightest state nuclei that contain p-shell nucleons. The structure and properties of ^{6}Li nucleus are experimentally and theoretically well studied (especially form factors are of particular interest). For the conventional many particles shell model, the ^{6}Li nucleus is essentially a three-body system, two valence nucleons distributed over $1p_{3/2}$-$1p_{1/2}$ shell and presumably inert ^{4}He core. Table. 1 show the values of matrix elements for M3Y realistic interaction for the ^{6}Li nucleus, where j1, j2, j3, j4 represents the value of different states of angular momentum and T is repersent the isospin space for different nucleon and different state. Figure (3.1) represents the relation between Michigan sum of three-range Yukawa potential (M3Y) interaction as afunction J. In this figure, we shown that the distribution of M3Y potential according to total angular momentum J.

Table 3.1: *The values of M3Y realistic interaction matrix elements for the ^{6}Li nucleus.*

j1	j2	j3	j4	J	T	M3Y
2	6	2	1	2	1	3.7503
2	1	2	6	2	1	3.7503
2	6	2	1	2	2	1.2599
2	1	2	6	2	2	1.2599
2	6	2	1	3	1	-0.7349
2	1	2	6	3	1	-0.7349
2	6	2	1	3	2	-0.0706
2	1	2	6	3	2	-0.0706
2	6	2	4	2	1	2.6933
2	4	2	6	2	1	2.6933
2	6	2	4	2	2	-1.3283
2	4	2	6	2	2	-1.3283
2	6	2	4	3	1	1.1851
2	4	2	6	3	1	1.1851
2	6	2	4	3	2	0.1622
2	4	2	6	3	2	0.1622
2	6	2	4	4	1	0.5259
2	4	2	6	4	1	0.5259

2	6	2	4	4	2	-1.8035
2	4	2	6	4	2	-1.8035
2	6	2	5	2	1	-0.7163
2	5	2	6	2	1	-0.7163
2	6	2	5	2	2	0.4365
2	5	2	6	2	2	0.4365
2	6	2	5	3	1	0.0723
2	5	2	6	3	1	0.0723
2	6	2	5	3	2	0.1073
2	5	2	6	3	2	0.1073
2	6	2	6	1	1	-4.0451
2	6	2	6	1	1	-4.0451
2	6	2	6	1	2	-1.3015
2	6	2	6	1	2	-1.3015
2	6	2	6	2	1	-2.8657
2	6	2	6	2	1	-2.8657
2	6	2	6	2	2	1.0797
2	6	2	6	2	2	1.0797
2	6	2	6	3	1	-2.1499
2	6	2	6	3	1	-2.1499
2	6	2	6	3	2	-0.7762
2	6	2	6	3	2	-0.7762
2	6	2	6	4	1	-2.5102
2	6	2	6	4	1	-2.5102
2	6	2	6	4	2	-1.0314
2	6	2	6	4	2	-1.0314
2	6	3	1	1	1	-2.5983
2	6	3	1	1	2	0.6608
2	6	3	1	2	1	4.9118
2	1	3	6	2	1	-0.0791
2	6	3	1	2	2	0.332
2	1	3	6	2	2	1.8505
2	1	3	6	3	1	1.6209
2	1	3	6	3	2	0.5541
2	4	3	6	2	1	1.5626
2	4	3	6	2	2	-2.7595
2	6	3	4	3	1	0.595
2	4	3	6	3	1	1.0607
2	6	3	4	3	2	-0.3013
2	4	3	6	3	2	0.1906
2	6	3	4	4	1	-2.7373
2	6	3	4	4	2	1.5041
2	6	3	5	1	1	3.0481
2	6	3	5	1	2	0.0036
2	6	3	5	2	1	-1.1799
2	5	3	6	2	1	0.3836

2	6	3	5	2	2	1.2044
2	5	3	6	2	2	-0.789
2	5	3	6	3	1	0.4311
2	5	3	6	3	2	-0.2772
2	6	3	6	2	1	-1.6316
2	6	3	6	2	1	-1.6316
2	6	3	6	2	2	-0.4453
2	6	3	6	2	2	-0.4453
2	6	3	6	3	1	2.0575
2	6	3	6	3	1	2.0575
2	6	3	6	3	2	-0.0574
2	6	3	6	3	2	-0.0574
2	6	4	2	2	1	-2.6933
2	2	4	6	2	1	-2.9977
2	6	4	2	2	2	-1.3283
2	6	4	2	3	1	1.1851
2	6	4	2	3	2	-0.1622
2	2	4	6	3	2	0.4912
2	6	4	2	4	1	-0.5259
2	2	4	6	4	1	-1.6284
2	6	4	2	4	2	-1.8035
2	3	4	6	2	1	3.115
2	3	4	6	2	2	0.1491
2	6	4	3	3	1	-0.595
2	3	4	6	3	1	3.5066
2	6	4	3	3	2	-0.3013
2	3	4	6	3	2	0.5206
2	6	4	3	4	1	-2.7373
2	6	4	3	4	2	-1.5041
2	6	5	2	2	1	0.7163
2	2	5	6	2	1	-0.6918
2	6	5	2	2	2	0.4365
2	6	5	2	3	1	0.0723
2	6	5	2	3	2	-0.1073
2	2	5	6	3	2	-0.0963
2	6	5	3	1	1	-3.0481
2	6	5	3	1	2	0.0036
2	6	5	3	2	1	-1.1799
2	3	5	6	2	1	1.695
2	6	5	3	2	2	-1.2044
2	3	5	6	2	2	-0.204
2	3	5	6	3	1	0.0787
2	3	5	6	3	2	0.4798
2	6	6	2	1	1	4.0451
2	6	6	2	1	2	-1.3015
2	2	6	6	1	2	2.3762

2	6	6	2	2	1	-2.8657
2	2	6	6	2	1	-0.2815
2	6	6	2	2	2	-1.0797
2	6	6	2	3	1	2.1499
2	6	6	2	3	2	-0.7762
2	2	6	6	3	2	0.1774
2	6	6	2	4	1	-2.5102
2	2	6	6	4	1	1.6113
2	6	6	2	4	2	1.0314
2	6	6	3	2	1	1.6316
2	3	6	6	2	1	-0.7124
2	6	6	3	2	2	-0.4453
2	6	6	3	3	1	2.0575
2	6	6	3	3	2	0.0574
2	3	6	6	3	2	0.8121
2	7	2	2	3	2	0.2244
2	2	2	7	3	2	0.2244
2	7	2	2	4	1	0.9837
2	2	2	7	4	1	0.9837
2	7	2	3	3	1	-0.5199
2	3	2	7	3	1	-0.5199
2	7	2	3	3	2	1.4137
2	3	2	7	3	2	1.4137
2	7	3	2	3	1	-0.5199
2	7	3	2	3	2	-1.4137
2	2	3	7	4	1	2.4165
2	1	4	7	2	1	-0.1691
2	1	4	7	2	2	-0.7448
2	7	4	1	3	1	-0.2338
2	1	4	7	3	1	-0.3089
2	7	4	1	3	2	0.7684
2	1	4	7	3	2	0.2875
2	7	4	1	4	1	0.8796
2	7	4	1	4	2	-0.5326
2	4	4	7	2	1	-0.0578
2	4	4	7	2	2	0.8441
2	4	4	7	3	1	0.396
2	7	4	4	3	2	-0.0389
2	4	4	7	3	2	0.6512

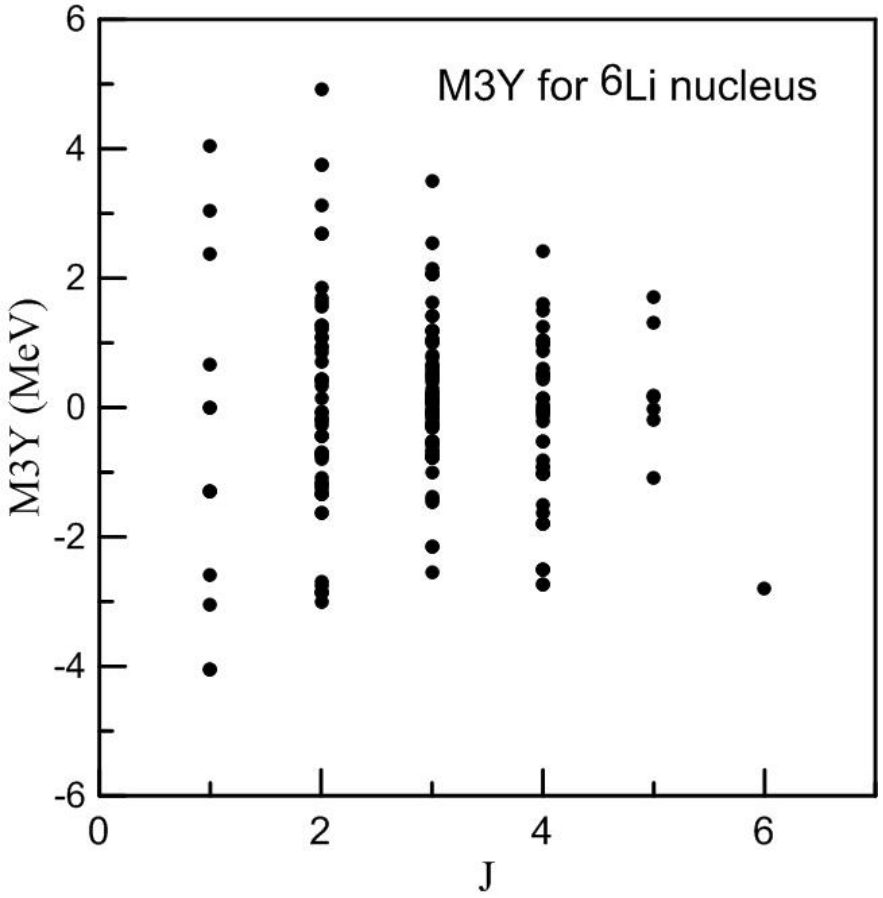


Fig. (3.1) M3Y potential in the ^{6}Li nucleus calculated as a function of angular momentum (J).

3.3 ^{7}Li nucleus

The ^{7}Li nucleus, According to the conventional p-shell model, it is described in terms of three nucleons outside a closed 1s-shell, with size parameter b_{rms}=1.77 fm obtained from a fit to nuclear charge radius [12].

Table. 1 show the values of matrix elements for M3Y realistic interaction for the ^{6}Li nucleus, where j1, j2, j3, j4 represents the value of different states of angular momentum and T is repersent the isospin space for different nucleon and different state. Figure (3.2) represents the relation between Michigan sum of three-range Yukawa potential (M3Y) interaction as afunction J. In this figure, we shown that the distribution of M3Y potential according to total angular momentum J.

Table 3.2: *The values of M3Y realistic interaction matrix elements for the ^{7}Li nucleus.*

j1	j2	j3	j4	J	T	M3Y
2	6	2	1	2	1	3.7503
2	1	2	6	2	1	3.7503
2	6	2	1	2	2	1.2599
2	1	2	6	2	2	1.2599
2	6	2	1	3	1	-0.7349
2	1	2	6	3	1	-0.7349
2	6	2	1	3	2	-0.0706
2	1	2	6	3	2	-0.0706
2	6	2	4	2	1	2.6933
2	4	2	6	2	1	2.6933
2	6	2	4	2	2	-1.3283
2	4	2	6	2	2	-1.3283
2	6	2	4	3	1	1.1851
2	4	2	6	3	1	1.1851
2	6	2	4	3	2	0.1622
2	4	2	6	3	2	0.1622
2	6	2	4	4	1	0.5259
2	4	2	6	4	1	0.5259
2	6	2	4	4	2	-1.8035
2	4	2	6	4	2	-1.8035
2	6	2	5	2	1	-0.7163
2	5	2	6	2	1	-0.7163
2	6	2	5	2	2	0.4365

2	5	2	6	2	2	0.4365
2	6	2	5	3	1	0.0723
2	5	2	6	3	1	0.0723
2	6	2	5	3	2	0.1073
2	5	2	6	3	2	0.1073
2	6	2	6	1	1	-4.0451
2	6	2	6	1	1	-4.0451
2	6	2	6	1	2	-1.3015
2	6	2	6	1	2	-1.3015
2	6	2	6	2	1	-2.8657
2	6	2	6	2	1	-2.8657
2	6	2	6	2	2	1.0797
2	6	2	6	2	2	1.0797
2	6	2	6	3	1	-2.1499
2	6	2	6	3	1	-2.1499
2	6	2	6	3	2	-0.7762
2	6	2	6	3	2	-0.7762
2	6	2	6	4	1	-2.5102
2	6	2	6	4	1	-2.5102
2	6	2	6	4	2	-1.0314
2	6	2	6	4	2	-1.0314
2	6	3	1	1	1	-2.5983
2	6	3	1	1	2	0.6608
2	6	3	1	2	1	4.9118
2	1	3	6	2	1	-0.0791
2	6	3	1	2	2	0.332
2	1	3	6	2	2	1.8505
2	1	3	6	3	1	1.6209
2	1	3	6	3	2	0.5541
2	4	3	6	2	1	1.5626
2	4	3	6	2	2	-2.7595
2	6	3	4	3	1	0.595
2	4	3	6	3	1	1.0607
2	6	3	4	3	2	-0.3013
2	4	3	6	3	2	0.1906
2	6	3	4	4	1	-2.7373
2	6	3	4	4	2	1.5041
2	6	3	5	1	1	3.0481
2	6	3	5	1	2	0.0036
2	6	3	5	2	1	-1.1799
2	5	3	6	2	1	0.3836
2	6	3	5	2	2	1.2044
2	5	3	6	2	2	-0.789
2	5	3	6	3	1	0.4311
2	5	3	6	3	2	-0.2772
2	6	3	6	2	1	-1.6316

2	6	3	6	2	1	-1.6316
2	6	3	6	2	2	-0.4453
2	6	3	6	2	2	-0.4453
2	6	3	6	3	1	2.0575
2	6	3	6	3	1	2.0575
2	6	3	6	3	2	-0.0574
2	6	3	6	3	2	-0.0574
2	6	4	2	2	1	-2.6933
2	2	4	6	2	1	-2.9977
2	6	4	2	2	2	-1.3283
2	6	4	2	3	1	1.1851
2	6	4	2	3	2	-0.1622
2	2	4	6	3	2	0.4912
2	6	4	2	4	1	-0.5259
2	2	4	6	4	1	-1.6284
2	6	4	2	4	2	-1.8035
2	3	4	6	2	1	3.115
2	3	4	6	2	2	0.1491
2	6	4	3	3	1	-0.595
2	3	4	6	3	1	3.5066
2	6	4	3	3	2	-0.3013
2	3	4	6	3	2	0.5206
2	6	4	3	4	1	-2.7373
2	6	4	3	4	2	-1.5041
2	6	5	2	2	1	0.7163
2	2	5	6	2	1	-0.6918
2	6	5	2	2	2	0.4365
2	6	5	2	3	1	0.0723
2	6	5	2	3	2	-0.1073
2	2	5	6	3	2	-0.0963
2	6	5	3	1	1	-3.0481
2	6	5	3	1	2	0.0036
2	6	5	3	2	1	-1.1799
2	3	5	6	2	1	1.695
2	6	5	3	2	2	-1.2044
2	3	5	6	2	2	-0.204
2	3	5	6	3	1	0.0787
2	3	5	6	3	2	0.4798
2	6	6	2	1	1	4.0451
2	6	6	2	1	2	-1.3015
2	2	6	6	1	2	2.3762
2	6	6	2	2	1	-2.8657
2	2	6	6	2	1	-0.2815
2	6	6	2	2	2	-1.0797
2	6	6	2	3	1	2.1499
2	6	6	2	3	2	-0.7762

2	2	6	6	3	2	0.1774
2	6	6	2	4	1	-2.5102
2	2	6	6	4	1	1.6113
2	6	6	2	4	2	1.0314
2	6	6	3	2	1	1.6316
2	3	6	6	2	1	-0.7124
2	6	6	3	2	2	-0.4453
2	6	6	3	3	1	2.0575
2	6	6	3	3	2	0.0574
2	3	6	6	3	2	0.8121
2	7	2	2	3	2	0.2244
2	2	2	7	3	2	0.2244
2	7	2	2	4	1	0.9837
2	2	2	7	4	1	0.9837
2	7	2	3	3	1	-0.5199
2	3	2	7	3	1	-0.5199
2	7	2	3	3	2	1.4137
2	3	2	7	3	2	1.4137
2	7	3	2	3	1	-0.5199
2	7	3	2	3	2	-1.4137
2	2	3	7	4	1	2.4165
2	1	4	7	2	1	-0.1691
2	1	4	7	2	2	-0.7448
2	7	4	1	3	1	-0.2338
2	1	4	7	3	1	-0.3089
2	7	4	1	3	2	0.7684
2	1	4	7	3	2	0.2875
2	7	4	1	4	1	0.8796
2	7	4	1	4	2	-0.5326
2	4	4	7	2	1	-0.0578
2	4	4	7	2	2	0.8441
2	4	4	7	3	1	0.396
2	7	4	4	3	2	-0.0389

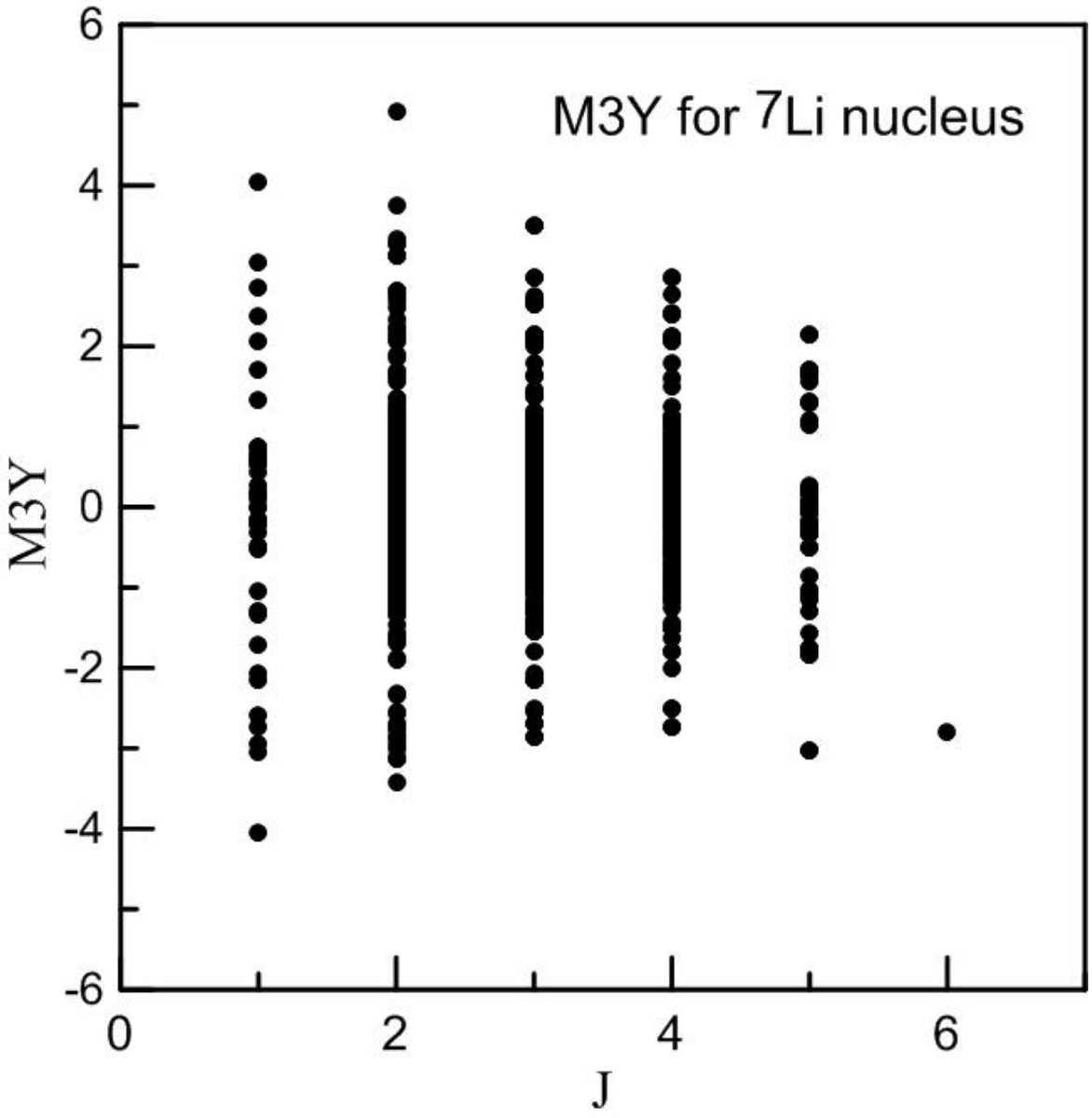


Fig. (3.2) M3Y potential in the ^{7}Li nucleus calculated as a function of angular momentum (J).

3.4 ^{9}Be nucleus

The nucleus 9Be is considered as an inert core of 4He plus five nucleons distributed over 1p1/2-1p3/2 shell. The value of the size parameter of the HO potential for the single particle wave function used for this state is 1.753 fm [12]. Table. 2 show the values of matrix elements for M3Y realistic interaction for the ^{6}Li nucleus, where j1, j2, j3, j4 represents the value of different states of angular momentum and T is repersent the isospin space for different nucleon and different state. Figure (3.2) represents the relation between Michigan sum of three-range Yukawa potential (M3Y) interaction as afunction J. In this figure, we shown that the distribution of M3Y potential according to total angular momentum J.

Table 3.3: *The values of M3Y realistic interaction matrix elements for the ^{9}Be nucleus.*

j1	j2	j3	j4	J	T	M3Y
2	4	2	1	2	1	-0.2606
2	1	2	4	2	1	-0.2606
2	4	2	1	2	2	1.6235
2	1	2	4	2	2	1.6235
2	4	2	1	3	1	1.6885
2	1	2	4	3	1	1.6885
2	4	2	1	3	2	-0.489
2	1	2	4	3	2	-0.489
2	4	3	1	2	1	-1.5635
2	4	3	1	2	2	-2.077
2	1	3	4	3	1	4.2671
2	1	3	4	3	2	-0.3132
2	5	2	1	2	1	-0.2367
2	1	2	5	2	1	-0.2367
2	5	2	1	2	2	0.0303
2	1	2	5	2	2	0.0303
2	5	2	1	3	1	-0.5826
2	1	2	5	3	1	-0.5826
2	5	2	1	3	2	-0.6633
2	1	2	5	3	2	-0.6633
2	5	3	1	2	1	-1.7429
2	1	3	5	2	1	-1.7429
2	5	3	1	2	2	1.0735
2	1	3	5	2	2	1.0735
2	6	2	1	2	1	3.7835

2	1	2	6	2	1	3.7835
2	6	2	1	2	2	1.2711
2	1	2	6	2	2	1.2711
2	6	2	1	3	1	-0.7369
2	1	2	6	3	1	-0.7369
2	6	2	1	3	2	-0.0718
2	1	2	6	3	2	-0.0718
2	6	3	1	1	1	-2.6054
2	6	3	1	1	2	0.6622
2	6	3	1	2	1	4.9524
2	1	3	6	2	1	-0.0828
2	6	3	1	2	2	0.34
2	1	3	6	2	2	1.8629
2	1	3	6	3	1	1.6418
2	1	3	6	3	2	0.5631
2	7	2	2	3	1	0
2	2	2	7	3	1	0
2	7	2	2	3	2	0.2204
2	2	2	7	3	2	0.2204
2	7	2	2	4	1	0.9864
2	2	2	7	4	1	0.9864
2	7	2	2	4	2	0
2	2	2	7	4	2	0
2	7	2	3	3	1	-0.5175
2	3	2	7	3	1	-0.5175
2	7	2	3	3	2	1.4235
2	3	2	7	3	2	1.4235
2	7	3	2	3	1	-0.5175
2	7	3	2	3	2	-1.4235
2	2	3	7	4	1	2.4326
2	2	3	7	4	2	0
2	8	2	2	1	1	0
2	2	2	8	1	1	0
2	8	2	2	1	2	-0.2999
2	2	2	8	1	2	-0.2999
2	8	2	2	2	1	-0.1367
2	2	2	8	2	1	-0.1367
2	8	2	2	2	2	0
2	2	2	8	2	2	0
2	8	2	2	3	1	0
2	2	2	8	3	1	0
2	8	2	2	3	2	-0.3837
2	2	2	8	3	2	-0.3837
2	8	2	2	4	1	-1.1478
2	2	2	8	4	1	-1.1478
2	8	2	2	4	2	0

2	2	2	8	4	2	0
2	8	2	3	2	1	0.8765
2	3	2	8	2	1	0.8765
2	8	2	3	2	2	0.4085
2	3	2	8	2	2	0.4085
2	8	2	3	3	1	-0.5803
2	3	2	8	3	1	-0.5803
2	8	2	3	3	2	-0.4218
2	3	2	8	3	2	-0.4218
2	8	3	2	2	1	-0.8765
2	2	3	8	2	1	-1.309
2	8	3	2	2	2	0.4085
2	2	3	8	2	2	0
2	8	3	2	3	1	-0.5803
2	2	3	8	3	1	0
2	8	3	2	3	2	0.4218
2	2	3	8	3	2	0.7332
2	8	3	3	1	1	0
2	8	3	3	1	2	-1.0602
2	8	3	3	2	1	0.5592
2	3	3	8	2	1	0.1287
2	8	3	3	2	2	0
2	3	3	8	2	2	0.0854
2	3	3	8	3	1	-2.1714
2	3	3	8	3	2	0.4617
2	9	2	2	2	1	2.5056
2	2	2	9	2	1	2.5056
2	9	2	2	2	2	0
2	2	2	9	2	2	0
2	9	2	2	3	1	0
2	2	2	9	3	1	0
2	9	2	2	3	2	0.5565
2	2	2	9	3	2	0.5565
2	9	2	2	4	1	0.9136
2	2	2	9	4	1	0.9136
2	9	2	2	4	2	0
2	2	2	9	4	2	0
2	9	2	3	2	1	-0.9965
2	3	2	9	2	1	-0.9965
2	9	2	3	2	2	0.6331
2	3	2	9	2	2	0.6331
2	9	2	3	3	1	2.8734
2	3	2	9	3	1	2.8734
2	9	2	3	3	2	0.2513
2	3	2	9	3	2	0.2513
2	9	3	2	2	1	0.9965

2	9	3	2	2	2	0.6331
2	9	3	2	3	1	2.8734
2	2	3	9	3	1	0
2	9	3	2	3	2	-0.2513
2	2	3	9	3	2	1.1198
2	2	3	9	4	1	-0.3943
2	2	3	9	4	2	0
2	9	3	3	2	1	-2.9651
2	9	3	3	2	2	0
2	3	3	9	3	1	-0.8584
2	3	3	9	3	2	0.4144
2	10	2	2	2	1	0.4439
2	2	2	10	2	1	0.4439
2	10	2	2	2	2	0
2	2	2	10	2	2	0
2	10	2	2	3	1	0
2	2	2	10	3	1	0
2	10	2	2	3	2	-0.1103
2	2	2	10	3	2	-0.1103
2	10	2	3	2	1	-1.4965
2	3	2	10	2	1	-1.4965
2	10	2	3	2	2	-0.2961
2	3	2	10	2	2	-0.2961
2	10	2	3	3	1	-1.3508
2	3	2	10	3	1	-1.3508
2	10	2	3	3	2	-0.9022
2	3	2	10	3	2	-0.9022
2	2	3	10	1	1	0
2	2	3	10	1	2	-1.0602
2	10	3	2	2	1	1.4965
2	2	3	10	2	1	0.5592
2	10	3	2	2	2	-0.2961

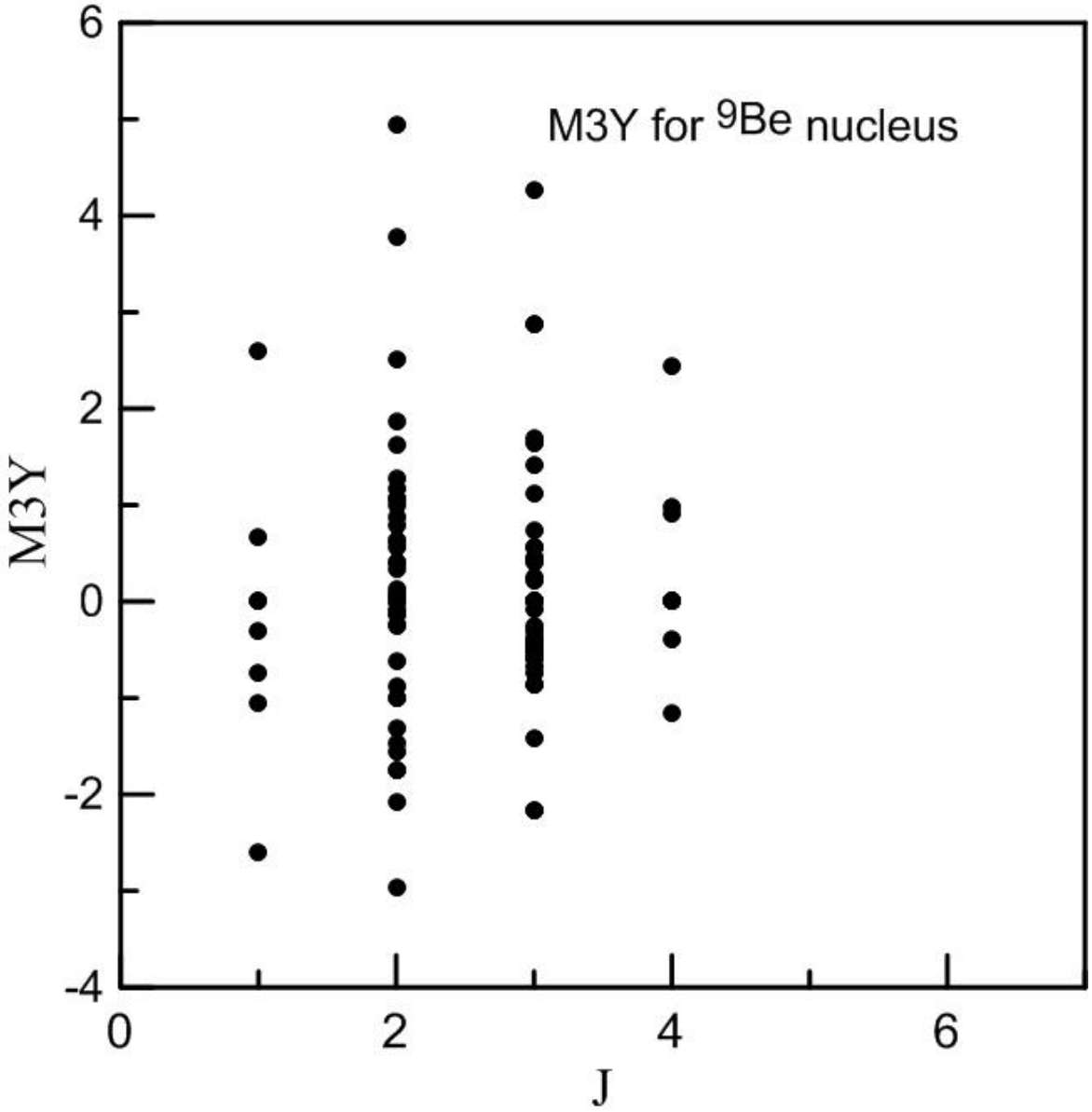


Fig. (3.3) M3Y potential in the ^{9}B nucleus calculated as a function of angular momentum (J).

3.5 ^{10}B nucleus

The nucleus ^{10}B is one of the complex nuclei in the 1p-shell region. It is studied both theoretically and experimentally. According to the conventional 1p-shell model, 10B is considered as a ^{4}He core in the 1s-shell and six nucleons outside the core distributed over the 1p-shell space. The single-particle wave functions are of the oscillator form with size parameter b=1.71 fm [١2].

Table. 3 show the values of matrix elements for M3Y realistic interaction for the ^{6}Li nucleus, where j1, j2, j3, j4 represents the value of different states of angular momentum and T is repersent the isospin space for different nucleon and different state. Figure (3.3) represents the relation between Michigan sum of three-range Yukawa potential (M3Y) interaction as afunction J. In this figure, we shown that the distribution of M3Y potential according to total angular momentum J.

Table 3.4: *The values of M3Y realistic interaction matrix elements for the ^{10}B nucleus.*

j1	j2	j3	j4	J	T	M3Y
2	4	2	1	2	1	-0.2003
2	1	2	4	2	1	-0.2003
2	4	2	1	2	2	1.6606
2	1	2	4	2	2	1.6606
2	4	2	1	3	1	1.7192
2	1	2	4	3	1	1.7192
2	4	2	1	3	2	-0.5523
2	1	2	4	3	2	-0.5523
2	4	3	1	2	1	-1.6379
2	4	3	1	2	2	-2.1998
2	1	3	4	3	1	4.5141
2	1	3	4	3	2	-0.3533
2	5	2	1	2	1	-0.2129
2	1	2	5	2	1	-0.2129
2	5	2	1	2	2	0.0644
2	1	2	5	2	2	0.0644
2	5	2	1	3	1	-0.5932
2	1	2	5	3	1	-0.5932
2	5	2	1	3	2	-0.7488
2	1	2	5	3	2	-0.7488

2	5	3	1	2	1	-1.8975
2	1	3	5	2	1	-1.8975
2	5	3	1	2	2	1.1631
2	1	3	5	2	2	1.1631
2	6	2	1	2	1	4.0458
2	1	2	6	2	1	4.0458
2	6	2	1	2	2	1.3593
2	1	2	6	2	2	1.3593
2	6	2	1	3	1	-0.7503
2	1	2	6	3	1	-0.7503
2	6	2	1	3	2	-0.0816
2	1	2	6	3	2	-0.0816
2	6	3	1	1	1	-2.6528
2	6	3	1	1	2	0.6687
2	6	3	1	2	1	5.2701
2	1	3	6	2	1	-0.1127
2	6	3	1	2	2	0.4063
2	1	3	6	2	2	1.9584
2	1	3	6	3	1	1.8099
2	1	3	6	3	2	0.6369
2	7	2	2	3	1	0
2	2	2	7	3	1	0
2	7	2	2	3	2	0.1851
2	2	2	7	3	2	0.1851
2	7	2	2	4	1	1.0033
2	2	2	7	4	1	1.0033
2	7	2	2	4	2	0
2	2	2	7	4	2	0
2	7	2	3	3	1	-0.495
2	3	2	7	3	1	-0.495
2	7	2	3	3	2	1.499
2	3	2	7	3	2	1.499
2	7	3	2	3	1	-0.495
2	7	3	2	3	2	-1.499
2	2	3	7	4	1	2.5551
2	2	3	7	4	2	0
2	8	2	2	1	1	0
2	2	2	8	1	1	0
2	8	2	2	1	2	-0.2419
2	2	2	8	1	2	-0.2419
2	8	2	2	2	1	-0.0849
2	2	2	8	2	1	-0.0849
2	8	2	2	2	2	0
2	2	2	8	2	2	0
2	8	2	2	3	1	0
2	2	2	8	3	1	0

2	8	2	2	3	2	-0.4141
2	2	2	8	3	2	-0.4141
2	8	2	2	4	1	-1.2167
2	2	2	8	4	1	-1.2167
2	8	2	2	4	2	0
2	2	2	8	4	2	0
2	8	2	3	2	1	0.9044
2	3	2	8	2	1	0.9044
2	8	2	3	2	2	0.4598
2	3	2	8	2	2	0.4598
2	8	2	3	3	1	-0.6308
2	3	2	8	3	1	-0.6308
2	8	2	3	3	2	-0.4386
2	3	2	8	3	2	-0.4386
2	8	3	2	2	1	-0.9044
2	2	3	8	2	1	-1.3745
2	8	3	2	2	2	0.4598
2	2	3	8	2	2	0
2	8	3	2	3	1	-0.6308
2	2	3	8	3	1	0
2	8	3	2	3	2	0.4386
2	2	3	8	3	2	0.7861
2	8	3	3	1	1	0
2	8	3	3	1	2	-1.1072
2	8	3	3	2	1	0.6125
2	3	3	8	2	1	0.0193
2	8	3	3	2	2	0
2	3	3	8	2	2	0.1216
2	3	3	8	3	1	-2.3232
2	3	3	8	3	2	0.4785
2	9	2	2	2	1	2.6775
2	2	2	9	2	1	2.6775
2	9	2	2	2	2	0
2	2	2	9	2	2	0
2	9	2	2	3	1	0
2	2	2	9	3	1	0
2	9	2	2	3	2	0.5895
2	2	2	9	3	2	0.5895
2	9	2	2	4	1	1.0307
2	2	2	9	4	1	1.0307
2	9	2	2	4	2	0
2	2	2	9	4	2	0
2	9	2	3	2	1	-1.1027
2	3	2	9	2	1	-1.1027
2	9	2	3	2	2	0.6637
2	3	2	9	2	2	0.6637

2	9	2	3	3	1	3.0544
2	3	2	9	3	1	3.0544
2	9	2	3	3	2	0.2486
2	3	2	9	3	2	0.2486
2	9	3	2	2	1	1.1027
2	9	3	2	2	2	0.6637
2	9	3	2	3	1	3.0544
2	2	3	9	3	1	0
2	9	3	2	3	2	-0.2486
2	2	3	9	3	2	1.203
2	2	3	9	4	1	-0.4446
2	2	3	9	4	2	0
2	9	3	3	2	1	-3.1308
2	9	3	3	2	2	0
2	3	3	9	3	1	-0.9846
2	3	3	9	3	2	0.3942
2	10	2	2	2	1	0.4342
2	2	2	10	2	1	0.4342
2	10	2	2	2	2	0
2	2	2	10	2	2	0
2	10	2	2	3	1	0
2	2	2	10	3	1	0
2	10	2	2	3	2	-0.0911
2	2	2	10	3	2	-0.0911
2	10	2	3	2	1	-1.506
2	3	2	10	2	1	-1.506
2	10	2	3	2	2	-0.329
2	3	2	10	2	2	-0.329
2	10	2	3	3	1	-1.4312
2	3	2	10	3	1	-1.4312
2	10	2	3	3	2	-0.97
2	3	2	10	3	2	-0.97
2	2	3	10	1	1	0
2	2	3	10	1	2	-1.1072
2	10	3	2	2	1	1.506
2	2	3	10	2	1	0.6125
2	10	3	2	2	2	-0.329

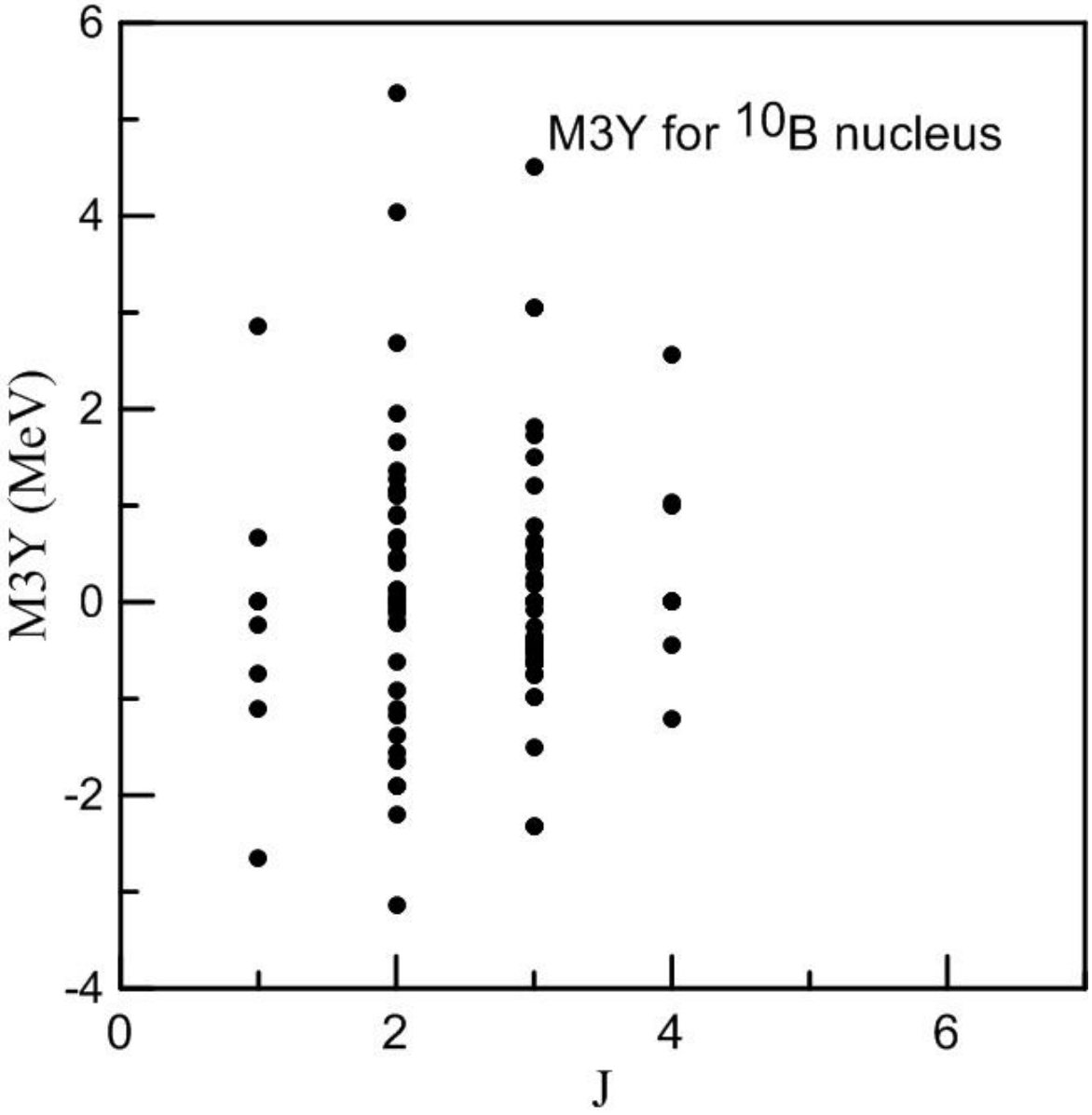


Fig. (3.4) M3Y potential in the ^{6}B nucleus calculated as a function of angular momentum (J).

3.6 ^{12}C nucleus

This nucleus is considered as an inert 4He core plus eight nucleons distributed over 1p3/2-1p1/2 shell model space. The single-particle radial wave functions are those of the HO potential with size parameter brms=1.64 fm [13].

Table. 4 show the values of matrix elements for M3Y realistic interaction for the ^{6}Li nucleus, where j1, j2, j3, j4 represents the value of different states of angular momentum and T is repersent the isospin space for different nucleon and different state. Figure (3.4) represents the relation between Michigan sum of three-range Yukawa potential (M3Y) interaction as afunction J. In this figure, we shown that the distribution of M3Y potential according to total angular momentum J.

Table 3.5: *The values of M3Y realistic interaction matrix elements for the ^{12}C nucleus.*

j1	j2	j3	j4	J	T	M3Y
2	6	2	1	2	1	4.4222
2	1	2	6	2	1	4.4222
2	6	2	1	2	2	1.4864
2	1	2	6	2	2	1.4864
2	6	2	1	3	1	-0.7612
2	1	2	6	3	1	-0.7612
2	6	2	1	3	2	-0.0966
2	1	2	6	3	2	-0.0966
2	6	2	4	2	1	3.0541
2	4	2	6	2	1	3.0541
2	6	2	4	2	2	-1.5575
2	4	2	6	2	2	-1.5575
2	6	2	4	3	1	1.4793
2	4	2	6	3	1	1.4793
2	6	2	4	3	2	0.2182
2	4	2	6	3	2	0.2182
2	6	2	4	4	1	0.6475
2	4	2	6	4	1	0.6475
2	6	2	4	4	2	-2.1922
2	4	2	6	4	2	-2.1922
2	6	2	5	2	1	-0.9449
2	5	2	6	2	1	-0.9449
2	6	2	5	2	2	0.5936

2	5	2	6	2	2	0.5936
2	6	2	5	3	1	0.0417
2	5	2	6	3	1	0.0417
2	6	2	5	3	2	0.1012
2	5	2	6	3	2	0.1012
2	6	2	6	1	1	-4.503
2	6	2	6	1	1	-4.503
2	6	2	6	1	2	-1.4458
2	6	2	6	1	2	-1.4458
2	6	2	6	2	1	-2.8746
2	6	2	6	2	1	-2.8746
2	6	2	6	2	2	1.4339
2	6	2	6	2	2	1.4339
2	6	2	6	3	1	-2.6453
2	6	2	6	3	1	-2.6453
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2	6	2	6	3	2	-0.9899
2	6	2	6	4	1	-2.9527
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2	6	2	6	4	2	-1.1305
2	6	2	6	4	2	-1.1305
2	6	3	1	1	1	-2.6914
2	6	3	1	1	2	0.6631
2	6	3	1	2	1	5.7167
2	1	3	6	2	1	-0.1562
2	6	3	1	2	2	0.5122
2	1	3	6	2	2	2.0879
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2	4	3	6	3	1	1.3209
2	6	3	4	3	2	-0.3418
2	4	3	6	3	2	0.2376
2	6	3	4	4	1	-3.2694
2	6	3	4	4	2	1.7903
2	6	3	5	1	1	3.554
2	6	3	5	1	2	-0.1489
2	6	3	5	2	1	-1.5762
2	5	3	6	2	1	0.5604
2	6	3	5	2	2	1.5449
2	5	3	6	2	2	-0.979
2	5	3	6	3	1	0.5026
2	5	3	6	3	2	-0.3631
2	6	3	6	2	1	-1.854

2	6	3	6	2	1	-1.854
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2	6	3	6	3	1	2.4541
2	6	3	6	3	1	2.4541
2	6	3	6	3	2	-0.1138
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2	6	4	2	2	1	-3.0541
2	2	4	6	2	1	-3.415
2	6	4	2	2	2	-1.5575
2	6	4	2	3	1	1.4793
2	6	4	2	3	2	-0.2182
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2	6	4	2	4	1	-0.6475
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2	6	4	2	4	2	-2.1922
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2	3	4	6	3	1	4.1163
2	6	4	3	3	2	-0.3418
2	3	4	6	3	2	0.58
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2	6	4	3	4	2	-1.7903
2	6	5	2	2	1	0.9449
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2	6	6	2	3	1	2.6453
2	6	6	2	3	2	-0.9899

2	2	6	6	3	2	0.1291
2	6	6	2	4	1	-2.9527
2	2	6	6	4	1	2.0758
2	6	6	2	4	2	1.1305
2	6	6	3	2	1	1.854
2	3	6	6	2	1	-0.9697
2	6	6	3	2	2	-0.4628
2	6	6	3	3	1	2.4541
2	6	6	3	3	2	0.1138
2	3	6	6	3	2	0.9557
2	7	2	2	3	2	0.1214
2	2	2	7	3	2	0.1214
2	7	2	2	4	1	1.015
2	2	2	7	4	1	1.015
2	7	2	3	3	1	-0.4502
2	3	2	7	3	1	-0.4502
2	7	2	3	3	2	1.6021
2	3	2	7	3	2	1.6021
2	7	3	2	3	1	-0.4502
2	7	3	2	3	2	-1.6021
2	2	3	7	4	1	2.7182
2	1	4	7	2	1	-0.3819
2	1	4	7	2	2	-0.6789
2	7	4	1	3	1	-0.1049
2	1	4	7	3	1	-0.1673
2	7	4	1	3	2	0.8049
2	1	4	7	3	2	0.383
2	7	4	1	4	1	0.9151
2	7	4	1	4	2	-0.7208
2	4	4	7	2	1	-0.354
2	4	4	7	2	2	0.6778
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2	7	4	4	3	2	0.1452
2	4	4	7	3	2	0.8843

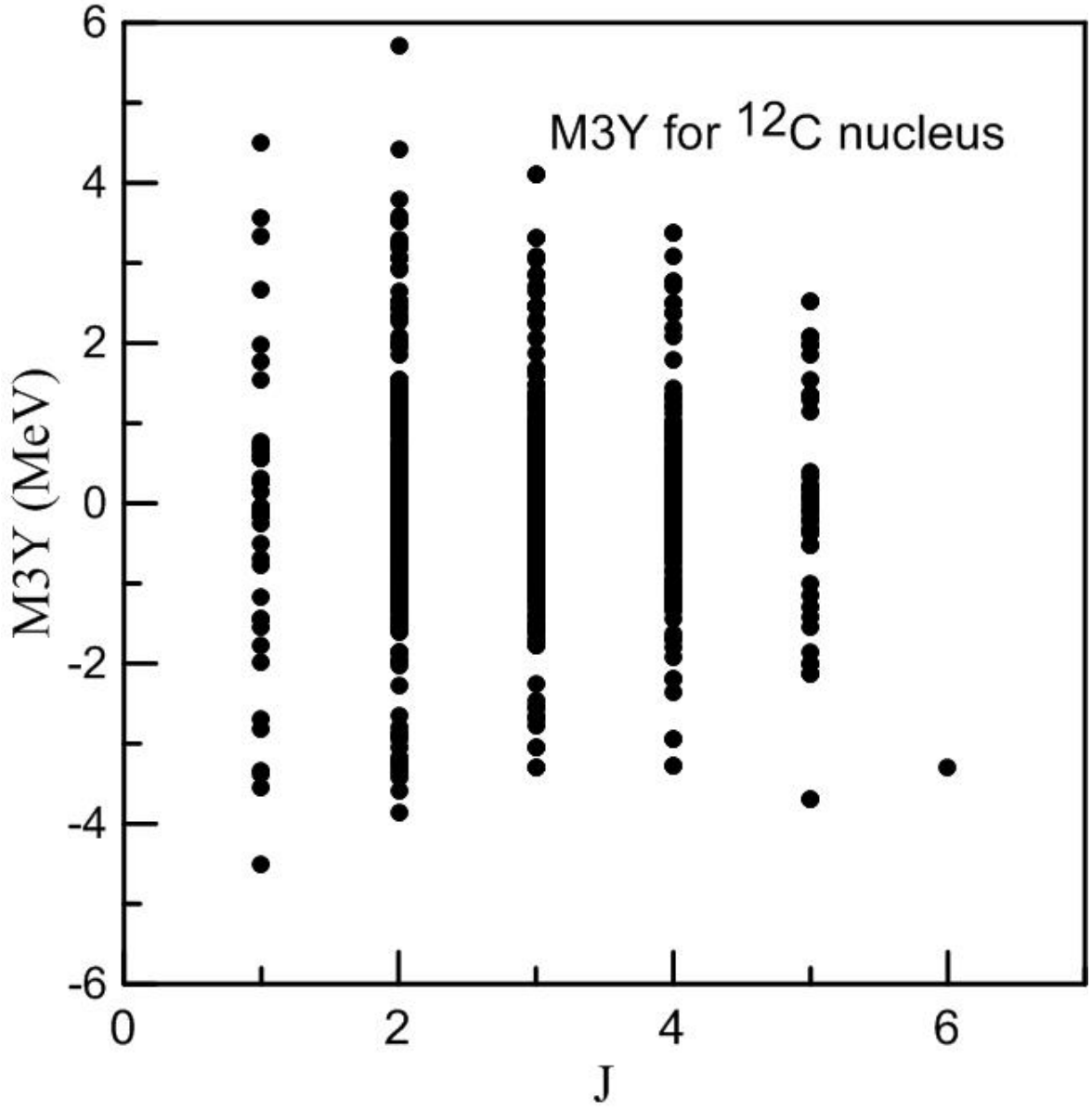

Fig. (3.5) M3Y potential in the ^{12}C nucleus calculated as a function of angular momentum (J).

3.7 Conclusions

We noticed that the results of M3Y give some conclusions as following :

1-the distribution of M3Y value

s as a function of anglar momentum J give different distribution depended on the nucleus and the recure of J value dependent on the initial and final state of J1 and J2 ,respectively .which gives the total values of J.

2- the M3Y is more realistic interaction to studied the nucleus for wide range of nuclei.

References

[1] H.Yukawa,proc Math.phYs.Soc.Japan17,48 (1935) .

[2] A.Fassler,ACTA physica polonica B,vol.29 (1998) .

[3] R.Bock mann,C.Hahant,O.krehl,S.krewald,and J.speth,phYs.Rev.C,V60,(1999

[4] B.Mihaila,ph.D.Thesis,University of New Hampshire(1998) .

[5] R.D Lawson,Theory of The nuclear shell model , Clarendon press. Oxford (1980) .

[6] P.Elliott and T.H.R.SKyme,proc.Roy.SOC.A323.561 (1955) .

[7] H.NaKada, (arxivinucl th/0304021 v223 MaY 2003 .

[8] T.Hamada and l.D Johnston, Nucl.phys.43,382 (1962) .

[9] J.P.Elliott,A.D.Jackson,H.A.Mavromatis,B.A.Sandeson and B.singh,Nucl. Phys. Al21,241 (1968) .

[10] T.W.Donnelly and J.D walecka,Nucl.Phys.A201,81 (1973 .

[11] G.Bersth, Borysowicz,H.MCManus and W.G.Love,Nucl.Phys. A284,399 (1977) .

[12] E.de Vries et al.,At.Data Nucl.Data Tables ,36,500 (1987) .

[13] J.B.Flanz,R.S.Hicks,R.A.Lind grens,G.A. Peterson,A.Hotta.B.Parker, R.C.york, Phys.Rev.Lett.41,1642 (1978) .

الخلاصة

تفاعلات النوية مع النوية الواقعية والمشتقة من جهود واقعية لبعض النوى : (^{6}Li, ^{7}Li, ^{9}Be, ^{10}B, ^{12}C) والتي حسبت بأستخدام جهد M3Y . الدوال الموجية لعناصر مصفوفة الجسيم المنفرد حسبت بأستخدام جهد المتذبذب التوافقي البسيط .في هذا البحث تم استخدام كود M3Y والذي يكتب بلغة فورتران 90 . تفاعلات عناصر مصفوفة الجسيمتين لجهد M3Y والتي اعطيت بدلالة ازدواج LS و JJ وذلك لانجاز الحسابات والعلاقة بين عناصر مصفوفة الجسيمتين واحداثيات مركز الكتلة وبأستعمال المتذبذب التوافقي البسيط مع احداثيات تيلمي- موشنسكي. في هذا البحث حسبت قيم عناصر مصفوفة الجسيمتين ورتبت في جداول ثم رسمت القيم مع قيمة الزخم الزاوي الكلي J لتوضيح التوزيع بالنسبة لقيم J .

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تفاعلات النوية مع النوية من جهود واقعية لبعض النوى الخفيفة

بحث مقدم

إلى مجلس كلية التربية للعلوم الصرفة في جامعة بابل وهو جزء من متطلبات نيل درجة الدبلوم العالي تربية / فيزياء المواد وتطبيقاتها

من قبل الطالب

وضاح محمد مراد فرحان

بكالوريوس تربية فيزياء
جامعة بابل ٢٠١٢ م

بإشراف

أ. د. خالد صالح جاسم

١٤٤٢ هـ ٢٠٢١ م