Nucleon Momentum Distributions and Elastic Electron Scattering form Factors for some 1p-Shell Nuclei

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Abstract

The Nucleon Momentum Distributions (*NMD*) and elastic electron scattering form factors of the ground state for 1p-shell nuclei with Z=N (such as ^{6}Li, ^{10}B, ^{12}C and ^{14}N nuclei) have been calculated in the framework of the Coherent Density Fluctuation Model (*CDFM*) and expressed in terms of the weight function $|f(x)|^2$. The weight function has been expressed in terms of the Nucleon Density Distributions (*NDD*) of the nuclei and determined from theory and experiment. The feature of the long-tail behavior at high momentum region of the *NMD's* has been obtained by both the theoretical and experimental weight functions. The experimental form factors $F(q)$ of all considered nuclei are very well reproduced by the present calculations throughout all values of momentum transfer q. It is found that the contributions of the quadrupole form factors $F_{C2}(q)$ in ^{10}B and ^{14}N nuclei, which are described by the undeformed p-shell model, are essential in obtaining a remarkable agreement between the theoretical and experimental form factors.

Introduction

High-energy elastic electron scattering is a clear and precise tool for probing nuclear structure, in particular, cross sections, form factors and nucleon densities [1,2]. It has been about half a century since the pioneering study of electron scattering on atomic nuclei by Hofstadter et al. [3,4]. Since then, a lot of work in this area has been done, and many valuable and precise data on the nuclear electromagnetic properties have been accumulated [5,6]. Electrons interact with nuclei basically through the electromagnetic force. If the energy of the electrons is high enough, they become a relatively clean probe to explore precisely the internal structure of nuclei [7]. There are many reasons why inclusive electron scattering provides a powerful tool for studying the structure of nuclei and nucleons. First, the interaction is known and second, the interaction is relatively weak, thus one can make measurements without greatly disturbing the structure of the target[8]. Several theoretical methods used to study elastic electron-nucleus scattering, such as the plan-wave Born approximation (PWBA), the eikonal approximation and the phase-shift analysis method. The PWBA method can give qualitative results and has been used widely for its simplicity. To include the Coulomb distortion effect, which is neglected in PWBA, the other two methods may be used [9]. For light nuclei where $Z\alpha \ll 1$ (α is the fine-structure constant), one can use, to a good approximation, the PWBA to describe the scattering process [10]. In the PWBA, the incident and scattered electron waves are considered as plane waves. The elastic electron scattering form factors from spin zero nuclei can be determined purely by the ground state density distribution, where the form factor is Fourier transform of the density distribution and vice versa [11]. In the past few years, some theoretical studies of elastic and inelastic electron scattering form factors of 1p-shell nuclei have been performed [12-17].

There is no method for directly measuring the nuclear momentum distribution (*NMD*) in nuclei. The quantities that are measured by particle-nucleus and nucleus-nucleus collisions are the cross sections of different reactions, and these contain information on the *NMD* of target nucleons. The experimental evidence obtained from inclusive and exclusive electron scattering on nuclei established the existence of long-tail behavior of *NMD* at high momentum region ($k \geq 2\ fm^{-1}$) [18-21]. In principle, the mean field theories cannot describe correctly *NMD* and form factors $F(q)$ simultaneously [22] and they exhibit a steep-slope behavior of *NMD* at high momentum region. In fact, *NMD* depends a little on the effective mean field considered due to its sensitivity to short range and tensor nucleon-nucleon correlations [22,23] which are not included in the mean field theories.

In coherent density fluctuations model (*CDFM*), which is exemplified by the work of Antonov *et al.* [18,24,25], the local density distribution and *NMD* are simply related and expressed in terms of experimentally obtainable fluctuation function (weight function) $|f(x)|^2$. They [18,24,25] studied the *NMD* of (^{4}He and ^{16}O), ^{12}C and (^{39}K, ^{40}Ca and ^{48}Ca) nuclei using weight functions $|f(x)|^2$ expressed in terms of, respectively, the experimental *NDD* of 2PF [26], the experimental data of Ref. [27] and the experimental *NDD* of model-independent [26]. It is important to point out that all above calculations obtained in the framework of *CDFM* proved a high momentum tail in the *NMD*. Elastic electron scattering from ^{40}Ca nucleus was also investigated in [18], where the calculated elastic differential cross sections $\frac{d\sigma}{d\Omega}$ are in good agreement with those of experimental data.

The aim of the present study is to derive an analytical form for the *NDD*, applicable throughout all p-shell nuclei, based on the use of the single particle harmonic oscillator wave functions and the occupation numbers of the states. The derived form of the *NDD* is employed in determination the theoretical weight function $|f(x)|^2$ which is used in the *CDFM* to study the *NMD* and elastic $F(q)$ for some 1p-shell nuclei with Z=N, such as, ^{6}Li, ^{10}B, ^{12}C and ^{14}N nuclei. We shall see later that the theoretical $|f(x)|^2$, based on the derived form of the *NDD*, is capable to give information about the *NMD* and elastic $F(q)$ as do those of the experimental two parameter Fermi (2PF), three parameter Fermi (3PF) and harmonic oscillator (HO) densities[26].

Theory

The nucleon density distribution *NDD* of one body operator can be written as [29,30]:

$$\rho(r) = \frac{1}{4\pi}\sum_{nl} h_{nl}\, 4(2l+1)|R_{nl}(r)|^2 \quad \text{.......................} (1)$$

Where h_{nl} is the nucleon occupation probability of the state *nl* (h_{nl} = 0 or 1 for closed shell nuclei and $0<h_{nl}<1$ for open shell nuclei) and $R_{nl}(r)$ is the radial part of the single particle harmonic oscillator wave function. To derive an explicit form for the *NDD* of 1p-shell nuclei, we assume that there is a core of filled 1s-shell and the nucleon occupation numbers in 1p, $2s_{1/2}$ and $1f_{7/2}$ orbits are equal to, respectively, (A-4-α), α_1 and α_2, and not to (A-4), 0 and 0 as in the simple shell model. Using this assumption in eq. (1), an analytical form for the ground state *NDD* of 1p-shell nuclei is obtained as:

$$\rho(r) = \frac{2}{\pi^{3/2}b^3}\exp(-r^2/b^2) \times\left[2+\frac{3\alpha_1}{4}+\frac{(A-4-\alpha-3\alpha_1)}{3}\left(\frac{r}{b}\right)^2+\frac{\alpha_1}{3}\left(\frac{r}{b}\right)^4+\frac{4\alpha_2}{105}\left(\frac{r}{b}\right)^6\right] \quad \text{.....} (2)$$

where A is the nuclear mass number, b is the harmonic oscillator size parameter and α ($\alpha=\alpha_1+\alpha_2$) is the deviation of the nucleon occupation numbers from the prediction of the simple shell model (α=0). It is important to remark that for Z=N nuclei (Z and N are the proton and neutron numbers), the ground state charge density distribution *CDD*, $\rho_{ch}(r)$, is related to the ground state *NDD* by $\rho_{ch}(r) = \frac{\rho(r)}{2}$ [31].

The normalization condition of the *NDD* is given by [18,26]:

$$A = 4\pi\int_0^\infty \rho(r)r^2dr \quad \text{....................................} (3)$$

and the mean square radii (*MSR*) of considered 1p-shell nuclei is given by [18,26]:

$$\langle r^2\rangle = \frac{4\pi}{A}\int_0^\infty \rho(r)r^4dr \quad \text{................................} (4)$$

The central *NDD*, ρ(r=0), is obtained from eq. (2) as:

$$\rho(0) = \frac{2}{\pi^{3/2}b^3}\left[2+\frac{3\alpha_1}{4}\right] \quad \text{............................} (5)$$

Then α_1 is obtained from eq. (5) as:

$$\alpha_1 = \frac{2\left(\rho_0(0)\pi^{3/2}b^3-4\right)}{3} \quad \text{............................} (6)$$

Substituting eq. (2) into eq. (4) and after simplification gives :

$$\langle r^2\rangle = \frac{b^2}{A}\left[\frac{5}{2}A-4-\alpha_1+2\alpha\right] \quad \text{..........................} (7)$$

The parameter α is obtained by substituting eq. (6) into eq. (7) as:

$$\alpha = \frac{A}{2b^2}\langle r^2\rangle + 2 - \frac{5}{4}A + \frac{1}{3}\left(\rho(0)\pi^{3/2}b^3-4\right) \quad \text{........} (8)$$

The parameter α_2 is then obtained by $\alpha_2 = \alpha - \alpha_1$. In eq's (6) and (8), the values of $\rho(0)$ and $\langle r^2 \rangle$ are taken from the experiments while the parameter *b* is chosen in such a way as to reproduce the experimental root mean square radii of nuclei.

The nucleon momentum distributions $NMD, n(k)$, for 1p-shell nuclei is studied in two distinct methods. In the first, it is determined by the shell model using the single particle harmonic oscillator wave functions in momentum representation and is given by [31]:

$$n(k) = \frac{2b^3}{p^{3/2}} e^{-b^2k^2} \left[2 + \frac{(A-4)}{3}(bk)^2 \right] \quad (9)$$

In the second method, the *NMD* is determined by the *CDFM* , where the mixed density is given by [18,24] :

$$r(r,r') = \int_0^\infty |f(x)|^2 r_x(r,r')dx \quad (10)$$

Since:

$$r_x(r,r') = 3r_0(x)\frac{j_1(k_F(x)|\bar{r}-\bar{r}'|)}{k_F(x)|\bar{r}-\bar{r}'|} q(\bar{x} - \frac{1}{2}|\bar{r}+\bar{r}'|) \quad (11)$$

is the density matrix for A-nucleons uniformly distributed in the sphere with radius x and fixed mean density $r_0(x)$ where :

$$r_0(x) = \frac{3A}{4px^3}. \quad (12)$$

The step function q ,in eq. (11), is define by:

$$q(y) = 1 \;,\; for \;\; y \geq 0$$
$$= 0 \;,\; for \;\; y < 0 \quad (13)$$

and the Fermi momentum is defined by:

$$k_F(x) = \left(\frac{3p^2}{2} r_0(x) \right)^{1/3} \equiv \frac{h}{x} \;,\; h \equiv \left(\frac{9pA}{8} \right)^{1/3} \quad (14)$$

According to the density matrix definition of equation (10), one-particle density $r(r)$ is given by it's diagonal elements as :

$$r(r) = r(r,r')|_{r=r'} = \int_0^\infty |f(x)|^2 r_x(r)dx \quad (15)$$

In eq. (15), $r_x(x)$ and $|f(x)|^2$ have the forms [18,24]:

$$r_x(r) = r_0(x)q(x-r) \quad (16)$$

$$|f(x)|^2 = \frac{-1}{r_0(x)} \left. \frac{dr(r)}{dr} \right|_{r=x} \quad (17)$$

It is important to point out that the weight function $|f(x)|^2$ of eq. (17), determined in terms of the ground state *NDD,* satisfies the normalization condition:

$$\int_0^\infty |f(x)|^2 dx = 1 \quad (18)$$

and holds only for monotonically decreasing *NDD*, i.e. $\left(\frac{dr(r)}{dr} \right) < 0$ [18,24].

On the basis of eq. (15), the *NMD* is expressed as [18,24]:

$$n(k) = \int_0^\infty |f(x)|^2 n_x(k)dx \quad (19)$$

Where :

$$n_x(k) = \frac{4}{3}px^3 q(k_F(x) - |\vec{k}|) \quad (20)$$

is the Fermi-momentum distribution of a system with density $r_0(x)$. By means of eq's (17), (19) and (20), an explicit form for the *NMD* is expressed in terms of $r(r)$ as:

$$n_{CDFM}(k;[r]) = \left(\frac{4p}{3} \right)^2 \frac{4}{A} \left[6 \int_0^{h/k} r(x)x^5 dx - \left(\frac{h}{k} \right)^6 r\left(\frac{h}{k} \right) \right]. \quad (21)$$

The normalization condition of eq's (9) and (21) is given by [24] :

$$\int n_{CDFM}(k) \frac{d^3k}{(2p)^3} = A \quad (22)$$

The elastic monopole form factors $F_{C0}(q)$ of the target nucleus is also expressed in the *CDFM* as [18,24] :

$$F_{C0}(q) = \frac{1}{A} \int_0^\infty |f(x)|^2 F(q,x)dx \quad (23)$$

Where the form factor of uniform nucleon density distribution is given by [24]:

$$F(q,x) = \frac{3A}{(qx)^2} \left[\frac{\sin(qx)}{(qx)} - \cos(qx) \right]. \quad (24)$$

Inclusion the corrections of the nucleon finite size $f_{fs}(q)$ and the center of mass corrections $f_{cm}(q)$ in the calculations requires multiplying the form factor of equation (23) by these corrections. Here, $f_{fs}(q)$ is considered as free nucleon form factor and assumed to be the same for protons and neutrons. This correction takes the form [32] :

$$f_{fs}(q) = e^{\left(\frac{-0.43q^2}{4} \right)} \quad (25)$$

The correction $f_{cm}(q)$ removes the spurious state arising from the motion of the center of mass when shell model wave function is used and given by [32] :

$$f_{cm}(q) = e^{\left(\frac{b^2q^2}{4A} \right)} \quad (26)$$

It is important to point out that all physical quantities studied in the frame work of the *CDFM* such as the *NMD* and form factors are expressed in terms of the weight function $|f(x)|^2$. In Refs [18,24], the weight function was obtained from the two parameter Fermi *NDD*, $r_{2PF}(r)$, extracted from the analysis of elastic electron-nuclei scattering experiments. In the present study, the weight function $|f(x)|^2$ is obtained from theoretical consideration, using the derived *NDD* of eq. (2) in eq. (17), and given by:

$$|f(x)|^2 = \frac{8px^4}{3Ab^2} r(x) - \frac{16x^4 e^{-x^2/b^2}}{3A\sqrt{p}\, b^5} \times \left[\frac{(A-4-a-3a_1)}{3} + \frac{2a_1}{3}\left(\frac{x}{b}\right)^2 + \frac{4(a-a_1)}{35}\left(\frac{x}{b}\right)^4 \right] \quad .... (27)$$

In this study, the quadrupole form factors, which is important in ^{10}B and ^{14}N nuclei, is described by the undeformed p-shell model as [33]:

$$F_{C2}(q) = \frac{\langle r^2 \rangle}{Q} \left(\frac{4}{5P_J} \right)^{1/2} \int j_2(qr)\, r_{2ch}(r) r^2 dr \quad ..... (28)$$

where $j_2(qr)$ is the spherical Bessel functions, Q is the quadrupole moment and considered as a free parameter to fit the theoretical form factors with the experimental data , $r_{2ch}(r)$ is the quadrupole charge density distributions, according to the undeformed *p-shell* model, we assume that the dependence of the quadrupole charge density distributions $r_{2ch}(r)$ is the same as that of ground state charge density distributions $r_{ch}(r)$ and P_J is a quadrupole projection factor given by $P_J = J(2J-1)/(J+1)(2J+3)$, where J is the ground state angular momentum (J = 3 and 1 for ^{10}B and ^{14}N, respectively).

Results and Discussion

The nucleon momentum distribution $n(k)$ and elastic electron scattering form factors $F(q)$ for some 1p-shell nuclei which are carried out using the *CDFM*. The distribution $n(k)$ of eq. (21) is calculated by means of the *NDD* obtained firstly from theoretical consideration as in eq. (2) and secondly from experiments, such as, 2PF, 3PF and HO [26]. The harmonic oscillator size parameters b are chosen in such a way as to reproduce the experimental root mean square radii (*rms*) of nuclei. The parameters a_1 and a are determined by eq's (6) and (8), respectively. Then the parameter a_2 is determined by $a_2 = a - a_1$. In table (1), we present the values of the parameters b, a, a_1, a_2 and Q together with the experimental values of c, a, z, t, $r_{\exp}(0)$ and $\langle r^2 \rangle^{1/2}_{\exp}$ employed in the present calculations for ^{6}Li, ^{10}B, ^{12}C and ^{14}N nuclei.

The dependence of the *NDD* (in *fm*$^{-3}$) on r (in *fm*) for ^{6}Li, ^{10}B, ^{12}C and ^{14}N nuclei are displayed in Fig.(1). The long-dashed and solid distributions are the calculated *NDD*, using eq. (2), with $a = a_1 = a_2 = 0$ and $a \neq a_1 \neq a_2 \neq 0$, respectively. These distributions are compared with those of experimental data [26], denoted by the dotted symbols. It is clear that the long-dashed distributions are in poor agreement with the experimental data, especially for small r. Considering the higher orbits $2s_{1/2}$ and $1f_{7/2}$ due to introducing the parameters a_1 and a_2 into the calculations leads to a good agreement with the experimental data as shown by the solid curves.

The dependence of the $n(k)$ (in *fm*^{3}) on k (in *fm*$^{-1}$) for ^{6}Li, ^{10}B, ^{12}C and ^{14}N nuclei is shown in Fig.(2). The dash-dotted distributions are the calculated *NMD* of eq. (9) obtained by the shell model calculation using the single particle harmonic oscillator wave functions in momentum representation. The dotted symbols and solid distributions are the *NMD* obtained by the *CDFM* of eq. (21) using the experimental and theoretical *NDD*, respectively. It is obvious that the behavior of the dash-dotted distributions obtained by the shell model calculations in contrast with those of the dotted and solid distributions reproduced by the *CDFM*. The main feature of the dash-dotted distributions is the steep slope behavior when k increases. This behavior is in disagreement with other studies [18,21,22,23] and it is attributed to the fact that the ground state shell model wave function given in terms of a Slater determinant does not take into account the important effect of the short range dynamical correlation functions. Hence, the short-range repulsive features of the nucleon-nucleon forces are responsible for the high momentum behavior of the *NMD* [21,22]. It is seen that the general structure of the dotted and solid distributions at the region of high momentum components is almost the same for ^{6}Li, ^{10}B, ^{12}C and ^{14}N nuclei, where these distributions have the feature of the long-tail behavior at momentum region k ≥ 2 fm^{-1}. The feature of the long-tail behavior obtained by the *CDFM* is related to the existence of high densities $r_x(r)$ in the decomposition of eq. (15), though their weight functions $|f(x)|^2$ are small.

The dependence of the $F(q)$ on q (in fm^{-1}) for ^{6}Li and ^{12}C nuclei is shown in Fig.(3). The solid curves are the calculated $F(q)$'s obtained by the framework of the *CDFM* using the theoretical weight function of eq. (27). The symbols, in this figure, represent the experimental data. In ^{6}Li nucleus, the calculated form factors are in very good agreement with the experimental data of Ref. [10] (open circles) and Ref. [36] (triangles) throughout all values of momentum transfer q. In the ^{12}C nucleus, the calculated form factors agree quite well with those of experimental data of Ref. [37] (open circles), Ref.[38] (rhombs) and Ref.[39](triangles) up to momentum transfer q ≈ 1.85 fm^{-1} and underestimate these data at q > 1.85 fm^{-1}. It is evident from this figure that the calculated results of ^{12}C are very well predicated the location of the observed first diffraction minimum.

The dependence of the $F(q)$ on q (in fm^{-1}) for ^{10}B and ^{14}N nuclei is shown in Fig.(4). The dashed and dash-dotted curves represent the contributions of the monopole form factors $F_{C0}(q)$ and quadrupole form factors $F_{C2}(q)$, respectively, while the solid curves represent the total contribution $F(q)$, which is obtained as the sum of $F_{C0}(q)$ and $F_{C2}(q)$. Here, the experimental data are represented by the symbols. In ^{10}B nucleus, the calculated $F_{C0}(q)$ is not able to give a satisfactory description with the experimental data of Ref. [40] (open circles) and Ref. [33] (triangles) for the region of momentum transfer q > 1.4, but once the contribution of the $F_{C2}(q)$ is added to the $F_{C0}(q)$, the obtained results for the form factors $F(q)$ become in excellent agreement with the experimental data as shown by the solid curve. In ^{14}N nucleus, the experimental data of Ref. [28] (open circles) are very well described by the calculated $F_{C0}(q)$ up to momentum transfer q ≈ 1.6 fm^{-1}, whereas for q > 1.6 fm^{-1} the calculated $F_{C0}(q)$ underestimate these experimental data. It is very clear that the contribution of the $F_{C2}(q)$ gives a strong modification to the $F_{C0}(q)$ and bring the calculated values very close to the experimental data. Besides, the location of the first diffraction minimum is located in the correct place when the contribution of the $F_{C2}(q)$ are included in the calculations.

Summary and Conclusions

The *NMD* and elastic electron scattering form factors calculated by means of the *CDFM* are expressed in terms of the weight function $|f(x)|^2$. The weight function, which is related with the local density $r(r)$, is obtained from theory and experiment. The feature of the long-tail behavior of the *NMD* is reproduced by both of the theoretical and experimental weight functions and is related to the existence of high densities $r_x(r)$ in the decomposition of eq. (15), though their weight functions are small. The experimental form factors for elastic electron scattering from ^{6}Li and ^{12}C nuclei are well reproduced by the monopole form factors. It is found that the contribution of the quadrupole form factors in ^{10}B and ^{14}N nuclei, which are described by the undeformed p-shell model, are essential in obtaining a remarkable agreement between the theoretical and experimental form factors. It is concluded that the derived form of *NDD* of eq. (2) employed in the determination of theoretical weight function of eq. (27) is capable to reproduce information about the *NMD* and elastic form factors as do those of the experimental data.

Table (1)
Parameters to the NDD of 1p-shell nuclei.

Nucleus	Parameters of the experimental NDD [26]				$r_{exp}(0)$ (fm^{-3}) [26]	$\langle r^2 \rangle^{1/2}_{exp}$ (fm) [26]	b (fm)	a	a_1	a_2	Q
	model	c or a (fm)	z or t (fm)	w							
^6Li	2PF	1.447	0.61		0.154	2.5	1.7	1.059	0.143	0.916	
^{10}B	HO	1.63	0.837		0.1831	2.442	1.63	0.861	0.278	0.583	1.6
^{12}C	2PF	2.24	0.5		0.1688	2.476	1.65	0.585	0.149	0.435	
^{14}N	3PF	2.57	0.515	-0.19	0.1792	2.55	1.68	0.871	0.489	0.382	18.8

The values are given for the parameters c and z if the 2PF or 3PF model has been used, for the parameters a and t if the HO model has been used and the parameter w of the 3PF model.

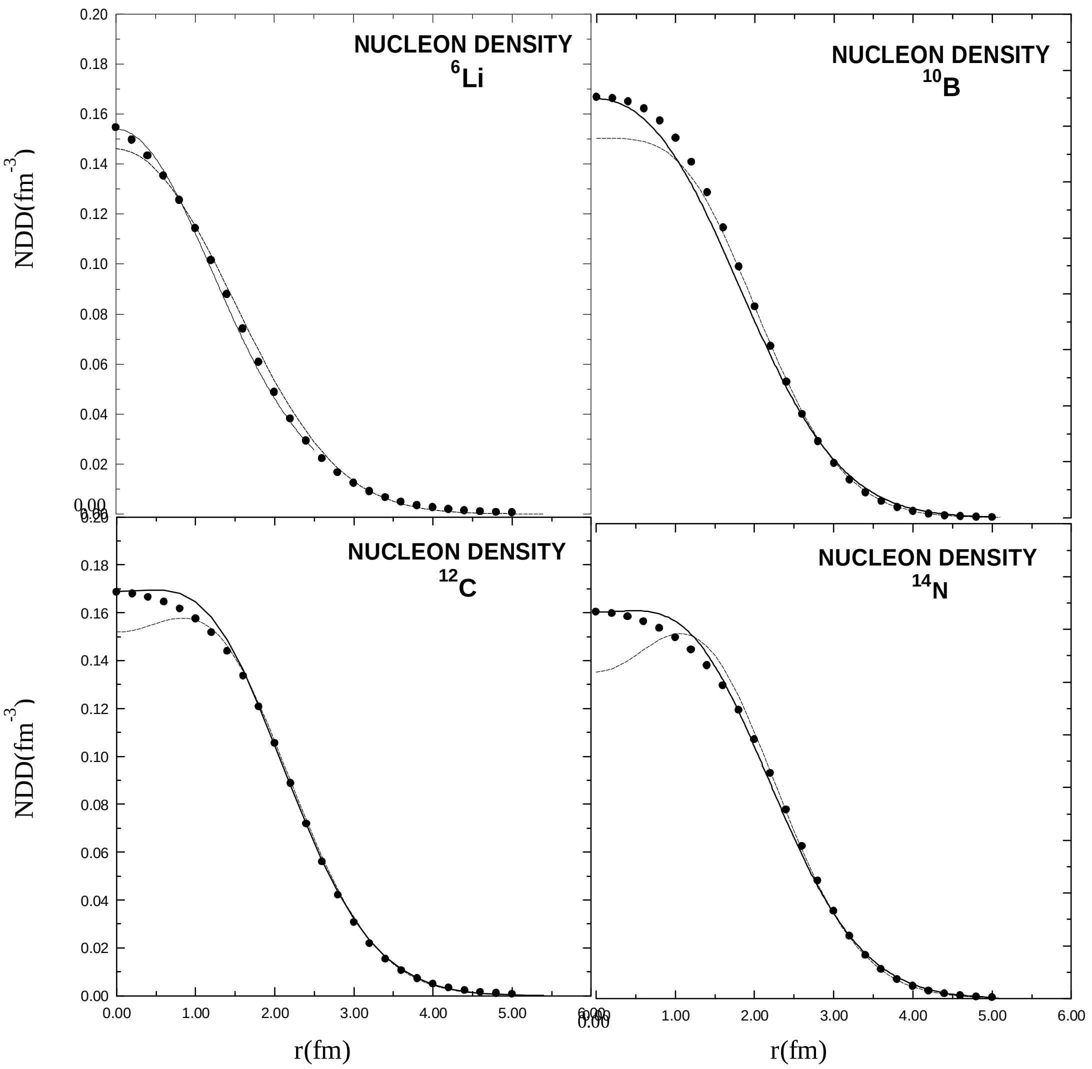

Fig.(1) Dependence of NDD on r for ^{6}Li, ^{10}B, ^{12}C and ^{14}N nuclei. The long-dashed and solid curves are the calculated NDD of eq. (2) when $a = a_1 = a_2 = 0$ and $a \neq a_1 \neq a_2 \neq 0$, respectively. The dotted symbols are the experimental data of Ref. [26].

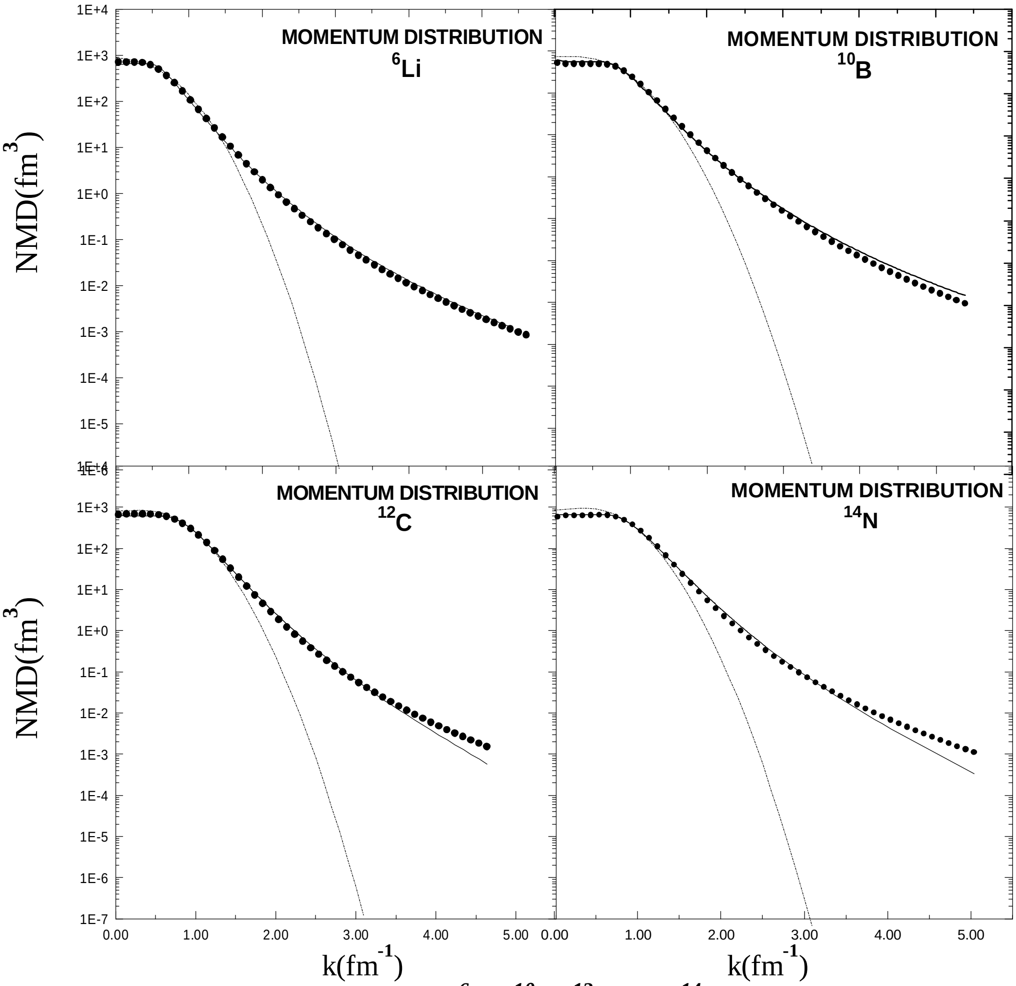

Fig.(2) Dependence of NMD on k for ^{6}Li, ^{10}B, ^{12}C and ^{14}N nuclei. The solid curves and dotted symbols are the calculated NMD obtained in terms of the CDFM of eq. (21) using the theoretical NDD of eq. (2) and the experimental data [26], respectively. The dash-dotted curves are the calculated NMD of eq. (9) obtained by the shell model calculations using the single particle harmonic oscillator wave functions in momentum representation.

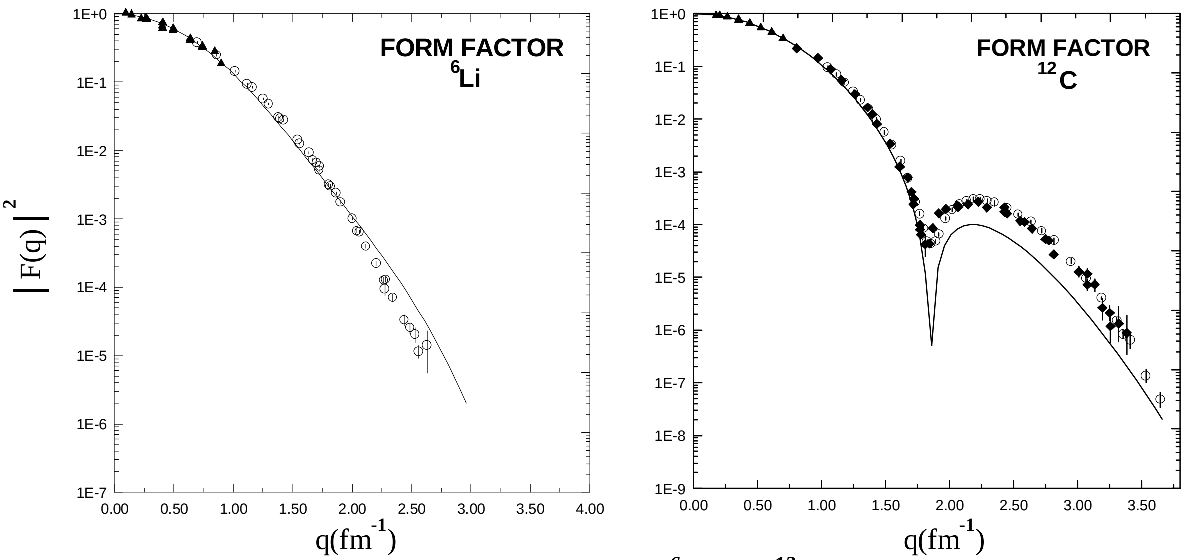

Fig.(3) Dependence of the form factors on q for ^{6}Li and ^{12}C nuclei. The solid curves are the form factors calculated by means of eq. (23). The experimental data for ^{6}Li are taken from Ref. [10] (open circles) and Ref.[36](triangles) while the experimental data for ^{12}C are taken from Ref.[37](open circles), Ref.[38] (rhombs) and Ref.[39](triangles).

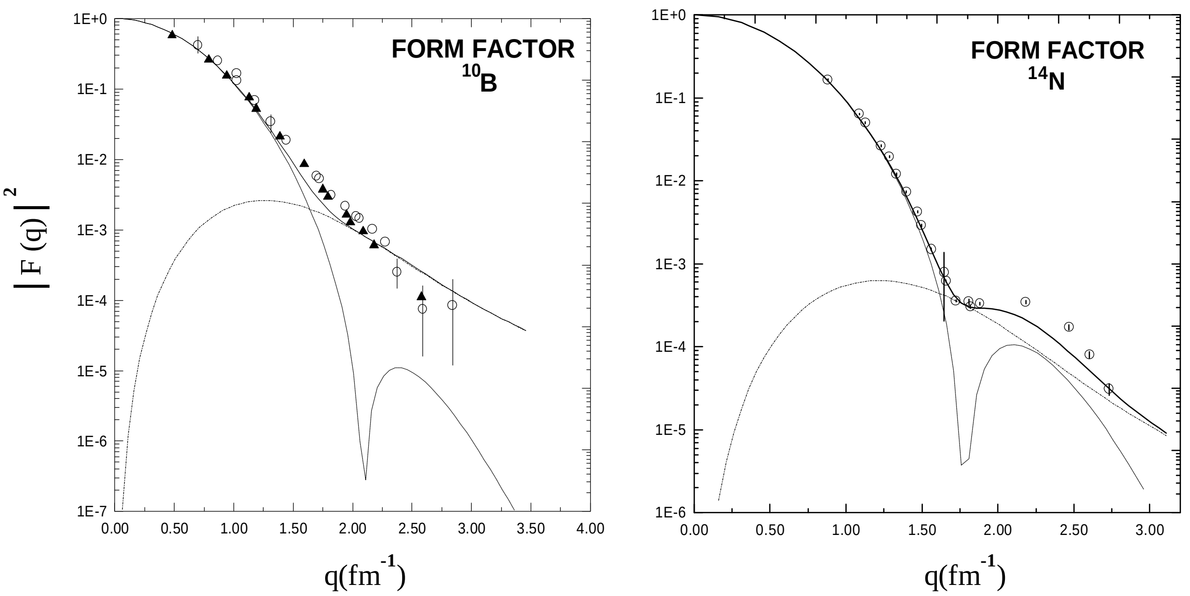

Fig. (4) Dependence of the form factors on q for ^{10}B and ^{14}N nuclei. The dashed and dash-dotted curves represent the contribution of the monopole form factors $|F_{C0}(q)|^2$ and the quadrupole form factors $|F_{C2}(q)|^2$, respectively. The solid curves represent the form factors of both contributions. The experimental data for ^{10}B are taken from Ref. [40] (open circles) and Ref. [33] (triangles) while the experimental data for ^{14}N are taken from Ref. [28] (open circles).

References

[1] T. W. Donnelly and I. Sick , (*elastic magnetic electron scattering from nuclei*), Rev. Mod. Phys., **56**, 1984, 461-467.

[2] I. Sick , (*Elastic electron scattering from light nuclei*), Prog. Part. Nucl. Phys., **47,** 2001, 245-318.

[3] R. Hofstadter, B. Hahn, A. W. Knudsen and J. A. Mclntyre , (*High energy electron scattering and nuclear structure determinations*) , Phys. Rev., **95,** 2, 1954, 512-515.

[4] R. Hofstadter , (*electron scattering and nuclear structure*), Rev. Mod. Phys., **28,** 1956, 214-255.

[5] G. Fricke, C. Bernhardt, K. Heiling, L. A. Schaller, L. Shellenberg, E. B. Shera and C. W. de Jager , (*Nuclear ground state charge radii from electromagnetic interactions*), At. Data Nucl. Data Tables, **60**, 1995, 177-193.

[6] I. Angeli , (*A consistent set of nuclear rms charge radii: properties of the radius surface R(N,Z)*), At. Data Nucl. Data Tables, **87,** 2004, 185-206.

[7] X. Roca-Maza, M. Centelles, F. Salvat and X. Vinas, (*Theoretical study of elastic electron scattering off stable and exotic nuclei*), Phys. Rev., **C78**, 2008, 044332.

[8] J. D. Walecka,“ *Electron scattering for nuclear and nucleon structure* ”, Cambridge University Press, United Kingdom, 2004, 14-18.

[9] Y. Chu, Z. Ren, T. Dong and Z. W. Wang, (*Theoretical study of nuclear charge densities with elastic electron scattering*), Phys. Rev.**, C79,** 2009, 044313.

[10] L. R. Suelzle, M. R. Yearian and Hall Crannell,(*Elastic electron scattering from ^{6}Li and ^{7}Li*), Phys. Rev., **162**, 4, 1967, 992-1005.

[11] R. Anni, G. Co’, P.Pellegrino ,(*Nuclear charge density distributions from elastic electron scattering data*), Nucl. Phys., **A584,** 1995, 35-59.

[12] R. A. Radhi, A. A. Abdullah, Z. A. Dakhil and N. M. Adeeb, (*Core-polarization effects on C2 form factors of p-shell nuclei*), Nucl. Phys**., A 696**, 2001, 442-452.

[13] R. B. Wiringa and R. Schiavilla, (*Microscopic calculation of ^{6}Li elastic and transition form factors*), Phys. Rev. Lett., **81**, 20, 1998, 4317-4320.

[14] E. Cravo, (*Three-body calculation of ^{9}Be electromagnetic observables*), Phys. Rev., **C54,** 2, 1996, 523-533.

[15] Z. Wang and Z. Ren, (*Systematic study of charge form factors of elastic electron-scattering with the relativistic eikonal approximation*), Phys. Rev., **C71,** 2005, 054323.

[16] R. A. Radhi, (*Microscopic calculations of C2 form factors of ^{6}Li*), Nucl. Phys., **A716,** 2003, 100-106.

[17] A. N. Antonov, D. N. Kadrev, M. K. Gaidarov, E. Moya de Guerra, P. Sarriguren, J. M. Udias, V. K. Lukyanov, E. V. Zemlyanaya and G. Z. Krumova, (*Charge and matter distributions and form factors of light, medium, and heavy neutron-rich nuclei*), Phys. Rev**.,** **C72**, 2005, 044307.

[18] A. N. Antonov, P. E. Hodgson and I. Zh. Petkov , " *Nucleon Momentum and Density Distributions in Nuclei* " , Clarendon Press, Oxford , 1988, 134-141.

[19] S. Frankel, W. Frati, O. Van Dyck, R. Werbeck and V.Highland ,(*Inclusive cross sections for 180° production of high-energy protons, deuterons, and tritons in p-nucleus collisions at 600 and 800 Mev*), Phys. Rev. Lett., **36,** 12, 1976, 642-645.

[20] V. I. Komarov, G. E. Kosarev, H.Muler, D. Netzband and T.stiehler ,(*Inclusive spectra and the angular distribution of protons emitted backwards in the interaction of 640 Mev protons with nuclei*), Phys. Lett., **B69**, 1, 1977, 37-40.

[21] Ch. C. Moustakidis and S. E. Massen, (*One-body density matrix and momentum distribution in s-p and s-d shell nuclei*), Phys. Rev., **C62,** 2000, 034318.

[22] M. Traini and G. orlandini, (*Nucleon momentum distributions in doubly closed shell nuclei*), Zeitschrift fur Physik, **A321,** 1985, 479-484.

[23] M. Dal Ri, S. Stringarl and O. Bohigas, (*Effects of short range correlations on one- and two-body properties of nuclei*), Nucl. Phys., **A376**, 1982, 81-93.

[24] A.N.Antonov, V.A. Nikolaev and I.Zh. Petkov, (*Nucleon momentum and density distribution of nuclei*), Zeitschrift fur Physik., **A297,** 1980, 257-260.

[25] A. N. Antonov, P. E. Hodgson and I. Zh. Petkov , " *Nucleon Correlations in Nuclei*", Springer - Verlag, Berlin – Heidelberg - New York, 1993, 233-239.

[26] H. De Vries, C. W. De Jager and C. De Vries, (*Nuclear charge – density - distribution parameters from elastic electron scattering*), Atomic Data and Nuclear Data Tables., **36**, 3, 1987, 495-536.

[27] W. Reuter, G. Fricke, K. Merle and H. Miska, (*Nuclear charge distribution and rms radius of ^{12}C from absolute electron scattering measurement*), Phys. Rev., **C26,** 3, 1982, 806-818.

[28] E. B. Dally, M. G. Croissiaux and B. Schweitz ,(*Scattering of high-energy electrons by Nitrogen-14 and -15*) Phys. Rev., **C2,** 6, 1970, 2057-2067.

[29] K. N. Flaih, (The effect of two body correlation function on the density distribution and electron scattering form factors for some light nuclei), Ph.D. Thesis. College of Science. University of Baghdad 2007.

[30] K. S. Jassim, (Nucleon-nucleon realistic interaction in electron scattering with core-polarization effect), Ph. D. Thesis. College of Science. University of Baghdad 2007.

[31] A. R. Ridha , (*Elastic electron scattering form factors and nuclear momentum distributions in closed and open shell nuclei*), M. SC. Thesis, University of Baghdad 2006.

[32] B. A. Brown, R. A. Radhi and B. H. Wildenthal , (*Electric quadrupole and hexadecupole nuclear excitations from the perspectives of electron scattering and modern shell-model theory*), Phys. Rep**.,** **101,** 5, 1983, 313-358.

[33] T. Stovall, J. Goldemberg and D. B. Isabelle ,(*Coulomb form factors of ^{10}B and ^{11}B*), Nucl. Phys., **86,** 1966, 225-240.

[34] S. Frankel, W. Frati, O. Van Dyck, R. Werbeck and V.Highland ,(*Inclusive cross sections for 180° production of high-energy protons, deuterons, and tritons in p-nucleus collisions at 600 and 800 Mev*), Phys. Rev. Lett., **36,** 1976 642-650.

[35] R. L. Hatch and S. E. Koonin ,(*High momentum nucleons from relativistic nuclear collisions*), Phys. Lett. **B81,** 1, 1979, 1-10.

[36] F. A. Bumiller, F. R. Buskirk, J. N. Dyer and W. A. Monson ,(*Elastic electron scattering from ^{6}Li and ^{7}Li at low momentum transfer*), Phys. Rev., **C5,** 2, 1972, 391-395.

[37] I. Sick and J. S. McCarthy ,(*Elastic electron scattering from ^{12}C and ^{16}O*), Nucl. Phys., **A150,** 1970, 631-654.

[38] H. Crannell, (*Elastic and inelastic electron scattering from ^{12}C and ^{16}O*), Phys. Rev., **148**, 3, 1966, 1107-1118.

[39] J. A. Jansen, R. Th. Peerdeman and C. De Vries,(*Nuclear charge radii of ^{12}C and ^{9}Be*), Nucl. Phys., **A188**, 1972, 337-352.

[40]A. Cichocki, J. Dubach, R. S. Hicks, G. A. peterson, C. W. de Jager, H. de Vries, N. Kalantar - Nayestanaki and T. Sato, (*Electron scattering from ^{10}B*), Phys. Rev.**,** **C51,** 5, 1995, 2406-2426.

الخلاصة

دقة تم استخدام أنموذج تموج الكثافة المتشاكه في حساب كل من توزيعات زخوم النيوكليونات (*NMD*) للحالة الأرضية وعوامل التشكل $F(q)$ للاستطارة الكترونية المرنة لبعض النوى (يكون فيها Z=N) الواقعة ضمن القشرة 1p. وقد تم التعبير عن كل من *NMD* و $F(q)$ بدلالة دالة التموج $|f(x)|^2$ التي تحسب بواسطة توزيعات كثافة النيوكليونات (*NDD*). في هذه الدراسة تم حساب دالة التموج من خلال استخدام النتائج النظرية والعملية لتوزيعات كثافة النيوكليونات. لقد تميزت نتائج توزيعات زخوم النيوكليونات (المستندة على دالة التموج النظرية والعملية) على صفة الذيل الطويل عند منطقة الزخم العالي.

أظهرت هذه الدراسة بأن النتائج النظرية لعوامل التشكل المرنة المستحصلة من الحسابات الحالية تتفق تماماً مع النتائج العملية ولكل قيم الزخم المنتقل q في النوى قيد الدراسة. وأظهرت ايضاً بأن عوامل التشكل الرباعية $F_{C2}(q)$ (المحسوبة بواسطة أنموذج القشرة (p) الغير مشوه) مهمة جداً وأساسية للحصول على توافق بين النتائج النظرية والعملية لعوامل التشكل في النوى ^{10}B و ^{14}N.