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QUANTIZATION OF NUCLEAR MASS DEFECT AND MASS DIFFERENCES IN ATOMS OF THE SAME ISOTOPE

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Abstract. *According to the fact of nuclear mass defect, and combined with the quantization features generally existing in microcosm, a quantization hypothesis of nuclear mass defect is proposed, which assumes that different atoms of the same isotope of an element could have different masses. The rationality of this hypothesis is verified by the change in nuclear state, the accuracy of the measurement of isotopic atomic mass, and the Einstein's Equation of Mass and Energy, and several experimental ideas are given. The high-precision atomic weight data is used to search for the quantum of the mass defect and obtain an alternative mass quantum. Also, this paper proposed a small neutron hypothesis about the mass defect, which assumes that the nuclear mass defect is the mass reduction of an object with actual mass; the nuclear mass defect is the result of small neutrons loss.*

Keywords: Mass defect, Quantization, Isotope, Atomic weight, Mass spectrometer

1. **Introduction.** Mass defect is a very important fact in nuclear physics. The sum of the masses of all the nucleons that make up the nucleus must be greater than that of the masses of the entire nucleus when the number of nucleons is greater than 1. The relationship between mass defect and binding energy of a nucleus can be quantitatively quantified by Einstein's Equation of Mass and Energy $\Delta E = \Delta m \cdot C^2$. Modern physics theory has proved the existing of quantization phenomena in microcosm. For example, the energy of electrons outside the nucleus can only take a series of discrete values, the angular momentum and magnetic moment of a nucleus is quantized, as well as the nucleus level. The mass defect phenomenon is categorized in the microcosm, so from a logical aspect, the nuclear mass defect is quantized. The quantization features of nuclear mass defect mean that the nuclear mass defect can only take a series of discrete values; while, there should be a minimum mass defect quantum, which makes all the nuclear mass defects an integer multiple of it.

The current physical theory confesses that isotopic atoms of an element hold the same mass defect [1,2], meaning that different atoms of the same isotope must have the same atomic mass. Implicit in the correctness of the above assertion is the high precision measurement of the atomic weight values of each isotope published by physicists [3]. Also, it can be said that physicists do not realize that the masses in different atoms of the same isotope will take different values. The concept that different atoms of an isotope have the same atomic weight is a common knowledge in physical theory, and there is no need to be more specific, nor has anyone ever doubted it. However, the thesis author doubted it because such judgment is not subjected to rigorous experimental tests. According to

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Einstein's Equation of Mass and Energy $\Delta E = \Delta m \cdot C^2$, there is a slight atomic mass difference in different atoms of the same isotope when they are at different energy levels. If a nucleus changes the energy level by absorbing or emitting a γ photon without changing its isotopic properties (the number of protons and neutrons in the nucleus remains the same), then the nucleus mass will change. If such mass change does exist, it should be attributed to the mass defect. That is, different atoms of the same isotope of an element can have different mass defects. In this case, the mass difference between different atoms may be very small compared to the entire mass defect value of the isotopic nucleus.

If we make the further hypothesis that the nuclear mass defect is the mass reduction of an object with actual mass in the nucleus and it is not just the reflection of energy change, then we are faced with the following questions: What is the material bearer of nuclear mass defect? Can it be detected? How does it relate to the known properties of the nucleus? This paper will provide an in-depth analysis of the relevant issues.

In Section 2, the quantization hypothesis of nuclear mass defect is presented based on the quantified phenomenon prevalent in the microcosm. In Section 3, the mass defect of atoms is studied from the nuclear energy changes and the existence of nuclear isomer. In Section 4, the mass defect of atoms is investigated from the measurement precision inconsistencies of the isotopic atomic weight, as well as the working principles of mass spectrometers. In Section 5, we propose a small neutron hypothesis on the nuclear mass defect. In Section 6, an alternative mass defect quantum is obtained using a computer algorithm and using atomic quantum data with partial isotopic precision. The last section is the conclusion.

2. **Quantization Phenomena in Microcosm and Quantization Hypothesis of Nuclear Mass Defect.** The microcosm has two basic and peculiar properties: volatility and quantization phenomena. In quantum mechanics, the law of volatility of an object and the quantization law have reached a perfect combination. Quantization phenomena are involved in many aspects of the microcosm, such as the energy, angular momentum, magnetic moment, spin, energy level transition, electromagnetic irradiation, and energy exchange. Physicists have made in-depth researches on physical properties of the nucleus, including the decay of nucleus, the precise measurement of atomic weight, the energy conversion in various nuclear reactions, energy measurement of γ-ray, the geometrical shape detection of the nucleus and the various bombardment experiments of high-speed particles on the nucleus. Both the theoretical and experimental achievements of nuclear physics are remarkable.

Mass defect is a very important property of nucleus. However, there is no systematic theory to explain mass defects from a quantitative perspective. Quantitative phenomena generally exist in microcosm, which has been confirmed by many physical experiments. Thus, the hypothesis that "the nuclear mass defects should be quantized" should be easy to accept. Since there are only about 110 elements in nature and a limited number of isotopes of each element, each isotope of each element has a corresponding, definite mass-defect value and therefore the mass-defect values of all isotopes of the elements are discrete and therefore quantifiable. In this paper, it is assumed that the nuclear mass defect of different elements can only take discrete values, and there is a minimum mass defect quantum, the mass defect of each isotope is an integer multiple of the minimum mass defect quantum.

This paper proposes a new hypothesis based on careful investigation and in-depth reflection on issues related to nuclear mass defects, consisting of three parts:

1) The nuclear mass defect is quantized, and there is a minimum mass defect quantum, the mass defect of any nucleus (in any relatively stable energy) is an integer multiple of the minimum mass defect quantum;

2) Different atoms of the same isotope can have different atomic weight, and if the different atoms of the same isotope differ in mass defect values, then the difference among them must be several times of the minimum mass defect quantum;

3) The nuclear mass defect is the defect of an object with an actual mass, and a mass defect is a neutral particle with a small mass and no charge, called a small neutron.

This paper will demonstrate the rationality of the hypothesis from several perspectives. The quantization hypothesis on nuclear mass defect could be proved from the following three aspects: 1) determine the high-precision mass defect data according to the already-measured high-precision atomic weight data of each isotope, searching for the minimum mass defect quantum by suitable computer programs; 2) carefully examine various nuclear reactions, calculating the change of atomic weight and the radiation or absorption energy of the γ photon before and after nuclear reactions with the help of Einstein's Equation of Mass and Energy, so it can be accurately predicted of the energy and mass changes of the nuclear reactions; 3) improve the precision of mass spectrometer and analyze the nuclear mass defects of different isotopes according to the high-precision observations.

For the first aspect, which seems to be a feasible and simple problem, there are two prerequisites: first, the atomic weight of different atoms of the same isotope must take the same values; and second, the measured error of atomic weight value must be far smaller than the minimum mass defect quantum. If the mass of different atoms of the same isotope can differ by one or several minimum mass defect quantum, then no matter how accurate the measuring instrument is, the actual measured atomic weight is only an average value, and the measurement error must be greater than the mass of the minimum mass defect quantum. However, it is impossible to try to determine the minimum mass defect quantum. For many isotopes, there appears to be a slight mass difference in the different atoms of the same isotope.

For the second aspect, regardless of nuclear reactions along with α decay and β decay, this paper only considers nuclear reactions involving the absorption or radiation of γ photons. The radiation energy of γ photons during nuclear reactions is not the entire energy of the nuclear reaction. Because of the recoil effect of nuclear radiation, the total energy of nuclear reactions should be estimated based on the quality of the nucleus and its recoil. Convert the nuclear reaction energy into mass defect value to see whether it can only take discrete values or not and whether a minimum γ-ray radiation or absorption energy exists in nuclear reactions should be considered. Generally speaking, it is not easy to accurately estimate the nuclear recoil velocity. Examine all the γ-ray radiation or absorption of nuclear reactions, if the existence of γ-rays of lowest energy can be confirmed, and then it can provide strong evidence for the hypothesis of minimum mass defect quantum. In fact, it is observed that the energy of γ-rays of the lowest energy during nuclear reactions is rough 0.05 MeV. It is shown that photons lower than 0.05 MeV cannot be absorbed by the nucleus; thus the nuclear reactions cannot be activated. The third aspect relates to the improvement of the instrument, which will not be discussed here without theoretical discussion at this stage.

3. **Investigation of Atomic Weight from Nuclear Energy Level Changes.** Physicists already know that nuclear isomers exist and that certain nuclei of the same isotope may be at different energy levels. According to Einstein's Equation of Mass and Energy $\Delta E = \Delta m/C^2$, the increase of energy means the reduction of mass, while the reduction of energy means the opposite. Assume that all the nuclei are in a quiescent state and

embed the atoms of the nuclear isomer in a certain low-temperature solid object. Since the energy level transition of nuclear isomer only involves the radiation or absorption of γ photons and the nuclear isotope properties do not change, the nuclear energy changes should be accompanied by atomic mass changes. In this process, the nuclei that released γ photons should be accompanied by mass increase, while those nuclei that absorbed γ photons should be accompanied by mass reduction. No matter how slight the nuclear mass changes caused by radiation or absorption of γ photons are, once it can be confirmed, then the idea that different nuclei of the same isotope have different masses could be explained. The slight changes in nuclear mass belong to mass defect. However, this is not recognized by the physical community, let alone a physical experiment specifically designed to observe the slight changes of nuclear mass caused by the radiation or absorption of γ photons.

Another approach to investigate the nuclear energy level is to observe the energy exchange in the internal transformation process. During the internal nuclear transformation, the nucleus directly gives energy to the nuclear electrons and the isotopic properties of the nucleus do not change. Through the energy measurement of the released electrons outside the nucleus in the internal transformation process, the corresponding nuclear energy level difference is obtained, which is about 0.05 MeV, about 1/10 of an electron mass. If 0.05 MeV is the smallest energy level difference, then it indicates that the atomic mass difference in different atoms of the same isotope is about 1/10 of an electron mass or several times of that. This means the minimum mass defect quantum may be equal to 1/10 of an electron mass.

4. **The Inconsistency of the Atomic Weight Measurement Precision of Isotopes and Its Physical Meaning.** The rationality of the proposed hypothesis will be investigated from the measurement precision of atomic weight. The measured values of the atomic weight of the stable isotopes with smaller atomic numbers are listed in Table 1. The unit of the atomic weight value in the table is u. And the number in parentheses is the standard deviation. It can be seen from Table 1 that the measurement precision of the atomic weight of isotopes in roughly the same mass range is quite different, which indicates that the precision of atomic weight measurement is not directly related to atomic weight.

Table 1. Measured values of the atomic weight of stable isotopes with smaller atomic numbers

Isotope	Atomic weight (u)	Isotope	Atomic weight (u)	Isotope	Atomic weight (u)
${}^{2}_{1}H$	2.0141017780 (4)	${}^{13}_{6}C$	13.0033548378 (10)	${}^{22}_{10}N_e$	21.99138551 (23)
${}^{3}_{1}H$	3.0160492675 (11)	${}^{14}_{6}C$	14.003241988 (4)	${}^{23}_{11}N_a$	22.98976967 (23)
${}^{3}_{2}H_e$	3.0160293097 (9)	${}^{14}_{7}N$	14.0030740052 (9)	${}^{24}_{12}M_g$	23.98504190 (20)
${}^{4}_{2}H_e$	4.0026032497 (10)	${}^{15}_{7}N$	15.0001088984 (9)	${}^{25}_{12}M_g$	23.98504190 (20)
${}^{6}_{3}L_i$	6.0151223 (5)	${}^{16}_{8}O$	15.9949146221 (15)	${}^{26}_{12}M_g$	25.98259304 (21)
${}^{7}_{3}L_i$	7.0160040 (5)	${}^{17}_{8}O$	16.99913150 (22)	${}^{27}_{13}Al$	26.98153844 (14)
${}^{9}_{4}B_e$	9.0121821 (4)	${}^{18}_{8}O$	17.9991604 (9)	${}^{28}_{14}S_i$	27.9769265327 (20)
${}^{10}_{5}B$	10.0129370 (4)	${}^{19}_{9}F$	18.99840320 (7)	${}^{29}_{14}S_i$	28.97649472 (3)
${}^{11}_{5}B$	11.0093055 (5)	${}^{20}_{10}N_e$	19.9924401759 (20)	${}^{30}_{14}S_i$	29.97377022 (5)
${}^{12}_{6}C$	12.0000000000 (0)	${}^{21}_{10}N_e$	20.99384674 (4)	${}^{31}_{15}P$	30.97376151 (20)

We have to analyze the atomic weight data for different isotopes. These data have different precisions, a few of them reaching 10^{-8} u or even higher, such as ${}^2_1H$, ${}^3_1H$, ${}^3_2H_e$, ${}^4_2H_e$, ${}^{13}_6C$, ${}^{16}_8O$, ${}^{20}_{10}N_e$, ${}^{28}_{14}S_i$, while the atomic weight measurement precision of most isotopes can only reach 10^{-6} u $\sim 10^{-5}$ u. It is worthy of thinking why atomic weight values of different precision are obtained with the same mass spectrometers and technology. The precision of mass spectrometer depends on the position accuracy that the particle beam can reach after passing through the electric field provided in the instrument. Mass spectrometer can measure the mass of microscopic particles with astonishing accuracy [4,5]. The particle beam is very thin, if the particle beam is well maintained after passing through the electric field provided in the instrument, then the high-precision measurements could be made. And if the particle beam cannot maintain its shape well and there appears coarsening phenomenon during the process of passing through the electric field, then high-precision measurements cannot be made [6,7].

Every atom entering into a mass spectrometer comes with the same charge. If the mass of each atom in the particle beam is exactly the same, and the position and initial velocity of the particles entering the instrument is technically guaranteed to be exactly the same, then it cannot be explained why some isotopes can be measured with high precision and others cannot. If there is no problem with the instrument, then the problem must be that the atoms entering into the mass spectrometer have different masses. Since different atoms come with the same charge, the electric force is necessarily the same. Thus, the mass difference of different atoms must result in the coarsening of particle beam. Considering the influence of slight difference of initial position and initial velocity and initial motion direction of the atoms entering the mass spectrometer, the following conclusions can be made: the measurement precision of the atomic weight depends both on experimental technique and on the atomic mass consistency. If the particle beam is sufficiently fine, and the more refined the experimental technique, the smaller the difference between the initial velocity and the initial direction of motion, the higher the measurement accuracy. The higher the consistency of the atomic mass is, the greater the consistency of the particle orbit is, and therefore the greater the measurement accuracy is. Under conditions where the experimental technique is sufficiently sophisticated, the measurement accuracy is not as expected, probably because of a slight difference in the atomic mass of the same isotope.

Furthermore, if the atomic mass difference for different atoms of the same isotope is quantified, the particle beam image should be discrete under conditions where the mass spectrometer has sufficient measurement precision. When measuring the atomic weight of an isotope with a mass spectrometer, it is conceivable that the fine structure of the particle beam image is likely to contain both the information of the atomic mass difference (the image is scattered in a space of a certain scale rather than concentrating on a point) and the information of the atomic mass quantization (the image presents a regularly approximately equidistant discrete distribution). As long as the fine structure of the particle beam is a regularly equidistant discrete state distribution rather than a continuous state distribution, it is certain that such an observation can provide strong evidence for the idea that “different atoms of the same isotope have different mass and with quantization features”. The smallest spacing in the fine structure of the image should correspond to the minimum mass defect quantum.

Figure 1 is a schematic diagram, which shows the particle trajectories of different isotopes of the same element in a mass spectrometer, where A, B, C, and D respectively represent the different isotopes of an element, the masses of these different isotopes differ by one or several neutrons. The isotope which A corresponds to is the smallest atomic weight and D corresponds to the largest atomic weight. If the isotopes B and C differ by one neutron mass, the particle trajectory shown in Figure 1 shows that the isotopes A

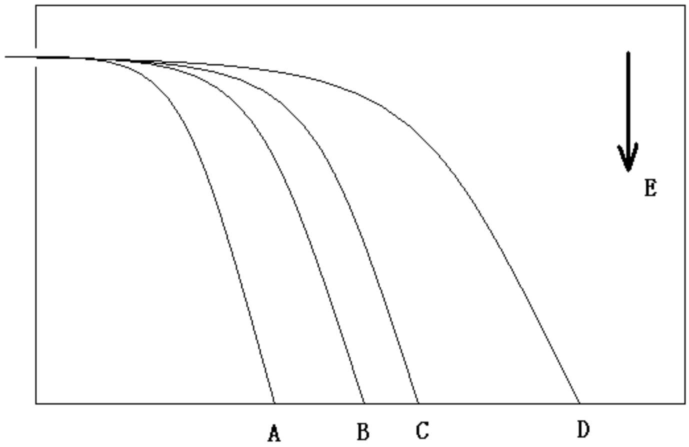

FIGURE 1. The particle trajectories of different isotopes of the same element in mass spectrometer

and B differ by two neutron masses, while the isotopes C and D differ by four neutron masses.

Figure 2 shows the fine structure of particle trajectories of the same isotope of the same element in a mass spectrometer. We only look at the trajectory of particle beam C in Figure 2, where C corresponds to C in Figure 1, which seems like to observe C in Figure 1 with high magnifying glasses. The four curves at C correspond to the trajectories of four atoms of a different mass of the same isotope, which indicates that the atomic weight presents in a regular discrete state. The mass spectrometer is required to distinguish atoms whose mass difference is about 1/10 electrons mass (5×10^{-5} u).

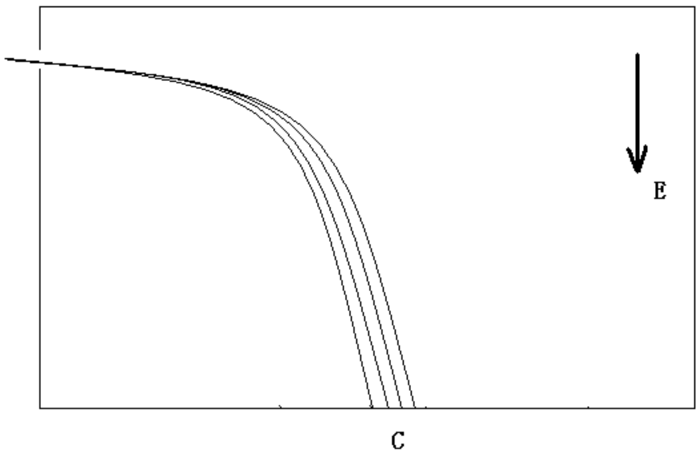

FIGURE 2. The particle trajectories of the same isotope of the same element in mass spectrometer

By the above analysis, such conclusions could be made: atomic weight with high accuracy (the error less than 10^{-8} u) has a nearly single atomic weight for different atoms of isotopes, while those with lower-precision atomic weight (the error less than 10^{-6} u) mean that the atoms are compound with different atomic mass for different atoms of isotopes. Physicists have made the measurement accuracy of the atomic weight of each isotope at a surprising level by continuously improving the performance of the mass spectrometer. It is believed that such high-precision measurement data of isotopic atomic weight has far exceeded the required accuracy, even if calculating the mass defect of the nucleus does not require such a high degree of accuracy. However, it is not difficult to find the measurement precision difference in the atomic weights of different isotopes. These differences might not be caused by experimental error, but rather indicate that different atoms of the same isotope have slightly different masses for certain elements. In this sense, it is necessary to ensure the measurement accuracy of the isotopic atomic mass as high as possible.

5. **Small Neutron Hypothesis of Nuclear Mass Defect.** Issues about mass defect will be discussed further in the following sections. While quantitative analysis of mass defects can be conducted with the help of Einstein's Equation of Mass and Energy, the physical mechanism still confuses physicists. People have known well of the quantization of nuclear energy level and the quantization of nuclear radiation and absorption of photon energy, but a unified theory about the relationship between the quantization of nuclear mass defect and nuclear energy level has not been established yet. Investigations are made in this paper by linking nuclear mass defect and quantization of microcosm, it is assumed that nuclear mass defect might have the following quantization rules: nuclear mass defect is quantified, that is to say, the mass defect of any nucleus is an integer multiple of the mass of one quantum; mass defect has its material bearer, i.e., the loss of certain neutral particles in the nucleus causes mass defect. If this idea holds, then the mass of the neutral particle should be a mass defect quantum, and thus the relationship between mass defect and quantification has a uniform material basis.

Based on the above considerations, this paper presents a small neutron hypothesis about mass defect that consists of the following three main parts.

1) There are several neutral particles inside each of the protons and neutrons, we called it a small neutron, and there are a number of small neutrons in vacuum. The mass of a small neutron is denoted as Δ. When small neutrons are expelled from a proton or a neutron (corresponding to the nuclear synthesis, which needs to absorb energy), the mass of the proton or neutron decreases and then a mass defect is formed; conversely, when some small neutrons entering into protons or neutrons (corresponding to the splitting of nucleus, which releases energy), the mass of protons and neutrons increases.

2) The atomic weight difference between different atoms of the same isotope can be an integer multiple of the mass quantum Δ. The nucleus also absorbs or releases several small neutrons when releasing or absorbing γ photons. In the condition without other energy loss, the energy E_γ of γ photon and the number of small neutrons n are linked by Einstein's Equation of Mass and Energy, which is $E_\gamma = (n \cdot \Delta)C^2$.

3) Any nuclear mass defect is an integer multiple of the mass quantum, which means that the nuclear mass defect is quantized.

The small neutron hypothesis is based on the quantization hypothesis of the nuclear mass defect proposed earlier in this article. This is an attempt to seek material bearers which can explain the loss of nuclear mass. The small neutron hypothesis is proposed based on classical physics. From the requirements of human wisdom, it is unsatisfactory to know only some mathematical formulas related to the mass defect. People need to know whether mass defect is the transfer of the actual material. People also want to know what kind of material transfer it is, which is the starting point of the small neutrons hypothesis. The hypothesis includes several points that need to be confirmed: 1) different atoms of the same isotope could have different atomic weight, which has been studied in depth in the study above; 2) the existence of small-mass quantum Δ; 3) the correctness of the idea that there is a number of small neutrons in vacuum; 4) when nuclear energy changes, there is a transfer of the actual mass, which is the result of the formation of nuclear mass defects.

6. **Search for the Quantum Δ of Small Mass with High-Precision Atomic Weight Data.** Table 2 presents the high-precision atomic weight measurement data of 16 isotopes. The high-precision mass defect values of these isotopes are calculated. The masses of elementary particles in Free State respectively are: electron mass = 0.0005485799094 u, neutron mass = 1.00866491597 u, proton mass = 1.00727646677 u. The calculation formula of mass defect values of the isotopes in Table 2 is:

$$\begin{aligned}\text{Mass defect} &= \text{Atomic number} \times (\text{proton mass} + \text{electron mass}) \\ &\quad + \text{Neutron number} \times \text{Neutron mass} - \text{Atomic weight}\end{aligned}$$

Searching for that mass quantum Δ in a wider scope is conducted in computer programs, and the calculation method is described as follows. Take the mass defect value of the i isotope as μ_i, $i = 1, 2, \ldots, 16$. And the mass of the alternative small quantum is taken as Δ. Δ is far less than the minimum of μ_i. Calculate the *error* according to the following expression:

$$error = \frac{1}{16}\sum_{i=1}^{16} \min\{\mathrm{mod}(\mu_i, \Delta), \Delta - \mathrm{mod}(\mu_i, \Delta)\}$$

$\mathrm{mod}(\mu_i, \Delta)$ is the remainder of μ_i after it is divided by Δ, $0 \le \mathrm{mod}(\mu_i, \Delta) < \Delta$; thus there is a positive integer n_i, which makes:

$$\mu_i = n_i\Delta + \mathrm{mod}(\mu_i, \Delta)$$

When there is $\mathrm{mod}(\mu_i, \Delta) > \frac{1}{2}\Delta$, the mass defect value is close to $(n_i + 1)\Delta$, and the error is $\Delta - \mathrm{mod}(\mu_i, \Delta)$.

TABLE 2. High-precision atomic weight data and mass defect values

Isotope	Atomic weight (u)	Mass defect (u)	Isotope	Atomic weight (u)	Mass defect (u)
${}_{1}^{2}H$	2.0141017780	0.002388185	${}_{8}^{16}O$	15.9949146221	0.137005079
${}_{1}^{3}H$	3.0160492675	0.009105611	${}_{9}^{19}F$	18.9984032000	0.158671380
${}_{2}^{3}H_e$	3.0160293097	0.008285700	${}_{10}^{20}N_e$	19.9924401759	0.172459451
${}_{2}^{4}H_e$	4.0026032497	0.030376676	${}_{14}^{28}S_i$	27.9769265327	0.253932944
${}_{6}^{12}C$	12.0000000000	0.098939776	${}_{14}^{29}S_i$	28.9764947200	0.263029673
${}_{6}^{13}C$	13.0033548378	0.104249854	${}_{14}^{30}S_i$	29.9737702200	0.274419089
${}_{7}^{14}N$	14.0030740052	0.112355733	${}_{17}^{35}Cl$	34.96885271	0.320141571
${}_{7}^{15}N$	15.0001088984	0.123985756	${}_{17}^{37}Cl$	36.96590260	0.340421513

Using computer programs to search for Δ, to make *error* reach its minimum value, finally, an optimal small mass quantum $\Delta = 5.84 \times 10^{-5}$ u is obtained. When the mass defect value of 16 isotopes is expressed as an integer multiple of the quantum Δ, the average error is less than 10% of Δ. When choosing other values as Δ, the average error is much higher. This result should not be interpreted as a coincidence, which indicates $\Delta = 5.84 \times 10^{-5}$ u might be close to the mass quantum value to some extent.

Based on the measurement of electron energy outside the nucleus of the nuclear internal transformation, the minimum energy level difference of the nucleus is about 0.05 MeV, it is equivalence about 1/10 of the electron mass. In this section, we take Δ as 5.84×10^{-5} u. We assume the small neutron mass is about 1/10 the electron mass if it does exist. Table 2 presents that when the number of nucleons is more than 1, the minimum mass defect value is 0.002388185 u of ${}_{1}^{2}H$, about the total mass of 40 small neutrons or more.

As the number of nucleons in a nucleus increases, the mass defect value also increases sharply. It is difficult to test the existence of smaller mass defect quantum with relatively large mass defect values of this kind. We should look for those nuclei changing within the scope of several small neutrons. With these high-precision atomic weight values, it is possible to search mass defect quantum. As we can see, the verification of the small neutron hypothesis depends on the assumption that different atoms of the same isotope have different mass and depends on its corresponding high-precision measurements. It is generally accepted that the atomic weight differences of different atoms of the same isotope can differ by a few small neutrons.

According to the view presented in this paper, the lack of accuracy in quantum measurements of isotopic atoms may be the result of intermixing of atoms of different weights in the same isotope. It is obviously inappropriate to use such measurement data to search for the mass quantum. This is because the measurement error of an atomic mass and the mass quantum may be on the same order of magnitude. If the mass quantum is found and the atomic weight of atoms of the same isotope with different masses could be measured precisely, then all the isotopic atomic weight data can be used to verify the small neutron hypothesis.

7. **Conclusions.** This paper proposed the quantization hypothesis of a nuclear mass defect according to the nuclear mass defect fact and the quantization features in microcosm. In this paper, it is also proposed that different atoms of the same isotope can take different masses. The rationality of the proposed hypothesis is demonstrated from the nuclear energy changes, the measurement precision of isotopic atomic weight, Einstein's Equation of Mass and Energy and other aspects, and thus some corresponding experimental assumptions are given. The existence of nuclear isomer and Einstein's Equation of Mass and Energy provide strong evidences for the idea that "different atoms of the same isotope can have different mass". The mass spectrometer performance defects and experimental techniques are not reasons for large measurement precision difference of atomic weight for different isotopes. However, the slight difference in different atoms of the same isotope should speak for it. An alternative mass defect quantum value is obtained by using high-precision isotopic atomic weight data. This paper also proposed a hypothesis about small mass defect neutrons, which assumes that nuclear mass defect is the mass reduction of an actual object which is caused by the loss of some small neutrons. A hypothesis about small neutrons is a new trial to explain the nuclear mass defect.

The hypothesis of small neutron and the hypothesis that different atoms of the same isotonic have different masses are only based on the fact that the nucleus absorbs and releases photons and the observations of the isotopic atomic weight measurement data, also the intuition and guesses. However, there are few strong experimental pieces of evidence for the assumptions. If the small neutron hypothesis is confirmed by experiments, then there will be a reasonable theoretical model for nuclear mass defect. The small neutron hypothesis is closely related to nuclear structure, vacuum properties, celestial mass and celestial energy. Under the assumption of the existence of small neutrons, the fine structure of the nucleus can be studied. There are some questions that need to be answered, including the physical mechanism of small neutrons entering and exiting the nucleus, how nucleons absorb energy and discharge a number of small neutrons when combining into nucleus, how nucleons release energy and absorb a number of small neutrons during a nuclear fission, and the quantitative relationship of small neutrons entering and exiting the nucleus with nuclear mass defect and energy changes. These issues are very important, but it will take a great number of theoretical and experimental researches to figure them out gradually.

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