NUCLEAR GEOMETRY: FROM HYDROGEN TO BORON

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Abstract. Possible ways of nuclear synthesis in the range from hydrogen to boron are studied. The geometric model of these nuclei is suggested. The basis for this model is the analogy between tetrahedral fullerene C₄ and helium ²He⁴. It is assumed that a nucleus of helium ²He⁴ has the form of a tetrahedron, where: 1) All the apices are equivalent and therefore they are protons, 2) Each neutron in a nucleus decomposes into a proton and three negatively charged particles having the charge ⅓ of that of an electron, 3) Interaction of the negative particles creates a special electronic pattern, which symmetry does not coincide with that of protons one, but determines it. On the basis of the postulates, the structure of other nuclei has been designed using geometric modeling. For hydrogen, deuterium, tritium and helium ³, a point, a linear and a plane structure respectively have been obtained. Helium ⁴ has tetrahedral symmetry. Then there was transition from three-fold symmetry prisms (lithium ⁶ and ⁷) to five-fold symmetry (boron ¹⁰ and ¹¹) through four-fold one (beryllium ⁸, ⁹, ¹⁰). The nuclear electron patterns are more complex; their polyhedrons resemble the electron pairs arrangement at the valence shells of molecules.

Keywords: beryllium, boron, deuterium, graph representation, helium, hydrogen, lithium, nuclear electron, nuclear geometry

1. Introduction

According to the Physical Encyclopedic Dictionary [1] "the consistent explanation of the most important properties of atomic nuclei on the basis of general physical principles is one of unsolved fundamental problems of nuclear physics." An atomic nucleus was discovered in 1911 by Ernst Rutherford, who studied scattering α-particles by thin metallic plates and came to conclusion that almost all the atomic mass is accumulated in a small core, charged positively. In the early twenties only two elementary particles were known: an electron (ηλεκτρον – amber) discovered in 1897 by Joseph Thomson and a proton (πρωτος – first, initial); the latter being a core of hydrogen. For this reason, it was a wide-spread opinion that the nuclei of all elements consist of protons and electrons (proton-electron conception). The conception originates from the hypothesis stated in 1815 by William Prout (1785-1850) that the atomic weights of chemical elements are numerical multiples of hydrogen atomic weight, hydrogen being a primary matter [2]. According to Prout's hypothesis, all the elements were produced by condensation of this primary matter.

However, in the late twenties of the twentieth century the electron-proton conception was confronted with difficulties interpreting spin properties of nitrogen ¹⁴N (so called nitrogen catastrophe, see below). After discovering a neutron (neuter – neither) in 1932 by James Chadwick [1,3,4], it was replaced with the proton-neutron conception, according to which a nucleus consists of protons and neutrons. "The absolutely new assumption about the constituents of a nucleus is the assumption, according to which each nuclear electron is
connected with one of nuclear protons forming a neutron", wrote George Gamov in 1932. It is generally taken that the neutrons are stable only as a part of nuclei [1]. A free neutron is unstable and decays according to the scheme $n \rightarrow p + e^- + \bar{\nu}_e$ into proton, electron and antineutrino ($\beta$–decay), the average life time being approximately 15.3 min [3,4].

There are various models of nuclear structure based on this concept, but all the nuclear models play the role of more or less probable working hypotheses. The nuclear models are approximate representations used for description of some properties of the nuclei. They are based on the identification of a nucleus with one of physical systems, which properties are well studied. Although these models often contradict each other, usually they describe different features of a nucleus and therefore supplement each other. Each model is based on experimental facts and allows explain some properties considered.

One of the first models was the liquid drop model [5], where the nucleus is thought over as a spherical drop of incompressible nuclear liquid. Using this model, it is possible to estimate the binding energy of nuclei [1].

The shell model is constructed by analogy with the vector model of an atom [3,6]. The latter considers an orbital moment and a spin moment as vectors $\mathbf{l}$ and $\mathbf{s}$. According to this model, an atom in any quantum state can be represented as a vector composed of the vectors $\mathbf{l}$, $\mathbf{s}$ and $\mathbf{j} = \mathbf{l} + \mathbf{s}$. At that the geometrical composition of vectors agrees with the algebraic composition of the corresponding quantum numbers. This circumstance simplifies the classification of nuclear states, but says nothing about the nucleus structure.

According to the proton-electron hypothesis, a nitrogen nucleus contains 21 particles, 14 protons and 7 electrons, each particle having spin $\frac{1}{2}$, so the nitrogen spin must be half-integer. However it is equal to 1. According to the proton-neutron conception, the nitrogen nucleus is a combination of 7 protons and 7 neutrons, each particle having spin $\frac{1}{2}$. So the combination gives only whole numbers and explains the 'nitrogen catastrophe'.

Similar to atomic properties, the properties of atomic nuclei show the rather smooth periodicity at increasing the number of protons and neutrons. However there are some nuclei which are more stable; they have larger natural occurrence. These nuclei are referred to as magic ones, and the corresponding numbers of their protons and neutrons as magic numbers. They are 2, 8, 20, 28, 50, 82 and 126.

The simplest nuclear models treat nuclei as a system consisting of separate nucleons. However for explaining some properties of light nuclei, later it has been suggested that some compact structures of two and more particles, clusters, can be formed inside the atomic nuclei [1,7]. The geometric structure of clusters is imaginative having no unified basis for designing. It should be emphasized that all the proton-neutron models are unstructured, i.e. they describe only quantum states but not the geometry of nuclei.

In this contribution, geometrical models of atomic nuclei for the nuclei from hydrogen to boron are submitted. The models are designed by analogy with that of fullerene structures developed in Ref. [8]

2. Parallels between tetrahedral fullerene $C_4$ and helium $^4_2$He

According to Ref. [8], tetrahedral fullerene $C_4$ can be inscribed into a sphere, the atoms and shared electron pairs, forming covalent bonds, are located on one and the same sphere. Besides, by analogy with the theory by Sidgwick and Powell [9,10], each shared electron pair can be treated as a point charge; all the charges repelling each other and arranging themselves into such configuration, which ensures their maximal removing from each other. It should be emphasized that the shared electron-pairs-bond must be represented not only as a straight line, but also as a small arc on a geodesic line (Fig. 1a). It is worth noting that a geodesic line on a sphere is just the same as a small arc of a great circle. Being less than a semicircle, it is the least path between the ends of this arc [11].
For tetrahedral fullerene $C_4$ we have four atoms and six point charges; all the charges being located on the great circles, which pass through any two atoms connected by a respective electron pair. It is interesting to note that six point charges form an octahedron inscribed into the same sphere (Figs. 1b and 1c).

![Fig. 1. Tetrahedral fullerene $C_4$; turquoise spheres are atoms and small green spheres are shared electron pairs (point charges). Here: (a) position of the shared electron pairs on geodesic lines; (b) point charge octahedron corresponding to (a); (c) more usual form of an octahedron](image)

Now consider a nucleus of helium $^{2}\text{He}^4$. According to the proton-neutron conception, it has 2 protons and 2 neutrons. Similar to tetrahedral fullerene $C_4$, they can form a tetrahedron. However such tetrahedron is asymmetric from the physical and geometric standpoint. Since it does not look aesthetically beautiful, it cannot be veritable one from an aesthetic point of view. In order to conserve the symmetry of proton-neutron tetrahedron and the similarity to the highly symmetric tetrahedral fullerene $C_4$, one is compelled to accept for a fact that

1) All the apices of tetrahedron are equivalent and therefore they are protons,
2) Each neutron in a nucleus has a complex structure consisting of a proton and three negatively charged particles having the charge $\frac{1}{3}$ of that of an electron.
3) For helium 4, the number of particles is equal to the number of the tetrahedron edges, the particle being named a tertion (tertia − one third).
4) Interaction of tertions leads to appearance of the hidden symmetry of special electronic pattern, which symmetry does not coincide with that of protonic one, but determines it.

On the basis of these postulates, it is possible to design the structure of other nuclei using geometric modeling. The modeling is founded on the principle "the minimum surface at the maximum volume" [12], conceptually being a special case of the more general principle of the least action [1]. The latter reflects the movement of a system and, in the specific cases, it is known under different names: the principle of least curvature (Hertz's principle), the principle of least compulsion (Gauss's principle), etc. Designing the structures through the use of geometric modeling, it is necessary to bear in mind that the structures obtained must satisfy also "the principle of least complexity", i.e. the structures are the simplest among all possible.

3. Deuteron $^1\text{H}^2$ and triton $^1\text{H}^3$

Let us continue the analogy between fullerenes and nuclei. Similar to the fusion reactions of fullerenes [13], consider reaction $n + p \rightarrow d$. We do not know the structure of a free neutron and a nucleus neutron in detail. Using the principle of least complexity, it is reasonable to accept that a free neutron is similar to a hydrogen atom. It is known that electric field leads to splitting atomic terms of a hydrogen atom [1,3,14]; so called Stark effect being discovered by Johannes Stark in 1913. If the principal quantum number $n=2$, there appear three states of an equal energy. The Stark effect justifies our postulate about the decomposition of a nuclear neutron, giving the physical validity to the geometric assumptions mentioned above.
Figure 2 illustrates the geometry of reaction $n + p \rightarrow d$. Here a proton (pink ball) and a neutron (grey ball) are moving towards each other (Fig. 2a). The proton creates an electric field which splits the neutron into a proton and three terti ons (Fig. 2b). Then two protons combine with each other forming an intermediate distorted nucleus (Fig. 2c). It should be emphasized that the nature of nuclear forces is beyond the scope of our consideration. Henceforth we will discuss only electron-proton interactions and electronic ones.

To my mind, nuclear electrons are similar to valence electrons in solids, having a possibility to remove from their parent neutrons in order to create so called 'covalent' bonds. This leads to relaxation of the proton-tertion bonds (blue lines in Fig. 2c). As a result, all the terti ons occupy such positions which are on the equal distance from both protons (Fig. 2d). They are located on a great circle which diameter is defined by an interprotonic spacing.

To gain a better insight into the structure obtained it is useful to turn to its graph representation (Fig. 3). It is interesting to note that the structure of the deuteron formed is similar to that of ionized acetylene $- \text{C} \equiv \text{C} -$, where two carbon atoms are connected by a triple covalent bond [6, 10].

Now consider the triton formation. According to Ref. [1] triton $^1\text{H}_3$ can be got using reaction $d + d \rightarrow t + p$. However, the simplest reaction is $d + n \rightarrow t$. It is shown in Fig. 4. At first a neutron penetrates into a deuteron (Fig. 4a), where it is decomposed by the action of deuteron electric field into a proton and terti ons (Fig. 4b). As a result, there forms an intermediate linear nucleus (Fig. 4c). However, such configuration is unstable with respect to transverse vibrations [16] and folds (Fig. 4d).

To gain a better understanding of the compact structure obtained, we consider separately its proton cell and terton net together with their graph representations (Fig. 5). One can see that the proton cell has the form of an equilateral triangle (Fig. 5a). At that, the
cotertiary bonds create a regular triangular prism (Fig. 5b), which graph is presented in Fig. 5c.

Fig. 4. Triton formation: a) neutron (grey ball) penetrates into a deuteron; b) decomposition of the neutron in the electrical field of the deuteron; c) intermediate nucleus; d) folding of the intermediate nucleus. Color graphics is identical to that of Fig. 2

4. Helium nuclei: $^2\text{He}^3$ and $^2\text{He}^4$

According to Ref. [1] helium $^2\text{He}^3$ can be obtained by means of reactions $p + d \rightarrow ^3\text{He} + \gamma$ and $d + d \rightarrow ^3\text{He} + n$. Consider the first, simpler reaction. Contrary to forming triton $^3\text{H}$, here a proton does not penetrate into a deuteron (Fig. 6a), but at once a compound nucleus is created (Fig. 6b). The following redistribution of tertions leads to a plane symmetric triangle configuration both of tertions and of protons (Figs. 6c). It should be emphasized that transforming the tertion configuration comes to an agreement with the principle of the least action; it is simply rotation and expansion of the initial tertion triangle.

The proton cell and the tertion net are shown separately in Fig. 7. Since the structures are plane, their graphs coincide with them.

Fig. 6. Formation of helium $^2\text{He}^3$: a) separate deuteron and proton; b) intermediate distorted nucleus; c) helium after relaxation. Color graphics is identical to those of the previous figures.
There are many reactions for getting helium $^4\text{He}$, viz. [1]:

$$d + d \rightarrow ^4\text{He} + \gamma, \quad d + t \rightarrow ^4\text{He} + n, \quad t + t \rightarrow ^4\text{He} + 2n, \quad ^3\text{He} + ^3\text{He} \rightarrow ^4\text{He} + 2p.$$

We consider a simpler reaction, i.e. $^3\text{He} + n \rightarrow ^4\text{He}$. It is presented in Fig. 8. Similar to the reaction $d + n \rightarrow t$, here a neutron (grey ball) penetrates into helium (Fig. 8a) and is decayed by the action of the helium electric field (Fig. 8b). As a result, there forms an intermediate compound nucleus. However, such configuration is also unstable with respect to transverse vibrations [16] and transforms into a compact structure in the form of a tetrahedron (Fig. 8c). The proton cell and the tertion net are shown separately in Fig. 9.

It should be emphasized that the cotertiary bonds arrange themselves into such configuration, which ensures their maximal removing from each other, creating a regular octahedron (Fig. 9c). The graphs of the tetrahedron and the octahedron are presented in Figs. 9b and 9d, respectfully.

5. Isotopes of lithium: $^6\text{Li}$ and $^7\text{Li}$

As discussed earlier, a free neutron is unstable and decays according to the scheme $n \rightarrow p + e^- + \bar{\nu}_e$ into proton, electron and antineutrino ($\beta$-decay). Triton is also unstable and
decays according to the similar scheme $^3H \rightarrow ^2He + e^- + \bar{\nu}_e$ into helium $^2He^3$, electron and antineutrino ($\beta$-decay) [1]. However, the average life time of a free neutron is approx. 15.3 min, whereas the half-decay period of triton being equal to 12.3 years. It means that "the absolutely new assumption about the constituents of a nucleus is the assumption, according to which each nuclear electron is connected with one of nuclear protons forming a neutron", (George Gamov, 1932) must be reformulated.

As already noted, the nuclear electrons are similar to valence electrons in solids, having a possibility to remove from their parent neutrons and to create 'covalent' bonds. Both subsystems, the nuclear protons and the nuclear electrons, produce their own patterns of different symmetry. It is hard to remove such bound electron from the tertion net; it requires more time. Nevertheless, triton is unstable. According to the geometric modeling, one can assume that the triton instability is connected with the fact that the tertion net is rather loose (Fig. 5b). Combining triton with helium through the use of reaction $^1H^3 + ^2He^3 \rightarrow ^3Li^6$, we obtain lithium $^3Li^6$ (Fig. 10). The proton cell and the tertion net, as well as their graphs, are shown separately in Fig. 11.

![Fig. 10. Formation of lithium $^3Li^6$: a) triton $^1H^3$; b) fusion of triton and helium $^2He^3$; c) $^3Li^6$](image1)

![Fig. 11. Structure of helium $^3Li^6$: a) proton cell; b) tertion net; c) graph of proton cell; d) graph of tertion net](image2)

According to Ref. [1] lithium $^3Li^7$ can be obtained using reaction $d + ^3Li^6 \rightarrow ^3Li^7 + p$. However, if we wish to gain a more penetrating insight into the nuclear geometry, it is better to consider the simplest reaction $n + ^3Li^6 \rightarrow ^3Li^7$. Here a neutron penetrates into lithium $^3Li^6$, where it is decayed by the action of surrounding electric field (Figs. 12a and 12b). As a result, there forms a denser tertion net (Fig. 13c), and the proton structure, having before a shape of a regular triangle prism (Fig. 11a), becomes a body-centered one (Fig. 13a).
When this result is compared with that of Fig. 10, two differences stand out: 7.5 and 92.5%. To our mind, this fact is connected with the following. Although both isotopes of lithium are stable, lithium $^{3}$Li$^{6}$ has a looser coat of mail (tertion net, Fig. 11), and therefore it is more defenseless against any attack of other nuclear particles.

![Diagram of lithium $^{3}$Li$^{7}$ formation and decay](image)

**Fig. 12.** Formation of lithium $^{3}$Li$^{7}$: a) neutron inside lithium $^{3}$Li$^{6}$; b) decay of the neutron by the electrical field of $^{3}$Li$^{6}$

![Diagram of helium $^{3}$Li$^{7}$ structure](image)

**Fig. 13.** Structure of helium $^{3}$Li$^{7}$: a) proton cell; b) graph of proton cell; c) tertion net; d) graph of tertion net

It should be emphasized the following. As mentioned above, the neutron is decomposed into a proton and three negatively charged particles, having charge $\frac{1}{3}$, they are marked in brown-green. Although these particles are incorporated into the tertion net, they conserve an association with their parent proton. As noted above, it is reasonable to accept that a neutron is similar to a hydrogen atom. It is known that spectral-line splitting in an electric field (Stark effect) depends on the principal quantum number $n$. For hydrogen, if $n=1$, there is no splitting at all; if $n=2$, there appear three states of an equal energy [3]. By analogy with the hydrogen atom, it is valid to say that formally the tertions give rise to $2s$, $2p_{x}$, $2p_{y}$ orbitals, producing a 'valent state' of the neutron. This state corresponds to the excited sp$^{2}$ state, where each of three valent tertions is not in s- or p-state, but in a hybridized state, which can be obtained by mixing a single 2s- state with two 2p-states. The latter is described by a wave function being a
linear combination of s- and p-functions. At that, three \( sp^2 \) orbitals are located on a plane normal to the three-fold axis of symmetry of lithium.

6. Isotopes of beryllium: \( _4Be^8, _4Be^9 \) and \( _4Be^{10} \)

Reactions \((d, n)\) are widely used for obtaining neutrons \([4]\), e.g. reaction \( Li^7 (d, n) Be^8 \). In this case the compound nucleus decays into a neutron and beryllium, the latter, being unstable, rather fast decomposes into two \( \alpha \)-particles. We are not interested in neutrons; our aim is designing nuclei structures, so consider a simpler reaction \( d + _3Li^6 \rightarrow _4Be^8 \), which is illustrated in Fig.14. From the figure it follows that for lithium only four protons (from six) and two tertions (from nine) take part really in the reaction. They are specially marked in the figure; the protons are pinked, the tertions are brown-green, the new proton-protons bonds are lilac, the old bonds, which were destroyed, are shown using red dot lines. The proton cell and the terton net of beryllium 8, as well as their graphs, are shown separately in Fig. 15. However, beryllium 8 is unstable \([4]\).

![Fig. 14. Formation of beryllium \( _4Be^8 \): a) fusion of deuteron and lithium \( _3Li^6 \); b) \( _4Be^8 \) unstable \([4]\)](image)

Fig. 15. Structure of beryllium \( _4Be^8 \): a) proton cell; b) graph of proton cell; c) Terton net; d) graph of terton net

Similar to the algorithm developed for lithium, which allows obtain a more abundant isotope, consider reaction \( n + _4Be^8 \rightarrow _4Be^9 \). Here a neutron penetrates into beryllium \( _4Be^8 \), where it decays (Figs. 16a and 16b). As a result, there forms a denser terton net (Fig. 17c), and the proton cell, having before a shape of a cube, becomes a body-centered cube (Fig. 17a). Since the abundance of \( _4Be^9 \) is 100\%, such structure has super stability. To my mind, the stability is ensured by two factors. The first is the packing density of the proton cell; the second is the density of coat of mail (tertion net). Both factors take place in that case.
One further comment should be made. Hitherto it was assumed that the particle charge is $\frac{1}{3}$. From the results obtained, it follows that the neutron decays into a proton and six negatively charged particles, having charge $\frac{1}{6}$. In order to conserve the tertion concept, one may assume that in the latter case there form six semi-tertions. The difference may be attributed again to the Stark effect, where spectral-line splitting depends on the principal quantum number $n$. If $n=2$, there are three states of an equal energy, for $n=3$, the number of states becomes six [3].

It is interesting to note that six semi-tertions are oriented in the same manner as three 2p-orbitals of a hydrogen atom. Their maximum probability density is located rather far from the atom center. One would assume that in this case the semi-tertions correspond to similar maxima. It means that although the tertions of the central proton are incorporated into the coat of mail, they conserve association with the parent proton.

In the case of lithium there is the intercell electric field of three-fold symmetry and so neutron splitting into three tertions takes place, whereas for beryllium the analogous process leads to neutron splitting into six semi-tertions. They correspond to 2p electronic configurations. In Figs. 16b and 17c they are marked in brown-green. It means that the geometric approach is able to distinguish electric fields of different symmetry.

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**Fig. 16.** Formation of beryllium $^{4}\text{Be}^{9}$: a) neutron inside beryllium $^{4}\text{Be}^{8}$; b) decomposition of the neutron inside beryllium $^{4}\text{Be}^{8}$

**Fig. 17.** Structure of beryllium $^{4}\text{Be}^{9}$: a) proton cell; b) graph of proton cell; c) tertion net; d) graph of tertion net
However, it should be emphasized that there appears an unforeseen contingency. It is known that in addition to the beryllium isotopes considered, there exists isotope $^4\text{Be}^{10}$ having the very large half-decay period being equal to $1.6 \times 10^6$ years. It can be incorporated into our scheme by the following way. Suppose that a neutron has penetrated into the nucleus of $^4\text{Be}^9$ (Fig. 18), where it decays into a proton and tertions. What will happen with the structure?

![Fig. 18. Neutron inside beryllium $^4\text{Be}^9$](image)

It is unnecessary to invent a bicycle, better to look around. The situation with beryllium resembles in some respects the evolution of an interstitial atom embedded into an octahedral hole of the bcc cell of alpha-iron, the process being modeled with the help of molecular dynamics by J.M. Beeler, Jr. in 1966 [17]. The interstitial displaces an atom from the center of bcc cell in the direction [110] forming together with it so called dumbbell configuration (Fig. A). The cell becomes distorted, but the topological symmetry [18] is conserved. It is felt that the similar distortion of beryllium-10 cell does not change its topological symmetry.

![Fig. A. Plane complex of the most displaced ten atoms forming a bow-tie lying in a (110) plane with wings along <111> directions. Atoms 1 are displaced by 17%, atoms 2 by 7%](image)

How to transform the bcc proton cell into the cube which has inside the bow-tie configuration? The reasoning is as follows. Suppose one inserted into beryllium 8 (simple cube) two neutrons, which decompose into two protons and six tertions. At that the embedded protons transformed the cube into the cube with the bow-tie configuration. How to make this structure stable? Let's again look around.
The shape of an ethylene molecule is similar to the bow-tie configuration. Consider the molecule structure [19,20]. Molecule C\textsubscript{2}H\textsubscript{2} has twelve valent electrons: eight from two carbon atoms \((2s^22p^2)\) and one by one from four hydrogen atoms \((1s)\). Ten electrons create five \(\sigma\)-bonds from \(sp^2\)-orbitals of carbon and \(s\)-orbitals of hydrogen in the manner shown in Fig. B. The remaining two electrons are used for producing \(\pi\)-bonds from \(p\) orbitals of carbon.

**Fig. B.** Scheme of bonds in molecule C\textsubscript{2}H\textsubscript{2}: \(sp^2\)-hybridization

However there is also another way of the description of an ethylene molecule. Here all the bonds are formed from the identical \(sp^3\)-orbitals of carbon as shown in Fig. C.

**Fig. C.** Scheme of bonds in molecule C\textsubscript{2}H\textsubscript{2}: \(sp^3\)-hybridization

Now there are all the necessary input data for designing the core structure of beryllium 10. There are two protons and six tertions. The protons will be identified with the carbon atoms and the six tertions with the six electron pairs. As a result, there arise two "electronic" isomers of beryllium 10, which are presented in Fig. 19. Here the old tertions of the external net are marked in turquoise, the new tertions in green, and the old semi-tertions in brown-green.
Fig. 19. Shape of beryllium $^4\text{Be}^{10}$: two 'electronic' isomers

The proton cell and the tertion net, as well as their graphs, are shown separately in Fig. 20. It should be emphasized that the tertion nets of the electronic isomers vary only in the particles lying on the fourfold-symmetry axis (vertical axis in the figure). For isomer shown in Fig. 19a, it is a semi-tertion, for isomer of Fig. 19b a tertion.

Fig. 20. Structure of beryllium $^4\text{Be}^{10}$: a) proton cell; b) graph of proton cell; c) external tertion net; d) graph of the external tertion net

7. Isotopes of boron: $^5\text{B}^{10}$ and $^5\text{B}^{11}$

As already noted, reactions (d, n) are widely used for obtaining neutrons [4], in particular reaction $\text{Be}^9$ (d, n) $\text{B}^{10}$. Since our aim is designing nuclei structures, consider a simpler reaction $\text{d} + ^4\text{Be}^8 \rightarrow ^5\text{B}^{10}$, which is presented in Fig. 21. From Fig. 21a it follows that for beryllium 8 only four protons (from eight) and two tertions (from twelve) take part in the reaction. They are specially marked in the figure; the protons are pinked, the tertions are brown-green, the new proton-protons bonds are lilac, the old bonds, which were destroyed, are shown using red dot lines. The proton cell and the tertion net of beryllium 10, as well as their graphs, are shown separately in Fig. 22.
Similar to the previous reasoning, consider reaction $n + ^5\text{B}^{10} \rightarrow ^5\text{Be}^{11}$ that allows obtain a more abundant isotope (Fig. 23). As before, a neutron penetrates into boron $^5\text{B}^{10}$, where it is decomposed (Figs. 23a and 23b). As a result, there forms a denser terton net (Fig. 24), and the proton cell, having before a shape of a pentagonal prism, becomes a body-centered prism (Fig. 23c). Since the abundance of $^5\text{B}^{11}$ is 80.1%, such structure is more stable. The stability is ensured by two factors. The first is the packing density of the proton cell; the second is the density of coat of mail (tertion net). Analogously to beryllium $^4\text{Be}^8$, both factors take place in the case of $^5\text{B}^{11}$.
Fig. 24. Structure of boron $^5\text{B}^{11}$: a) proton cell; b) graph of proton cell; c) tertation net; d) graph of tertation net

One further comment should be made again. From the results obtained, it follows that the neutron decomposes, besides a proton, into two negatively charged particles, having charge $\frac{1}{2}$. However our concept is based on the assumption that the particle charge is $\frac{1}{3}$. The difference is caused again by the Stark effect (spectral-line splitting in an electric field) and depends on the principal quantum number $n$. For hydrogen, if $n=1$, there is no splitting at all, if $n=2$, there appear three states of an equal energy, but if $n=3$, the number of states increases to six. However, if $n=4$ instead of 10 components, there appear only 7. It means that some components coincide [3].

Just the same effect takes place in the case of splitting a nuclear electron. It was assumed that in the case of boron 11, the intercell electric field being of five-fold symmetry, each of two split components has a complex nature, consisting of one tertation and one semi-tertation. It means that using the geometric approach it is possible to associate splitting with symmetry of a nuclear cell.

8. Summary and discussion
Possible geometry of nuclear synthesis has been studied in the range from hydrogen to boron. The corresponding scheme is presented in Fig. 25.

Fig. 25. Scheme reflecting simple possible ways of nuclear synthesis
On the basis of the results obtained, the geometric model of the nuclei studied is suggested. The model can be easily understood considering jointly tetrahedral fullerene $C_4$ and helium $^2\text{He}_4$. As it was discussed previously, tetrahedral fullerene $C_4$ can be inscribed into a sphere, the atoms and shared electron pairs, forming covalent bonds, are located on one and the same sphere. By analogy with the theory by Sidgwick and Powell, each shared-electron pair can be considered as a point charge, all the charges repelling each other and arranging themselves into such configuration, which ensures their maximal removing from each other. For tetrahedral fullerene $C_4$ we have four atoms and six point charges, all the charges being located on the great circles, which pass through any two atoms connected by a respective electron pair. The six point charges form an octahedron inscribed into the same sphere.

Now think over a nucleus of helium $^2\text{He}_4$. It has two protons and two neutrons. Similar to tetrahedral fullerene $C_4$, they can form a tetrahedron; however such tetrahedron is asymmetric from the physical and geometric standpoint. Since it does not look aesthetically beautiful, it cannot be veritable one. In order to conserve the symmetry of proton-neutron tetrahedron, we are compelled to accept for a fact that

1) All the apices of tetrahedron are equivalent and therefore they are protons,
2) Each neutron in a nucleus has a complex structure consisting of a proton and three negatively charged particles having the charge $\frac{1}{3}$ of that of an electron,
3) Interaction of these particles leads to appearance of the hidden symmetry of special electronic pattern, which symmetry does not coincide with that of proton one, but determines it.
4) Nuclear electrons are similar to valence electrons in solids, having a possibility to remove from their parent neutrons and to create 'covalent' bonds.

On the basis of these postulates, it is possible to design the nuclear geometry for other nuclei (Figs. 26 and 27). Designing the structures through the use of geometric modeling, it is necessary to bear in mind that the structures obtained must satisfy "the principle of least complexity", i.e. they are the simplest among all possible. For hydrogen, deuterium, tritium and helium 3, we have a point, a linear and a plane structure respectively. Helium 4 has a tetrahedral symmetry. Then we have transition from three-fold symmetry prisms (lithium 6 and 7) to five-fold symmetry (boron 10 and 11) through four-fold one (beryllium 8, 9, 10). The nuclear electron patterns are more complex; their polyhedrons resemble the electron pairs arrangement at the valence shells of molecules [10].

**Fig. 26.** Proton cells and tertion nets of hydrogen and helium and their isotopes
Fig. 27. Proton cell and terton net of isotopes of lithium, beryllium and boron

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