DOI: 10.24996/ijs.2024.65.2.11

ISSN: 0067-2904

Study of Nuclear Structure and Elastic Electron Scattering Form Factors for Neutron Halo Nuclei (^{22}N ,^{23}O and ^{24}F) Using Full Correlation Functions with Two Size Parameters

Abeer A. M. Hussein*, Ghaith N. Flaiyh

Department of Physics, College of Science, University of Baghdad, Baghdad, Iraq

Received: 7/11/2022 Accepted: 20/3/2023 Published: 29/2/2024

Abstract:

The study of neutron-rich nuclei's form factors, root-mean-square radius (*rms*), and nuclear density distributions is the focus of this work for the nuclei (^{22}N,^{23} O and ^{24}F). With the use of a strong short-range effect and a strong tensor force, the nucleons distribution function of the two oscillating harmonic particles in a two-frequency shell model operates with two different parameters: the first (b_{core}), for the inner (core) orbits, and the second ($b_{valence}$) for the outer (halo) orbits. This work demonstrated the existence of neutron halo nuclei for the nuclei (^{22}N, ^{23}O and ^{24}F) in the ($2s_{1/2}$) shell. The computed density distribution of neutron, proton and matter for these nuclei displayed the long tail performance. Using the Borne approximation of the plane wave, the elastic form factor of the electron scattering from the alien nucleus was calculated, this form factor is independent of the neutrons that make up the halo, but rather it results from a difference in the proton density distribution of the last proton in the nuclei. Fortran 95 power station program was used to the neutron, proton and matter density, elastic electron scattering form factor, and *rms* radii. The calculated outcomes for these exotic nuclei were in good agreement with the experimental data.

Keywords: Elastic form factors , one –neutron halo nuclei , root-mean square (*rms*) radii , two body full correlation.

دراسة التركيب النووي وعوامل التشكل للإستطارة الإلكترونية المرنة لنوى الهالة النيوترونيه (^{22}N ,^{23}O ,^{24}F) باستخدام دوال الارتباط الكامل مع معلمتين للحجم

عبير علي محمد حسين ,غيث نعمة فليح

قسم الفيزياء، كلية العلوم، جامعة بغداد، بغداد، العراق

الخلاصة:

إن دراسة توزيعات الكثافة النووية وعوامل التشكل بعض النوى الغنية بالنيوترونات ، ومعدل جذر لنصف القطر التربيعي (*rms*) ، هي محور هذا العمل للنوى (^{22}N و ^{23}O و ^{24}F) حيث تم استخدام توزيعين لكثافة شحنة الجسم (2BCDD's) مع تأثيرات قوة التنزورية القوية والمدى القصير ، تعمل دالة توزيع النكليونات للجسيمين التوافقيين المتذبذبين في نموذج غلاف ثنائي التردد بمعلمتين مختلفتين: الأولى ، (b_{core}) ، للمدارات الداخلية (القلب) والثانية ، ($b_{valence}$) ، للمدارات (الهالة) الخارجية. أظهر هذا العمل وجود نوى هالة نيوترونيه ، كما أظهر التوزيع المحسوب لكثافة النيوترونات والبروتونات ($2s_{1/2}$) في الغلاف (^{24}F و^{23}O و ^{22}N)للنوى والمادة لهذه النوى بوضوح الذيل الطويل بالتوزيع. باستخدام تقريب بورن للموجة المستوية ، تم حساب عامل

*Email: Abeer.Ali1104a@sc.uobaghdad.edu.iq

التشكل لتشتت المرن لإلكترون المستطار من النواة الغريبة ، أن عامل التشكل هذا لا يعتمد على النيوترونات التي تتكون منها الهالة ولكنه ينتج عن اختلاف في توزيع كثافات البروتون لآخر بروتون في النواة. تم استخدام برنامج Fortran 95 power station لحساب كثافة النيوترون ، البروتون والمادة ،وعامل التشكل تشتت الإلكترون المرن ومعدل جذر لنصف القطر التربيعي . تتوافق نتائج الحساب لهذه النوى الغريبة مع القيم العملية .

1. Introduction:

Several experiments [1,2] have been conducted to study the neutron (proton) in nuclei rich in neutrons (protons), which are well-identified. According to nuclear physics, the halo nucleus is a configuration in the nucleus of an atom where the primary part of the nucleus is surrounded by a secondary part of neutrons (protons) orbiting around the primary part. These neutrons (protons) have a short life, and the energy required to separate the outer nucleus of the nucleus near the drip line is very low. It is challenging to study short-range and tensor correlation impacts, specifically for the theories of nuclear structure. Multiple methods have been developed for dealing with the tensor forces and explaining their impact on the nuclear ground state [3,4]. Dellagiacoma et al. [5] provided a straightforward phenomenological technique for creating dynamical short-range and tensor correlations Da Proveidencia and Shakin [6] developed a similar correlation operator for explaining short-range correlation effects, as did Malecki and Picchi [7]. Several methods have been presented for dealing with the tensor forces and describing their impact on the nuclear ground state [8,9]. Using an alpha cluster model, Sugimoto et al. [10] investigated how the tensor force affects the alpha-alpha interaction in ^{8}Be. They used the projected Hartree-Fock approach to create the wave function of the alpha particle, which could account for the effects of tensor correlation. The ground state proton, neutron and matter densities and corresponding root mean square radii of unstable proton-rich ^{17}Ne and ^{27}P exotic nuclei are studied via the framework of the two frequency shell model The single particle harmonic oscillator wave functions are used in this model with two different oscillator size parameters by Hamoudi et al. [11]. This operator considers the impact of the tensor force with the short-range repulsion in the nucleon-nucleon forces. The nuclear shell model with the Skyrme–Hartree–Fock (SHF), as a nonrelativistic approach, and the Relativistic Hartree–Fock–Bogoliubov (RHFB) methods have been used to study the nuclear structure of some exotic nuclei at the proton and neutron drip lines ,for a neutron halo in ^{11}Li and ^{14}Be and proton halo in ^{17}Ne, ^{23}Al and ^{27}P , by Allami et al., [12].Abdullah [13] studied the ground-state density distribution of proton, neutron, and matter (Core + n) using the radial wave functions of the generalized Woods–Saxon potential inside the two-body model of protons, neutrons, and matter (Core + n). Ridha et al.,[14] the theoretical outlines of calculations assume that the nuclei understudy are composed of two parts: the stable core and the unstable halo. The core part is studied using the radial wave functions of harmonic-oscillator (HO) potentials, while the halo is studied through Woods-Saxon (WS) potential for some exotic nuclei. The ground state properties including the density distributions of the neutrons, protons and matter as well as the corresponding root mean square (*rms*) radii of proton-rich halo candidates have been studied by the single particle Bear-Hodgson (BH) wave functions with the two-body model of (core + p),by Abdullah [15].

The aim of the research is to study the nucleus with the halo for the nuclei (^{22}N, ^{23}O and ^{24}F) using the two–body charge density distribution's (2BCDD's) formula depending on the strength of the tensor and short-term effects and considering the nuclei to be made of two parts, taking into account the nuclei (core + *n*). Also, calculating the *rms* radii and form factors depending on 2BCDD's formula and observing the effects of the tensor force and the short-range effect of the neutron-rich halo nuclei.

2. Theory:

The operator used to define the nucleon density of (A) point-like particle nucleus is[16]:

$$\hat{\rho}^{(1)}(\vec{r}) = \sum_{i=1}^{A} \delta(\vec{r} - \vec{r}_i) \tag{1}$$

the ground state Nucleon Density Distributions (NDD) of a nucleus consisting of (A) point–like particles is:

$$\rho_{g.s}^{(1)}(r) = 4\sum_{n\ell}\left(\frac{(2\ell+1)}{4\pi}\left|R_{n\ell}(r)\right|^2\right) \tag{2}$$

This operator can be transformed to a two body density form($\hat{\rho}^{(1)}(\vec{r}) \Rightarrow \hat{\rho}^{(2)}(\vec{r})$) as [17]:

$$\sum_{i=1}^{A} \delta(\vec{r} - \vec{r}_i) \equiv \frac{1}{2(A-1)} \sum_{i\neq j}\left\{\delta(\vec{r} - \vec{r}_i) + \delta(\vec{r} - \vec{r}_j)\right\} \tag{3}$$

Another relevant transformation is that of the coordinates of the two‒particles, which may be expressed as ($\vec{r}_i$) , ($\vec{r}_j$) in terms of that relative $\vec{r}_{ij}$, center-of- mass $\vec{R}_{ij}$ coordinates [18] are:

$$\vec{r}_{ij} = \frac{1}{\sqrt{2}}(\vec{r}_i - \vec{r}_j) \tag{4}$$

$$\vec{R}_{ij} = \frac{1}{\sqrt{2}}(\vec{r}_i + \vec{r}_j) \tag{5}$$

Substituting Equations (4) and (5) in Equation (3), we obtain [19]:

$$\hat{\rho}^{(2)}(\vec{r}) = \frac{1}{2(A-1)} \sum_{i\neq j}\left\{\delta\left[\vec{r} - \frac{1}{\sqrt{2}}(\vec{R}_{ij} + \vec{r}_{ij})\right] + \delta\left[\vec{r} - \frac{1}{\sqrt{2}}(\vec{R}_{ij} - \vec{r}_{ij})\right]\right\} \tag{6}$$

Equation (6) may be written as:

$$\hat{\rho}^{(2)}(\vec{r}) = \frac{1}{2(A-1)} \sum_{i\neq j}\left\{\delta\left[\frac{1}{\sqrt{2}}(\sqrt{2}\,\vec{r} - \vec{r}_{ij} - \vec{R}_{ij})\right] + \delta\left[\frac{1}{\sqrt{2}}(\sqrt{2}\,\vec{r} + \vec{r}_{ij} - \vec{R}_{ij})\right]\right\}$$

$$\hat{\rho}^{(2)}(\vec{r}) = \frac{2\sqrt{2}}{2(A-1)} \sum_{i\neq j}\left\{\delta\left[\sqrt{2}\,\vec{r} - \vec{r}_{ij} - \vec{R}_{ij}\right] + \delta\left[\sqrt{2}\,\vec{r} + \vec{r}_{ij} - \vec{R}_{ij}\right]\right\} \tag{7}$$

$$\hat{\rho}^{(2)}(\vec{r}) = \frac{\sqrt{2}}{(A-1)} \sum_{i\neq j}\left\{\delta\left[\sqrt{2}\,\vec{r} - \vec{r}_{ij} - \vec{R}_{ij}\right] + \delta\left[\sqrt{2}\,\vec{r} + \vec{r}_{ij} - \vec{R}_{ij}\right]\right\} \tag{8}$$

Using the identity

$\delta(ax) = \{\frac{1}{|a|}\delta(x)\}$ (for one – dimension) (i)

$\delta(a\vec{r}) = \{\frac{1}{|a^3|}\delta(\vec{r})\}$ (for three – dimension) (ii)

Then Equation (8) becomes:

$$\hat{\rho}^{(2)}(\vec{r}) = \frac{\sqrt{2}}{(A-1)} \sum_{i\neq j}\left\{\delta\left[\sqrt{2}\,\vec{r} - \vec{R}_{ij} - \vec{r}_{ij}\right] + \delta\left[\sqrt{2}\,\vec{r} - \vec{R}_{ij} + \vec{r}_{ij}\right]\right\} \tag{9}$$

The operator from Equation (9), can be folded ,with the two‒body correlation functions $\tilde{f}_{ij}$ to yield an efficient two‒body charge density operator:

$$\hat{\rho}^{(2)}_{eff}(\vec{r}) = \frac{\sqrt{2}}{(A-1)} \sum_{i\neq j} \tilde{f}_{ij} \left\{ \delta\left[\sqrt{2}\,\vec{r} - \vec{R}_{ij} - \vec{r}_{ij}\right] + \delta\left[\sqrt{2}\,\vec{r} - \vec{R}_{ij} + \vec{r}_{ij}\right] \right\} \tilde{f}_{ij} \tag{10}$$

Where the from $\tilde{f}_{ij}$ is given by [10]:

$$\tilde{f}_{ij} = f(r_{ij})\,\Delta_1 + f(r_{ij})\left\{ 1 + \alpha(A)\, S_{ij} \right\}\Delta_2 \tag{11}$$

It is clear that Equation (11) contains two types of correlations:

i-The first term of equation (11) is a two‒body short-range correlation, expressed as $f(r_{ij})$. Here Δ_1, the except for $^3S_1$ and $^3D_1$ states, is a projection operator onto the space of all two-body wave functions. Short-range correlations should be observed as they are important functions of particle separation, which diminish the two‒body wave function at short distances. The repulsive core forces the particles apart and heal to unity at lengthy distances where the interactions are very weak. The two‒body short-range correlation is given by [10]:

$$f(r_{ij}) = \begin{cases} 0 & for\ r_{ij} \le r_c \\ 1 - \exp\left\{-\mu (r_{ij} - r_c)^2\right\} & for\ r_{ij} > r_c \end{cases} \tag{12}$$

Where: r_c(*fm*) is the radius of a suitable hard core and μ is the correlation parameter equal to 25 fm^{-2} [9].

ii- The strong tensor component in the nucleon-nucleon force induces the longer-range two-body tensor correlation shown in the second term of Equation (11). This projection operator only affects the $^3S_1$ and $^3D_1$ states. The typical tensor operator, S_{ij}, is known as [10]:

$$S_{ij} = \frac{3}{r_{ij}^2} (\vec{\sigma}_i . \vec{r}_{ij})(\vec{\sigma}_j . \vec{r}_{ij}) - \vec{\sigma}_i . \vec{\sigma}_j \tag{13}$$

Where: α (A) is the strength of tensor correlation. It is non-zero, just in the $^3S_1$ and $^3D_1$ channels.

It makes sense to parameterize the core and halo densities independently in the case of the exotic nuclei. Consequently, the following is how the halo nuclei's ground-state matter density distribution can be expressed [20 ,21]:

$$\rho_m(r) = \rho^{core}_{(p+n)}(r) + \rho^{valence}_n(r) \tag{14}$$

The *rms* of the corresponding above densities is given by Antonov et al. [22]:

$$\left\langle r^2 \right\rangle^{1/2}_w = \frac{4\pi}{w} \int_0^\infty \rho^w(r) r^4\, dr \tag{15}$$

Where: w is (proton, neutron or matter).

The Plane Wave Born Approximation (PWBA) was used to study the elastic electron scattering form factors for the nuclei under study. The charge form factor in PWBA is [23]:

$$F(q) = \frac{4\pi}{qZ} \int_0^\infty \rho_o(r) \sin(qr)\, r\, dr \tag{16}$$

With inclusion of the finite nucleon size correction $F_{fs}(q)$. $F_{cm}(q)$ is the center of mass correction. Our calculations required multiplying the form factor of Equation (16) by these corrections.

$$F(q) = \frac{4\pi}{qZ} \int_0^\infty \rho_o(r) Sin(qr)\, r\, dr\, F_{fs}(q)\, F_{cm}(q) \tag{17}$$

The finite size correction F_{fs} *(q)* is defined [22]:

$$F_{fs}(q) = e^{-0.43q^2/4} \tag{18}$$

Where: $F_{fs}(q)$ is the free nucleon form factor for protons and neutrons considered to be the same. According to Brown et al. [25], the center of mass correction $F_{cm}(q)$ is as follows:

$$F_{cm}(q) = e^{q^2b^2/4A} \tag{19}$$

Where: b is the harmonic-oscillator size parameter and A is the nuclear mass number. As a result, when the shell model wave function is removes center of mass correction $F_{cm}(q)$ eliminates the spurious state caused by the center of mass's motion. The form factor $F(q)$ comprising the impact of two body correlation functions may now be calculated by entering the ground state of Equation (10) into Equation (17).

3. Results and Discussion:

The density distribution for (protons, neutrons and matter) of the ground state of (^{22}N,^{23}O and ^{24}F) nuclei, the *rms* radii and the form factors *F(q)* were studied by the two-body oscillator model (core +*n*) shell model using the parameters (b_{core}) and ($b_{velence}$). The nuclear ground state properties of the exotic nuclei were calculated using the two body correlation charge density 2BCCD's with the effect of short- range and tensor force using Equations (10,11,12) and (13). Table 1 summarizes some of the characteristics of halo nuclei [26]. The average radius of neutrons and protons was calculated based on Equations (10) and (15). The obtained results are shown in Table 2 for full correlation (r_c=0.5 *fm*, α =0.1) and without correlation (r_c=0, α=0). It was found that the neutrons *rms* radius are larger than that of protons.

Table 1: Some properties of halo (^{22}N, ^{23}O , ^{24}F) nuclei .

Halo nuclei	J^{Π}, T [24]	Half life time ($T_{1/2}$) [26]	Separation energy[26]
^{22}N	0^-,4	23*ms*	1.54*MeV*
^{23}O	$1/2^+$,7/2	97*ms*	2.73*MeV*
^{24}F	3^+,3	384*ms*	3.81*MeV*

Table 2: The calculated neutrons and protons *rms* radii for nuclei (^{22}N ,^{23}O and ^{24}F)

Exotic nuclei ^{22}N			
Proton size parameter	**b_p=1.77 *fm***	**Neutron size parameter**	**b_n=2.065 *fm***
$\langle r_p^2 \rangle^{1/2}_{r_c=0.5,\alpha=0.1}$	**2.614715**	$\langle r_n^2 \rangle^{1/2}_{r_c=0.5,\alpha=0.1}$	**3.419913**
$\langle r_p^2 \rangle^{1/2}_{r_c=0,\alpha=0}$	**2.61996**	$\langle r_n^2 \rangle^{1/2}_{r_c=0,\alpha=0}$	**3.430141**
$\langle r_p^2 \rangle^{1/2}_{exp}$ **[27]**	**2.61**	$\langle r_n^2 \rangle^{1/2}_{exp}$ [27]	**3.41±0.16**
$\langle r_p^2 \rangle^{1/2}_{FCs}$	**-0.0052**	$\langle r_n^2 \rangle^{1/2}_{FCs}$	**-0.01**
Exotic nuclei ^{23}O			
Proton size parameter	**b_p=1.79 *fm***	**Neutron size parameter**	**b_n=2.167*fm***
$\langle r_p^2 \rangle^{1/2}_{r_c=0.5,\alpha=0.1}$	***2.682703***	$\langle r_n^2 \rangle^{1/2}_{r_c=0.5,\alpha=0.1}$	***3.587601***
$\langle r_p^2 \rangle^{1/2}_{r_c=0,\alpha=0}$	***2.679315***	$\langle r_n^2 \rangle^{1/2}_{r_c=0,\alpha=0}$	***3.59960***
$\langle r_p^2 \rangle^{1/2}_{exp}$ **[27]**	***2.68***	$\langle r_n^2 \rangle^{1/2}_{exp}$ *[27]*	***3.58±0.05***

$\langle r_p^{\,2}\rangle^{1/2}_{FC's}$	*-0.003*	$\langle r_n^{\,2}\rangle^{1/2}_{FCs}$	*-0.01199*
	Exotic nuclei ^{24}F		
Proton size parameter	**b_p=1.965*fm***	**Neutron size parameter**	**b_n=1.98*fm***
$\langle r_p^{\,2}\rangle^{1/2}_{r_c=0.5,\alpha=0.1}$	**2.955663**	$\langle r_n^{\,2}\rangle^{1/2}_{r_c=0.5,\alpha=0.1}$	**3.286231**
$\langle r_p^{\,2}\rangle^{1/2}_{r_c=0,\alpha=0}$	**2.95916**	$\langle r_n^{\,2}\rangle^{1/2}_{r_c=0,\alpha=0}$	**3.288919**
$\langle r_p^{\,2}\rangle^{1/2}_{exp}$ **[27]**	**2.95**	$\langle r_n^{\,2}\rangle^{1/2}_{exp}$ [27]	**3.29±0.009**
$\langle r_p^{\,2}\rangle^{1/2}_{FC's}$	**-0.0002**	$\langle r_n^{\,2}\rangle^{1/2}_{FCs}$	**-0.002**

Table 3 shows the calculated *rms* radii for the core nuclei (^{21}N, ^{22}O and ^{23}F) and the exotic nuclei (^{22}N ,^{23}O and ^{24}F) when (r_c = 0.5, *fm*, α = 0.1) with two different parameters (b_{core}) for the inner (core) orbits and ($b_{valence}$) for the halo orbits. The calculated results are in good agreement with the experimental data of Ahmad et al. [27] and Ozawa et al. [28].

Table 3 : The calculated core, valance and matter radii *rms* compared with the experimental data for halo.

Halo nuclei	Core nuclei	b_c *(fm)*	b_v *(fm)*	b_m *(fm)*	*rms* matter radii for core nuclei $\langle r^2\rangle^{1/2}_c$ *(fm)*		*rms* matter radii for matter nuclei $\langle r^2\rangle^{1/2}_m$ *(fm)*	
					Calculated results	**Experimental Data [25,26]**	**Calculated results**	**Experimenta l Data [27,28]**
^{22}N	**^{21}N**	1.77	3.75	1.98	2.74801	2.75 ± 0.03	3.074975	3.07 ± 0.13
^{23}O	**^{22}O**	1.85	3.8	2.05	2.87261	2.88 ± 0.06	3.201470	3.2 ± 0.04
^{24}F	**^{23}F**	1.78	3.84	1.95	2.79355	2.79 ± 0.04	3.065238	3.03 ± 0.06

Figure (1) exhibits the relation between 2BNDDs (in fm^{-3}) of the ground state and r (in *fm*) for ^{22}N, ^{23}O and ^{24}F. The blue curve represents 2BNDDs for the core ^{21}N, ^{22}O, ^{23}F (proton + neutron) with oscillator size parameters (b_{core} =1.773, 1.85, 1.78 *fm*), respectively. The green curve represents 2BNDDs with oscillator size parameters valence ($b_{velence}$=3.75, 3.8, 3.84 *fm*) for ^{22}N, ^{23}O ,^{24}F, respectively. While the red curve represents the total calculations for the core nucleons and the valence one neutron with oscillator size parameters (b_m =1.98, 2.05, 1.95 *fm*) for ^{22}N, ^{23}O ,^{24}F, respectively, and the shaded curve represents the experimental of nucleon densities of ^{22}N, ^{23}O ,^{24}F, respectively [27,28]. Figure (1) shows the computed matter density distributions showing a long tail for all of these nuclei, consistent with the experimental data.

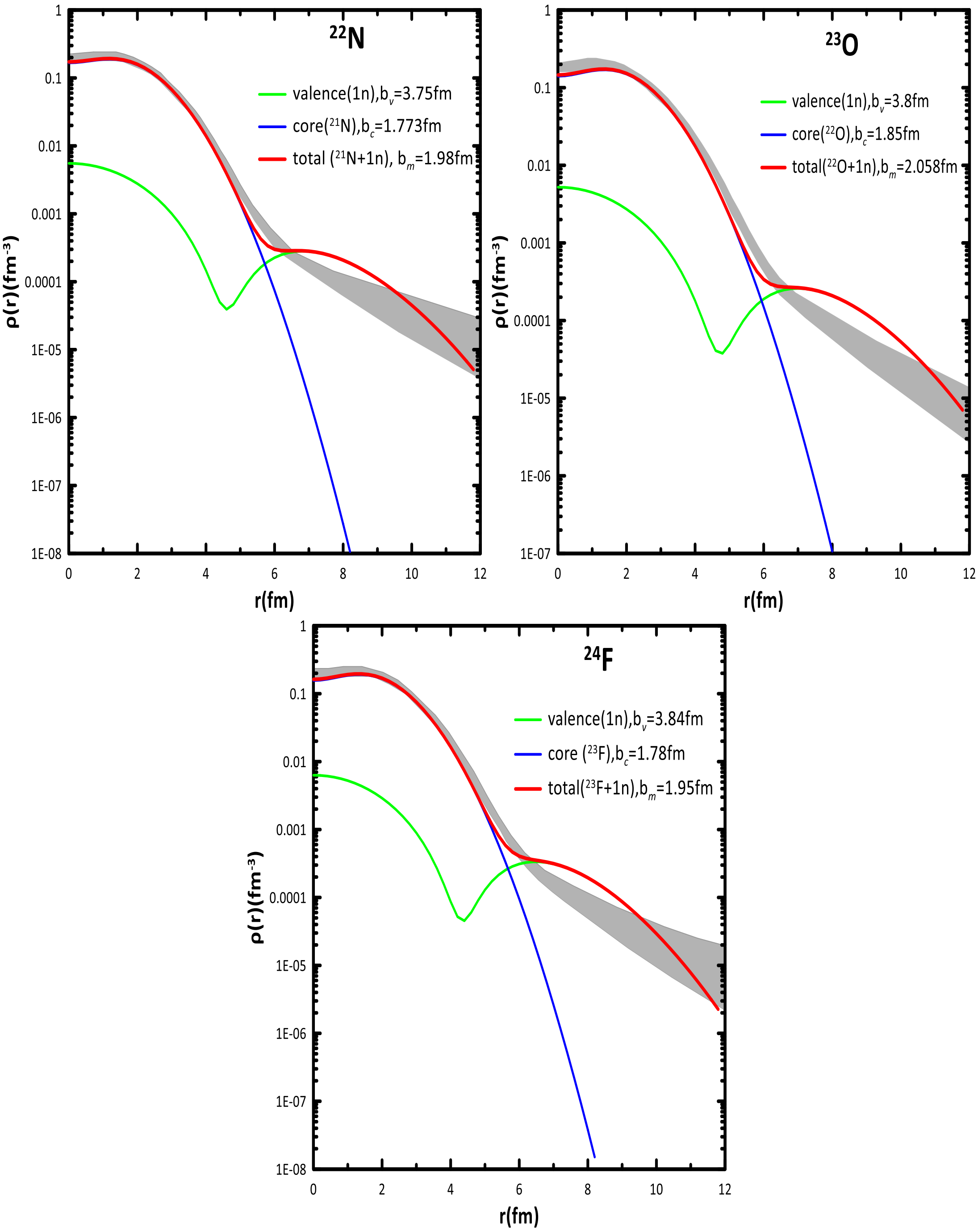


Figure 1: Core, halo and matter density distributions for (^{22}N, ^{23}O and ^{24}F) nuclei.

Figure (2) illustrates a comparison between the matter density distributions of halo (^{22}N, ^{24}F and ^{23}O) (red curve) with the matter density distributions of the stable nuclei (^{14}N, ^{19}F and ^{16}O) (yellow curve. A long tail is clear in the matter distribution of the halo nuclei.

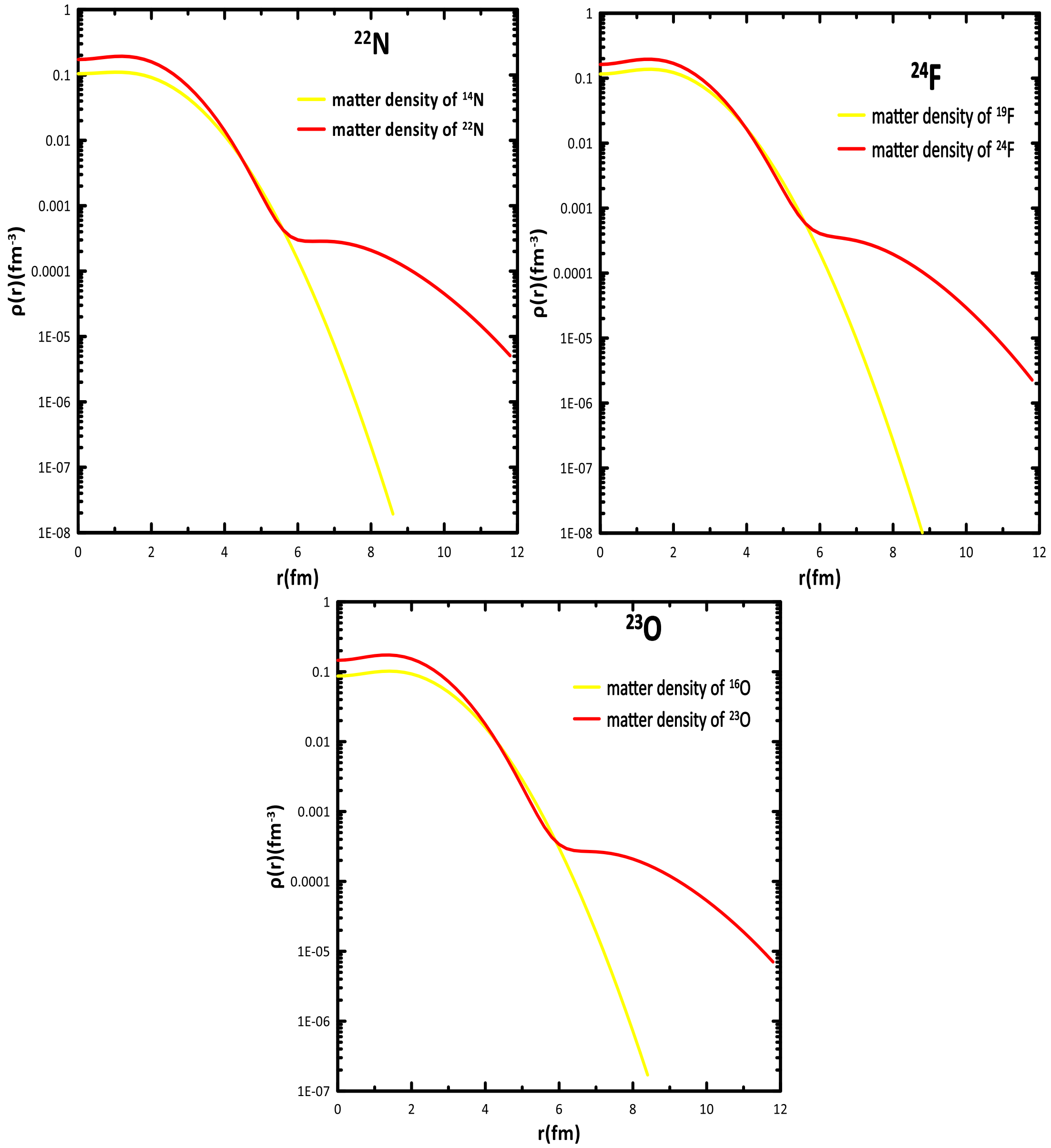


Figure 2: Comparison of matter density distribution of halo nuclei (^{22}N, ^{24} F and ^{23}O) with that of stable nuclei (^{14}N, ^{19}F and ^{16}O).

Figure (3) shows the neutrons density distributions (blue curve), protons density distributions (brown curve), and matter density distributions (red curve) densities for (^{22}N, ^{23}O, and ^{24} F), respectively. There was a large density difference between neutrons and protons in ^{22}N,^{23}O and ^{24}F. The usual performance of the exotic nucleus, i.e. the long tail, was clearly apparent in the neutron density distributions (red curves). As indicated by these figures, the neutron diffuseness is also larger than the proton diffuseness in these nuclei. It can be noted that the difference between the *rms* radii of the neutrons and that of the protons is (r_n- r_p = 0.8051, 0.9048, 0.3305 *fm*) for ^{22}N, ^{23}O, and ^{24}F, respectively. This difference is also supported by the halo structure of these alien cores.

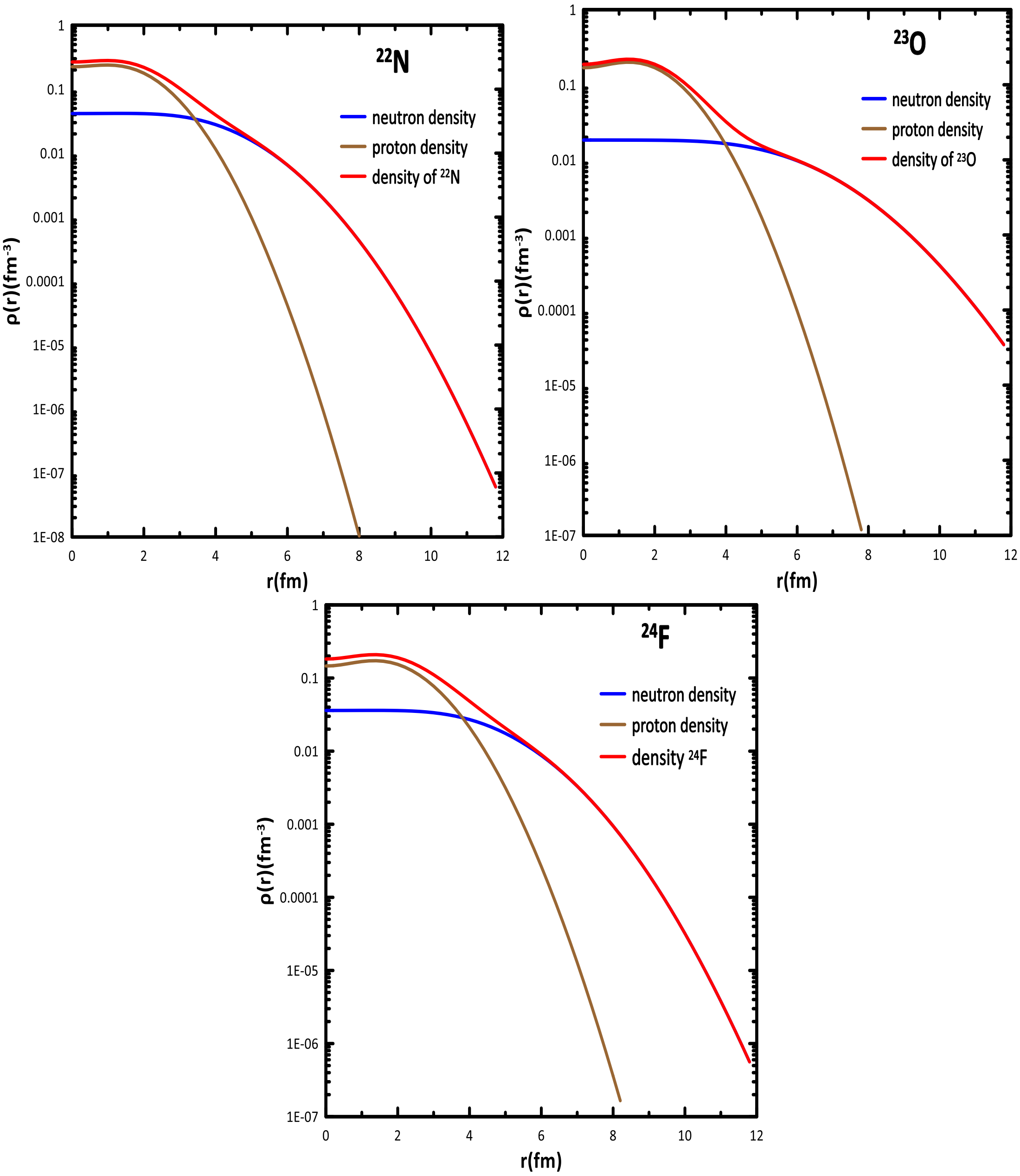


Figure 3: Calculated protons, neutrons and matter density distributions for nuclei ^{22}N, ^{23}O and ^{24}F.

Figure (4) presents the elastic form factors for (^{22}N, ^{23}O and ^{24}F) with FCs using PWBA. Where the average size parameter nuclei radii (b = 1.77, 1.79, 1.965 *fm*) were used, respectively. These values were adopted by comparing $\langle r^2 \rangle^{1/2}_{exp}$ with $\langle r^2 \rangle^{1/2}_{the}$; a match with experimental data was obtained. The blue curve represents the form factor of 2BCDDs with corrected finite nucleon size and with center of mass correction ($F_{fs}(q) \neq 0$, $F_{cm}(q) \neq 0$). The red curve represents the form factor of 2BCDDs without finite nucleon size correction ($F_{fs}(q) = 0$, $F_{cm}(q) = 0$), i.e. the finite nucleon size and the center of mass corrections were not taken into account, and the circle-packed curves represent the experimental data for (^{14}N, ^{16}O and ^{19}F) nuclei [29,30]. It was noted that the form factors are independent of the neutrons that make up the halo but result from a difference in the proton density distributions of the last proton in the nuclei. Good agreement was obtained at the momentum for q<3.6, and it was noted that the behavior of the theoretical results for the halo nuclei (^{22}N, ^{23}O, ^{24}F) matches the practical results of the (^{14}N,^{16}O and ^{19}F) stable nuclei.

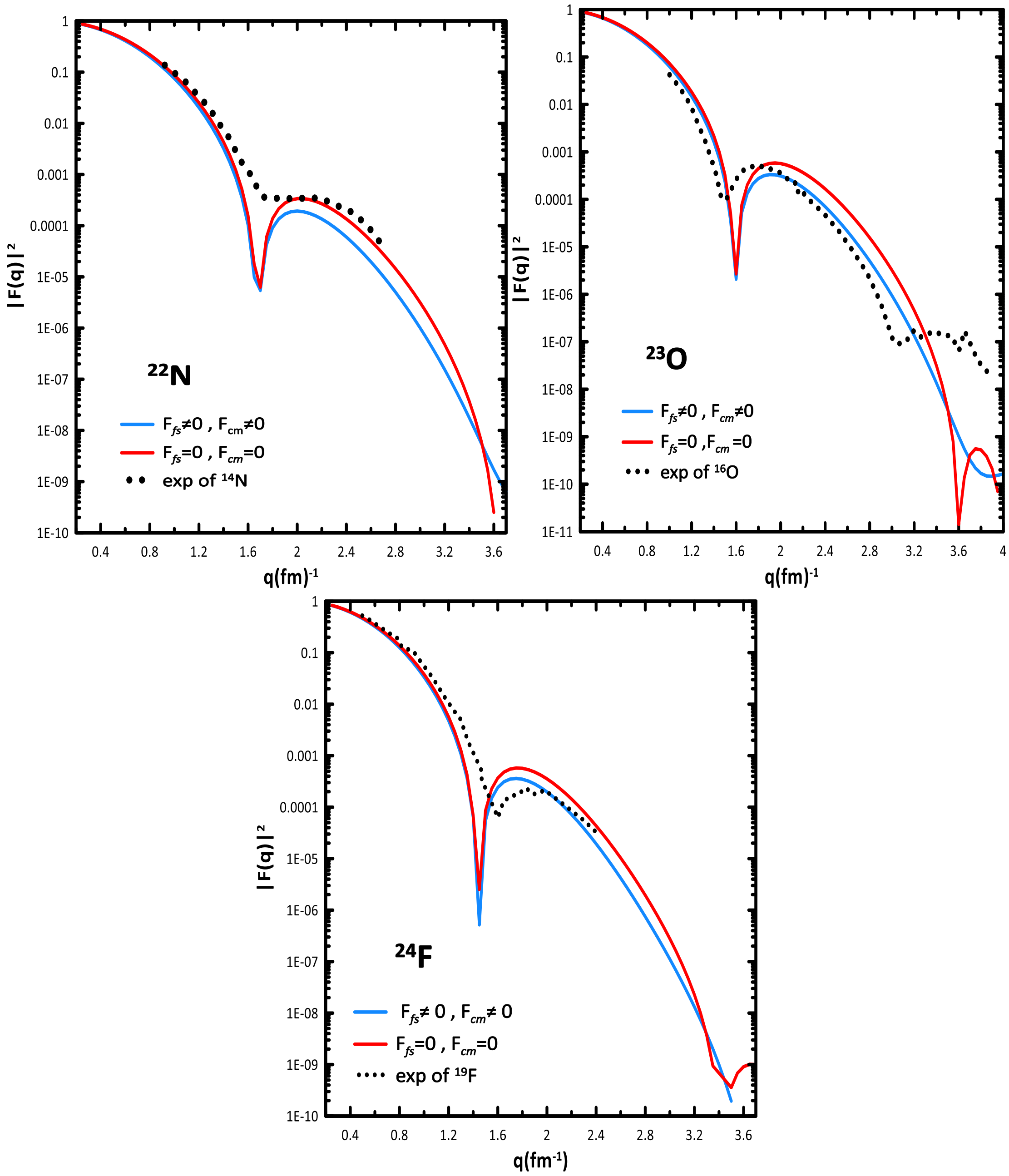
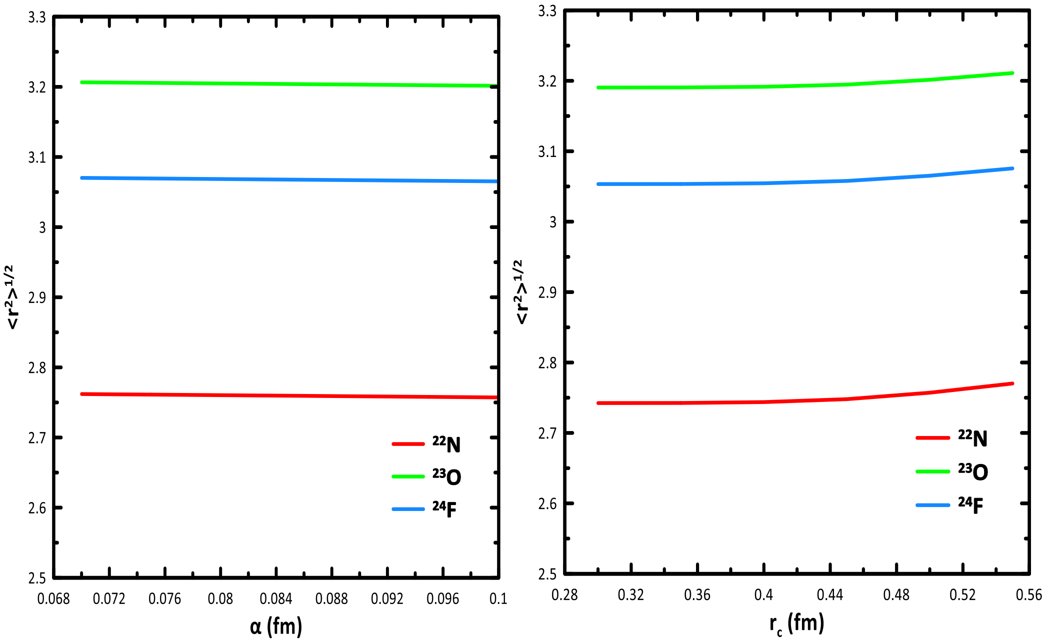


Figure 4: The form factors for ^{22}N, ^{23}O and ^{24}F nuclei compared with the experimental data of Dally et al. [29] and De Vries et al. [30].

The relation of the tensor force (correlation force) with *rms* ($\langle r^2 \rangle^{1/2}$ in *fm*) was studied with the inclusion of the correlation of the short-range (r_c= 0.5 *fm*). It was noted in Figure (5-a) that *rms* values decreased with the increase of the tensor force. The correlation short-range effect and *rms* with the inclusion of the correlation tensor force is equal to 0.1. An increase of the *rms* values with the increase of the short-range (correlation force) was noted, as shown in Figure (5-b).



(a) **(b)**

Figure 5: (a) The calculated $\left\langle r^2 \right\rangle^{1/2}$ with different values of Tensor force (b) The calculated $\left\langle r^2 \right\rangle^{1/2}$ with different values of short- range.

4. Conclusions:

Halo nuclei are known for having neutron valence; the neutron halo occupies the $2s_{1/2}$ orbits. The measured matter density for the understudy halo nuclei showed a long tail behavior using the two body nucleon density distributions (2BNDDs) framework with effects of tensor force and short-range with two different oscillator size parameters b_{core}, $b_{valence}$. The obtained results agreed with the experimental data. The considerable disparity in charge form factors between unstable nuclei (^{22}N, ^{23}O and ^{24}F) and stable isotopes (^{14}N, ^{16}O and ^{19}F) is due to the charge distribution of the neutrons themselves.

References

[1] T. Nilsson , F. Humbert , W. Schwab , H. Simon , M.H. Smedberg , M. Zinser , Th. Blaich , M.J.G. Borge , L.V. Chulkov , Th.W. Elze , H. Emling , H. Geissel , K. Grimm , D. Guillemaud-Mueller , P.G. Hansen , R. Holzmann , H. Irnich , B. Jonson , J.G. Keller , H. Klingler ,E. Zude , "^{6}He and neutron momentum distributions from ^{8}He in nuclear break-up reactions at 240 MeV/u ", *Nucl. Phys., A*, 598, 418 ,1996.

[2] R.Anne, S.E. Arnell, R. Bimbot , H. Emling , D.Guillemaud,Mueller , P.G. Hansen , L. Johanns en , B. Jonson , M. Lewitowicz , S. Mattsson , A.C. Mueller , R. Neugart , G. Nyman , F. Poughe on , A. Richter , K. Riisager , M.G. Saint-Laurent , G. Schrieder , O. Sorlin , K. Wilhelmsen ," Observation of forward neutrons from the break-up of the ^{11}Li neutron halo", *Phys. Lett., B* 250,19 ,1990.

[3] H. Bethe, B. H. Brandow and. A. G. Petschek,"Reference spectrum method for nuclear matter," *Phys. Rev*., vol. 129, no. 1, pp. 225-264, 1963.

[4] G.E. Brown and T.T.S. Kuo, “Structure of finite nuclei and the free nucleon- nucleon interaction : General discussion of the effective force," *Nucl. Phys. A*, vol.. 92, no. 3, Pages. 481-494, 1967.

[5] F. Dellagiacoma, G. Orlandiniand and M. Traini, " Dynamical correlations in finite nuclei: A simple method to study tensor effects," *Nucl. Phys. A*, vol. 393, no. 1, pp. 95- 108, 1983.

[6] J. da Providencia and C. M. Shakin, "Some aspects of short-range correlation in nuclei," *Ann. Phys.*, vol. 30, no. 1, pp. 95-118, 1964.

[7] A. Malecki and P. Picchi,"Elastic electron scattering from^{4}He," *Phys. Rev. Lett*., vol. 21, no. 19, pp. 1395-1398, 1968.
[8] T. T. S. Kuo, S. Y. Lee and K. F. Ratefcliff ,"A folded–digram expansion of the model–space effective Hamiltonian," *Nucl. Phys. A*, vol. 176, no. 1, pp. 65-88, 1971.
[9] T. T. S. Kuo and G. E. Brown, "Structure of finite nuclei and the free nucleon-nucleon interaction: An application to ^{18}O and ^{18}F," *Nucl. Phys*., vol. 85, no. 1, pp. 40-86, 1966.
[10] S. Sugimoto, K. Ikeda and H. Toki, "Study of the effect of the tensor correlation on the alpha alpha interaction in ^{8}Be with charge and parity projected Hartree-Fock method," *Nucl. Phys. A*, vol. 789, no. 1-4, pp. 155-163, 2007.
[11] A. K. Hamoudi, R. A. Radhi, A. R. Ridha." Elastic electron scattering from ^{17}Ne and ^{27}P exotic nuclei". *Iraqi Journal of Physics*, vol.13, no.28, pp. 68-81, 2015.
[12] A. A. Allami and A.A. Alzubadi, *International Journal of Modern Physics E*, vol. 29, no. 12, 2050090, 2020.
[13] A.N. Abdullah, "The neutron halo structure of ^{14}B, ^{22}N, ^{23}O and ^{24}F nuclei studied via the generalised Woods–Saxon potential," *Pramana*, vol. 94, article no. 154, 2020.
[14] A. R. Ridha, and W. Z. Majeed, " Theoretical Study of Elastic Electron Scattering from ^{8}B, ^{17}Ne, ^{11}Be and ^{11}Li Halo Nuclei", *Iraqi Journal of Science*, vol. 63, No. 3, pp: 977-987, 2022.
[15] A.N. Abdullah," The ground state properties of some exotic nuclei studied by the two-body model", *International Journal of Modern Physics E*, vol. 31, no. 08, 2250076, 2022.
[16] A. N. Antonov, I. S. Bonev, Chr V. Christov & I. Zh. Petkov, " Generator coordinate calculations of nucleon momentum and density distributions in^{4}He,^{16}O and^{40}Ca", *ILNuovo cimento A*(1965-1970), vol. 100, no. 5, pp. 779-788, 1988.
[17] S. Gartenhaus and C. Schwartz, "Center of mass in many particle systems," *Phys. Rev.*, vol. 108, no. 2, pp. 482-490, 1957.
[18] R. D. Lawson, "*Theory of the Nuclear Shell Model", Clarendon Press, Oxford, xii*, p. 534, 1980.
[19] L. A. Mahmood and G. N. Flaiyh," Charge density distributions and electron scattering form factors of ^{19}F, ^{22}Ne and ^{26}Mg nuclei," *Iraqi Journal of Science*, vol. 57, no. 3A, pp. 1742-1747, 2016.
[20] A. N. Abdullah,"I nvestigation of Halo Structure of Neutron Rich ^{14}B, ^{15}C, ^{19}C and ^{22}N Nuclei in The Two Body Model", *Int. J. Mod. Phys. E* 29, 2050015, 2020.
[21] S. A. Rahi and G. N. Flaiyh," Study of Matter Density Distributions, Elastic Electron Scattering Form factors and Root Mean Square Radii of ^{9}C, ^{12}N, ^{23}Al, ^{11}Be and ^{15}C Exotic Nuclei," *Iraqi Journal of Science*, vol. 63, no. 3, pp. 1018-1029, 2022.
[22] A. N. Antonov, M. K. Gaidarov, D. N. Kadrev, P. E. Hodgson and E. M. D. Guerr, " Charged Density Distributions and Related Form Factors in Neutron-Rich Light Exotic Nuclei", Int. J. Mod. Phys., E, vol. 13, no. 04, pp. 759-772, 2004.
[23] T. de Forest Jr. and J. D. Walecka, "Electron scattering and nuclear structure," *Adv. Phys.*, vol. 15, no. 57, pp. 1-102, 1966.
[24] J. D. Walecka, "*Electron Scattering for Nuclear and Nucleon Structure," Cambridge University Press, Cambridge*, pp. 14-16, 2001.
[25] B. A. Brown, R. Radhi and B. H. Wildenthal, "Electric quadrupole and hexadecupole nuclear excitations from the perspectives of electron scattering and modern shell model theory," *Phys. Rep.*, vol. 101, no. 5, pp. 313-358, 1983.
[26] M. Wang, G. Audi, F.G. Kondev, W.J. Huang, S. Naimi and Xu Xing, “The AME2016 atomic mass evaluation,” *Chin. Phys. C* , vol. 41, no. 3, p. 030003, 2017.
[27] S. Ahmad, A. A. Usmani and Z. A. Khan, “Matter radii of light proton-rich and neutron-rich nuclear isotopes,” *Phys. Rev. C, vol.* 96, p. 064602, 2017.
[28] A. Ozawa, T. Suzuki, I. Tanihata," Nuclear size and related topics", *Nucl. Phys. A*, vol. 693, no. 1-2, pp.32–62, 2001.
[29] E. B. Dally, M. G. Croissiaux and B. Schweitz, "Scattering of High-Energy Electrons by Nitrogen-14 and -15," *Phys. Rev. C*, vol. 2, no. 6, p. 2057, 1970.
[30] 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*, vol. 36, no. 3, pp. 495-536, 1987.