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Nuclear binding energy in Strong nuclear gravity

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ABSTRACT: It is noticed that ratio of coulombic energy coefficient and proton rest energy is close to the product of fine structure ratio and the strong coupling constant. Strong coupling constant plays a crucial role in binding energy saturation. Based on strong nuclear gravity, semi empirical mass formula and with reference to the gravitational mass generator, $X_E \cong 295.0606338$, an expression is proposed for neutron and proton rest masses at quantum numbers n =1 and 2. Nuclear binding energy can be fitted with 2 terms and one energy constant. For these 2 terms, coulombic energy constant $E_c \cong 0.7681$ MeV is applied. Another attempt is made to fit the nuclear binding energy with a product of 5 factors with 0.7681 MeV. At $Z = 2$ and $A = 4$ obtained binding energy is 28.8 MeV. For any Z error in binding energy is very small near the stable mass number and increasing above and below the stable mass number. In these two methods nuclear stability factor $S_f \cong X_E - \frac{1}{\alpha} - 1 \cong 157.0246341$ plays a crucial role in proton-neutron stability. It is noticed that $A_S - 2Z \cong \frac{Z^2}{S_f}$.

KEYWORDS: Strong nuclear gravity, atomic gravitational constant, Avogadro number, classical gravitational constant, semi empirical mass formula, fine structure ratio, strong coupling constant, coulombic energy constant, nuclear stability factor and nucleon rest masses**.**

I. INTRODUCTION

One of the main goals of a unified theory should explain the existence and calculate the properties of matter. The fundamental question to be answered is: is mass an inherent property of any elementary particle? Electroweak physics assumes that Higg's boson is the `mass generator' of all the massive elementary particles. If it is the case, how to estimate the mass of an atom? By assuming some energy constants the “semiempirical mass formula” estimates the mass of any atomic nucleus. If nuclear mass experiences strong interaction and mass of the atom or group of atoms experiences gravitational interaction, how to unify the strong and gravitational interactions?

The idea of `strong gravity' originally referred specifically to mathematical approach of Abdus Salam of unification of gravity and quantum chromo-dynamics, but is now often

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used for any particle level gravity approach. For defining the `strong gravitational constant' a large scaling factor is required. If the scaling factor is a known one, then to some extent - its historical data and physics background makes and brings the unification concepts into one stream. Whether it may be `real' or `effective', if it is existing as a `single constant' its physical significance can be understood. `Nuclear size' can be fitted with `nuclear Schwarzschild radius'. `Nucleus' can be considered as `a strong nuclear black hole'. Nuclear binding energy constants can be generated directly. Proton-neutron stability can be studied. Origin of `strong coupling constant' and 'Fermi's weak coupling constant' can be understood. Charged lepton masses can be fitted. Quark masses, baryon and meson masses can be fitted. Elementary particle magnetic moments can be understood. Mystery of Higg's physics and electroweak physics can be understood.

The key conceptual link that connects the gravitational and non-gravitational forces is - the classical force limit $\left(\frac{c^4}{G_C}\right)$ where G_C is the classical gravitational constant. This classical force limit plays a vital role in Black hole and Planck scale physics. If one wishes to unify electroweak, strong and gravitational interactions it is a must to implement the classical gravitational constant G_C in the sub atomic physics. By any reason if one implements the planck scale in elementary particle physics and nuclear physics automatically G_C comes into subatomic physics. Then a large `arbitrary number' has to be considered as a proportionality constant. The basic and important problem is : How to select the `arbitrary number' ? For this purpose `mole' concept can be considered as a fundamental tool. The combination of Avogadro number and the classical gravitational constant generates the `effective' `strong gravitational constant'. This can be considered as the beginning of `strong nuclear gravity'.

II. GRAND UNIFIED VIEWS IN STRONG NUCLEAR GRAVITY

Based on Avogadro's strong nuclear gravity [1-14], in our previous published papers [15-21], it is suggested that,

1. N being the Avogadro number, atomic gravitational constant G_A is N^2 times the classical gravitational constant G_C.

2. Electromagnetic and gravitational force ratio of proton can be expressed as $\ln\sqrt{\frac{e^2}{4\pi\varepsilon_0 G_C m_p^2}} \cong \sqrt{\frac{m_p}{m_e} - \ln\left(\frac{G_A}{G_C}\right)} \cong \sqrt{\frac{m_p}{m_e} - \ln\left(N^2\right)}$. This is a very accurate semi empirical expression. Here m_p and m_e are the rest masses of proton and electron. From this expression obtained $G_C \cong 6.666270142\times10^{-11}\ \mathrm{m^3Kg^{-1}sec^{-2}}$. This can be compared with the recommended value, $G_C \cong 6.6742867\times10^{-11}\ \mathrm{m^3Kg^{-1}sec^{-2}}$. Please note that till today no atomic principle implemented the gravitational constant in nuclear physics.

3. $X_E \cong \sqrt{\frac{4\pi\varepsilon_0 G_A m_e^2}{e^2}} \cong 295.0606338$ can be considered as the 'gravitational mass generator'. It is the square root of ratio of gravitational and electromagnetic forces of electron where the operating gravitational constant is $N^2 G_C \cong G_A$.

4. $X_S \cong \ln\left(X_E^2\sqrt{\alpha}\right) \cong 8.914239916 \cong \frac{1}{\alpha_s}$ can be considered as 'inverse of the strong coupling constant' [22].

5. Nuclear weak force magnitude is $F_W \cong \frac{c^4}{G_A} \cong 3.337152088\times10^{-4}$ newton and nuclear strong force and weak force magnitudes can be correlated as $\sqrt{\frac{F_S}{F_W}} \cong 2\pi\ln\left(\frac{G_A}{G_C}\right) \cong 2\pi\ln\left(N^2\right)$. Thus $F_S \cong 157.9944058$ newton.

6. Fine structure ratio is $\frac{1}{\alpha} \cong \frac{1}{2}\sqrt{X_E^2 - \left[\ln\left(N^2\right)\right]^2} \cong 136.9930484$. It can be expressed as $\frac{1}{\alpha} \cong \frac{1}{2}\sqrt{X_E^2 - \left(\frac{F_S}{4\pi^2 F_W}\right)} \cong 137.036$.

7. Characteristic nuclear size is $R_0 \cong \sqrt{\frac{e^2}{4\pi\varepsilon_0 F_S}} \cong 1.208398568\times10^{-15}$ meter.

8. Nuclear weak energy constant is $E_W \cong \sqrt{\frac{e^2 F_W}{4\pi\varepsilon_0}} \cong 1.731843735\times10^{-3}$ MeV.

9. Charged lepton rest masses can be fitted as $m_l c^2 \cong \left[X_E^3 + \left(n^2 X_E\right)^n \sqrt{N}\right]^{\frac{1}{3}} E_W$ where $n = 0, 1, 2$. At $n = 1$, $m_l c^2 \cong 105.95$ MeV, $n = 2$, $m_l c^2 \cong 1777.4$ MeV.

10. Nuclear strong energy constant is $E_S \cong \sqrt{\frac{e^2 F_S}{4\pi\varepsilon_0}} \cong 1.191630355$ MeV and nuclear coulombic energy constant is $E_c \cong \frac{3}{5} E_S \cong 0.714978213$ MeV.

11. Proton rest mass is $m_p c^2 \cong \left(\frac{F_S}{F_W} + X_E^2 - \frac{1}{\alpha^2} \right) E_W \cong 938.1791391$ MeV. Neutron, proton mass difference is $m_n c^2 - m_p c^2 \cong \sqrt{\frac{F_S}{F_W} + X_E^2} * E_W \cong 1.29657348$ MeV.

12. Electroweak energy scale is $\varepsilon_W \cong \frac{F_S}{F_W} \times m_e c^2 \cong 241927.7486$ MeV. This is a very simple confirmation for the definitions of F_S and F_W.

13. Relation between electron rest mass and up quark rest mass can be expressed as $\frac{Uc^2}{m_e c^2} \cong \left[\frac{G_A m_e^2}{\hbar c} \right]^{\frac{1}{3}} \cong 8.596650881$. Relation between Up quark and down quark rest masses is $\frac{Dc^2}{Uc^2} \cong \ln\left[\frac{Uc^2}{m_e c^2} \right] \cong 2.151372695$.

14. Weak coupling angle is $\sin\theta_W \cong \frac{1}{\alpha X_E} \cong 0.464433353 \cong \frac{\text{Up mass}}{\text{Down mass}}$.

15. Magnetic moment of electron is $\mu_B \cong \frac{ec}{2} \sqrt{\frac{e^2}{4\pi\varepsilon_0 F_W}} \sin\theta_W$ and magnetic moment of nucleon is $\mu_n \cong \frac{ec}{2} \sqrt{\frac{e^2}{4\pi\varepsilon_0 F_S}} \sin\theta_W \cong \frac{ecR_0}{2} \sin\theta_W$ where R_0 is the nuclear charge radius or radii of nucleons.

16. Electron rest energy can be expressed as $m_e c^2 \cong 2\sin^2\theta_W \times \sqrt{\frac{e^2 F_S}{4\pi\varepsilon_0}}$ and total energy of electron in hydrogen atom can be expressed as $\frac{e^2}{8\pi\varepsilon_0 a_0} \cong \frac{1}{2}\alpha^2 m_e c^2 \cong \alpha^2 \sin^2\theta_W \times \sqrt{\frac{e^2 F_S}{4\pi\varepsilon_0}} \cong \frac{1}{X_E^2} \times \sqrt{\frac{e^2 F_S}{4\pi\varepsilon_0}} \cong \frac{1}{X_E^2} \times \frac{e^2}{4\pi\varepsilon_0 R_0}$. Here a_0 is the Bohr radius and R_0 is the nuclear characteristic size. Thus it is noticed that $\hbar \cong \sqrt{\frac{G_A m_e^3 R_0}{2}}$ and $\frac{a_0}{R_0} \cong \frac{X_E^2}{2}$.

III. ABOUT THE SEMIEMPIRICAL MASS FORMULA

In nuclear physics, the semi-empirical mass formula [23-33] is used to approximate the mass and various other properties of an atomic nucleus. As the name suggests, it is based partly on theory and partly on empirical measurements. The theory is based on the liquid drop model proposed by George Gamow, which can account for most of the terms in the formula and gives rough estimates for the values of the coefficients. It was first formulated in 1935 by German physicist Carl Friedrich von Weizsacker, and although refinements have been made to the coefficients over the years, the structure of the formula remains the same today. It gives a good approximation for atomic masses and several other effects, but does not explain the appearance of magic numbers.

The liquid drop model in nuclear physics treats the nucleus as a drop of incompressible nuclear fluid. It was first proposed by George Gamow and then developed by Niels Bohr and John Archibald Wheeler. The fluid is made of nucleons (protons and neutrons), which are held together by the strong nuclear force. This is a crude model that does not explain all the properties of the nucleus, but does explain the spherical shape of most nuclei. It also helps to predict the binding energy of the nucleus. Mathematical analysis of the theory delivers an equation which attempts to predict the binding energy of a nucleus in terms of the numbers of protons and neutrons it contains. This equation has five terms on its right hand side. These correspond to the cohesive binding of all the nucleons by the strong nuclear force, the electrostatic mutual repulsion of the protons, a surface energy term, an asymmetry term (derivable from the protons and neutrons occupying independent quantum momentum states) and a pairing term (partly derivable from the protons and neutrons occupying independent quantum spin states).

The semi-empirical mass formula provides a good fit to heavier nuclei and a poor fit to very light nuclei, especially $^4\mathrm{He}$. This is because the formula does not consider the internal shell structure of the nucleus. For light nuclei, it is usually better to use a model that takes this structure into account. The coefficients are calculated by fitting to experimentally measured masses of nuclei. Their values can vary depending on how they are fitted to the data. In the following formulae, let A be the total number of nucleons, Z the number of protons, and N the number of neutrons. The mass of an atomic nucleus is given by

$$m = Zm_p + Nm_n - \left(B/c^2\right) \tag{1}$$

where m_p and m_n are the rest mass of a proton and a neutron, respectively and B is the binding energy of the nucleus. The semi-empirical mass formula states that the binding energy will take the following form,

$$B = E_v A - E_s A^{2/3} - E_c \frac{Z(Z-1)}{A^{1/3}} - E_a \frac{(A-2Z)^2}{A} + \delta(A,Z) \tag{2}$$

Here E_v = volume energy coefficient, E_s is the surface energy coefficient, E_c is the coulomb energy coefficient, E_a is the asymmetry energy coefficient and $\delta(A,Z)$ is the pairing energy term. If we consider the sum of the volume energy, surface energy, coulomb energy, asymmetry energy and pairing energy, then the picture of a nucleus as a drop of incompressible liquid roughly accounts for the observed variation of binding energy of the nucleus. By maximizing $B(A,Z)$ with respect to Z, we find the number of protons Z of the stable nucleus of atomic weight A as,

$$Z \approx \frac{A}{2+(E_c/2E_a)A^{2/3}}. \tag{3}$$

This is roughly $A/2$ for light nuclei, but for heavy nuclei there is an even better agreement with nature. By substituting the above value of Z back into B one obtains the binding energy as a function of the atomic weight $B(A)$.

IV. THE COULOMBIC ENERGY CONSTANT

The very interesting observation is that ratio of coulombic energy coefficient and proton rest energy is close to the product of fine structure ratio and strong coupling constant.

$$E_c \cong (\alpha \times \alpha_s) \times m_p c^2 \cong \left(\frac{\alpha}{X_S}\right) \times m_p c^2 \cong 0.768085862 \text{ MeV}. \tag{4}$$

Another interesting observation is that using this unified energy constant nuclear binding energy can be fitted with 2 terms. At present matching is observed only for the mass numbers close to the stable mass number. Error is 2 to 3%. Authors are working in this new direction. It is noticed that nuclear binding energy saturation mainly depends on $\ln\left[(A+1)X_S\right]$ and $(A+1)$. Extending this idea it is noticed that nuclear binding energy can be fitted with a product of 5 factors having E_c as the single energy coefficient.

V. NEW NUCLEAR STABILITY FACTOR S_f

Let $$X_E \cong \sqrt{\frac{4\pi\varepsilon_0 G_A m_e^2}{e^2}} \cong 295.0606338 \quad (5)$$

Let us define a new number S_f as

$$S_f \cong X_E - \frac{1}{\alpha} - 1 \cong 157.0246341 \quad (6)$$

Here α is the fine structure ratio. S_f can be called as the nuclear stability factor. With this new number S_f proton-nucleon stability can be given as [26]

$$A_S \cong 2Z + \frac{Z^2}{S_f} \cong 2Z + \frac{Z^2}{157.025} \quad (7)$$

For example, if Z= 29, A_S = 63.35, Z=47, A_S = 108.06 and Z=92, A_S = 237.90 By considering A as the fundamental input its corresponding stable Z = Z_S can be obtained as

$$Z_S \cong \left[\sqrt{\frac{A}{157.025}+1}-1\right]157.025 \quad (8)$$

Thus Green's stability formula [27] in terms of Z can be expressed as

$$\frac{0.4A^2}{A+200} \cong A_S - 2Z \cong \frac{Z^2}{S_f}. \quad (9)$$

Surprisingly it is noticed that this number S_f plays a crucial role in fitting the nucleons rest mass. Another interesting observation is that

$$\left(m_n - m_p\right)c^2 \cong \ln\left(\sqrt{S_f}\right)m_e c^2 \cong 1.291908 \text{ MeV} \quad (10)$$

Here m_n, m_p and m_e are the rest masses of neutron, proton and electron respectively. Both $(1/\alpha)$ and S_f can be obtained as

$$\frac{X_E}{2} \mp \ln\left(\frac{X_E}{2}\right)^2 - \frac{1}{2} \cong (137.04225 \text{ and } 157.01838) \quad (11)$$

VI. REST MASSES OF PROTON AND NEUTRON

$$\text{Let,} \qquad m_i c^2 \cong X_E S_f \sqrt{\frac{\hbar c^5}{G_A}} \cong \frac{S_f}{\sqrt{\alpha}} m_e c^2 \cong 939.3016819 \text{ MeV} \tag{12}$$

If $m_e c^2$ is the rest energy of electron, this intermediate state gains a mass-energy $\frac{1}{2} m_e c^2$ and transforms to neutron. By losing a mass-energy of $2m_e c^2$ transforms to proton. Neutron and proton mass difference is $\left(m_n - m_p\right)c^2 \cong \left(2.5 + \frac{E_c}{E_a}\right) m_e c^2$. Considering neutron and proton as the 2 different quantum states of nucleon at n = 1 and n = 2 it is noticed that

$$m_x c^2 \cong X_E S_f \sqrt{\frac{\hbar c^5}{G_A}} - x\left(2^x + \frac{E_c}{2E_a}\right) m_e c^2 \tag{13}$$

where, $x = (-1)^n$ and n = 1 or 2. For n = 1, x = -1 and n = 2, x = +1.

If E_a= 23.21 MeV, E_c= 0.71 MeV and n =1, neutron rest energy is

$$m_n c^2 \cong X_E S_f \sqrt{\frac{\hbar c^5}{G_A}} + \left(\frac{1}{2} + \frac{E_c}{2E_a}\right) m_e c^2 \cong 939.565 \text{ MeV} \tag{14}$$

At n =2, proton rest energy is

$$m_p c^2 \cong X_E S_f \sqrt{\frac{\hbar c^5}{G_A}} - \left(2 + \frac{E_c}{2E_a}\right) m_e c^2 \cong 938.2719 \text{ MeV} \tag{15}$$

These obtained mass units can be compared with the experimental values.

VII. SEMI EMPIRICAL MASS FORMULA ENERGY CONSTANTS

In this section authors made an attempt to couple the famous semi empirical mass formula with the grand unification scheme. The proposed nuclear stability number S_f plays a very interesting role.

$$E_p \cong \frac{m_n c^2 + m_p c^2}{S_f} \cong 11.9588711 \text{ MeV} \tag{16}$$

$$E_a \cong 2E_p \cong 23.91774221 \text{ MeV} \tag{17}$$

$$E_c \cong \alpha \times \alpha_s \times m_p c^2 \cong \frac{\alpha}{X_S} \times m_p c^2 \cong 0.768085862 \text{ MeV} \tag{18}$$

$$E_a - E_v \cong E_s - E_p \cong (X_S + 1) E_c \cong 7.614987519 \text{ MeV} \tag{19}$$

$$E_a + E_p \cong E_v + E_s \cong 3E_p \cong 35.87661331 \text{ MeV} \tag{20}$$

Hence, $E_v \cong 16.30275469$ MeV, $E_s \cong 19.57385862$ MeV

With these obtained energy constants it is noticed that,

$$\left(\frac{E_c}{2E_a}\right) \cong 0.016056822 \tag{21}$$

$$S_f \cong \frac{E_a}{E_c}\sqrt{\frac{E_s}{E_c}} = 157.1968166 \tag{22}$$

$$B = E_v A - E_s A^{2/3} - E_c \frac{Z(Z-1)}{A^{1/3}} - E_a \frac{(A-2Z)^2}{A} \pm \frac{E_p}{\sqrt{A}} \tag{23}$$

VIII. BINDING ENERGY WITH 2 TERMS AND ONE ENERGY CONSTANT 0.7681 MeV

An empirical method is proposed here for fitting the nuclear binding energy. It constitutes 2 terms and only the columbic energy constant = E_c = 0.7681 MeV. In this method the important point is at first for any Z its stable mass number A_S has to be estimated. Strong interaction mass generator X_S plays a crucial role in this method. For any Z error in binding energy is very small near the stable isotope A_S and increasing above and below A_S. In strong interaction, unifying 5 terms having 5 energy constants into 2 terms with one energy constant is not a simple task. Authors proposal can be given a chance. This method is applicable for light atoms also. For light atoms, when A=2Z, obtained binding energy is very close to the actual value. For $Z = 2$ and $A = 4$ is 28.8 MeV. Term-1 can be expressed as

$$T_1 \cong \left[(A+1)\left(1+\frac{2Z}{A_S}\right)\right] \ln\left[(A+1)X_S\right] E_c \tag{24}$$

Stable isotope of any Z can be estimated as

$$A_S \cong 2Z + \frac{Z^2}{S_f} \cong 2Z + \frac{Z^2}{157.025} \tag{25}$$

where $S_f \cong X_E - \frac{1}{\alpha} - 1 = 157.025$. Term T_1 indicates the factors for increase in binding energy. Interesting observation is $\ln\left[\left(A+1\right)X_S\right]$. This factor plays a key role in the saturation of the binding energy. It is observed that for any Z at its stable isotope A_S,

$$T_1 \cong \left[A_S + 2Z + \left(1 \text{ or } 2\right)\right] \times \ln\left[\left(A_S + 1\right)X_S\right] E_c \tag{26}$$

This idea suggests that T_1 is somehow related with $\left(A+2Z\right)$. The basic question is that how to extrapolate from the stable isotope A_S of any Z to above and below its stable and unstable isotopes? Authors are working in this direction also. Term-2 can be expressed as

$$T_2 \cong \left[\frac{A^2 + \left(f.Z^2\right)}{X_S^2}\right] E_c \tag{27}$$

$$\text{and} \quad f \cong 1 + \frac{2Z}{A_S} \cong \frac{4S_f + Z}{2S_f + Z} < 2 \tag{28}$$

Binding energy can be given as

$$B \cong T_1 - T_2 \tag{29}$$

Term T_2 indicates the factors for decrease in binding energy. Both of these terms indicates the importance of the number X_S and has to be analyzed at fundamental level. Whether obtained energy is the total binding energy that includes shell effects or liquid drop energy has to be decided with further analysis. This method has to be analyzed and extended for isotopes above and below the stable mass number of any Z value. The advantage of this method is that number of energy constants and number of terms can be minimized. Data prepared with equations (24), (25), (27) and (28).

IX. NUCLEAR BINDING ENERGY WITH A PRODUCT OF 5 FACTORS

In this section it is suggested that nuclear binding energy is a product of 5 factors and only one energy constant. Close to the stable mass number

$$B \propto \left(A+1\right) \cong f_1 \tag{30}$$

$$B \propto \ln\left[\left(A+1\right)X_S\right] \cong f_2 \tag{31}$$

$$B \propto 2\left[1-\frac{\sqrt{A_S}}{S_f}\right] \cong f_3 \tag{32}$$

$$B \propto \left(2-\frac{A}{2Z}\right) \cong f_4 \tag{33}$$

$$B \propto \left(\frac{A}{A_S}\right)^{\frac{3}{2}} \cong f_5 \tag{34}$$

$$B \cong f_1\ f_2\ f_3\ f_4\ f_5 \times E_c \tag{35}$$

The most interesting thing is- coulomb energy constant $E_c \cong 0.7681\,\mathrm{MeV}$ plays a vital role in estimating the nuclear binding energy. The basic question is that - how to extrapolate from the stable isotope A_S of any Z to above and below its stable and unstable isotopes? Observed error is $2\ \mathrm{to}\ 3\,\%$ and may be due to factors f_3 and f_5. For light atoms, ratio of (A_S/Z) is 2. Factor 3 indicates the smooth decreasing. For Z=2, $f_3 \cong 1.9745$ and for Z= 92, $f_3 \cong 1.8035$. Authors are working in this new direction.

X. RECENT IDEAS IN NUCLEAR BINDING ENERGY

In the Integrated nuclear model (INM), it is assumed that [34],

1. The nuclear binding energy is of the order of about one percent of the energy of the total rest mass of the constituent nucleons.
2. The nuclear binding energy is proportional to the volume of the nuclide.
3. The nuclear binding energy depends upon the asymmetry between the number of protons and neutrons (specially in heavy nuclides) and also depends upon the Coulomb repulsion force between protons.

It is proposed that

$$B(A,Z) \cong \left\{A-\left(\frac{\left(N^2-Z^2\right)+\delta(N-Z)}{3Z}+3\right)\right\}\frac{m_N c^2}{x}, \qquad A>5 \tag{36}$$

Here $m_N c^2$ is the mass of nucleon, x is defined as an adjusting coefficient, $x = 90-100$. δ stands for nuclear beta-stability line condition and is defined as

$$\delta(N-Z) = \begin{cases} 0 & for \quad N \neq Z, \\ 1 & for \quad N = Z, \end{cases} \tag{37}$$

The energy constant can be expressed as

$$\frac{m_N c^2}{x} \cong \frac{m_N c^2}{90 \text{ to } 100} \simeq \sqrt{S_f} \times E_c \cong 9.625 \text{ MeV} \tag{38}$$

Please see the following table for the nuclear binding energy in pages 14-25. Column-1 represents the proton number, column-2 represents the fitted stable mass number, column-3 represents the neutron number, column-4 represents the mass number, column-5 represents the reference binding energy, column-6 represents binding energy from section VII, column-7 represents binding energy from section VIII and column-8 represents binding energy from section XI. Reference binding energy [26] B_0 calculated at E_v = 15.78 MeV, E_s =18.34 MeV, E_c=0.71 MeV, E_a = 23.21 MeV and E_p=12.0 MeV. Same equation (23) is applied for both B_0 and B_1. Data prepared with C++ file and edited with MS Excel for better presentation.

XI. TO ESTIMATE THE CLASSICAL GRAVITATIONAL CONSTANT G_C FROM β DECAY

Till today no atomic model implemented the gravitational constant in the atomic or nuclear physics. Then, whatever may be its magnitude, measuring its value from existing atomic principles is impossible. Its value was measured in the lab within a range of 1 cm to 1 meter only where as the observed nuclear size is 1.2 fermi. For any experimental physicist it is a must to measure or estimate the magnitude of the classical gravitational constant in nuclear physics. Semi empirically it is noticed that, in β decay,

$$m_e \cong \sqrt{\frac{2E_a}{E_c} \cdot \frac{N}{e^{S_f}}} \cdot \sqrt{\frac{e^2}{4\pi\varepsilon_0 G_C}} \cong \sqrt{\frac{2E_a}{E_c} \cdot \frac{N^3}{e^{S_f}}} \cdot \sqrt{\frac{e^2}{4\pi\varepsilon_0 \left(N^2 G_C\right)}} \cong X_E \cdot \sqrt{\frac{e^2}{4\pi\varepsilon_0 G_A}} \tag{39}$$

Here E_a and E_c are the asymmetry and coulombic energy constants of the semi empirical mass formula. N is the Avogadro number and S_f is the proposed new nuclear stability factor. In this proposal the important question is: What is the role of Avogadro number in β decay ? From section VI, equation (12) and with reference to the ratio of neutron and electron rest masses, upper limit of S_f can be expressed as

$$S_f \le \sqrt{\alpha}\cdot\frac{m_n}{m_e} \cong 157.0687113 \tag{40}$$

From the semi empirical mass formula if E_a= 23.21 MeV and E_c= 0.71 MeV,

$$G_C \cong \frac{2E_a}{E_c}\cdot\frac{N}{e^{S_f}}\cdot\frac{e^2}{4\pi\varepsilon_0 m_e^{\,2}} \cong 6.6866323\times10^{-11}\ \ \mathrm{m^3Kg^{-1}sec^{-2}} \tag{41}$$

With reference to the ratio of proton and electron rest mass, lower limit of the proposed nuclear stability factor can be expressed as

$$S_f \ge \sqrt{\alpha}\cdot\frac{m_p}{m_e} \cong 156.8525026 \tag{42}$$

$$G_C \cong \frac{2E_a}{E_c}\cdot\frac{N}{e^{S_f}}\cdot\frac{e^2}{4\pi\varepsilon_0 m_e^{\,2}} \cong 8.300527\times10^{-11}\ \ \mathrm{m^3Kg^{-1}sec^{-2}} \tag{43}$$

It is quite reasonable to consider the ratio of neutron and electron rest masses as β decay refers to the emission of electron from the neutron. Not only that, G_C estimated at neutron and electron mass ratio is very close to the recommended value of the classical gravitational constant $6.6742867\times10^{-11}\ \ \mathrm{m^3Kg^{-1}sec^{-2}}$ [35]. If so accuracy of G_C depends upon E_a and E_c.

XII. CONCLUSION

Based on strong nuclear gravity in this paper nuclear binding energy coefficients are fitted in a unified way. Relation between the energy coefficients is highlighted. Common expression is proposed for proton and neutron masses. Nuclear binding energy is fitted with 2 terms and 5 factors. It is true that there is some error in fitting the binding energy. In both of these cases, only one energy coefficient is used. Very interesting thing is that both α and α_s are implemented in fitting the binding energy. In a grand unified program this type of fitting can be given a chance. Authors hope that the obtained results are not only simple to understand but also more physical and certainly leads to grand unification.

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Z	A_S	$A-Z$	A	B_0	B_1	B_2	B_3
2	4.0	2	4	22.0	20.9	28.8	28.5
2	4.0	3	5	19.8	18.6	36.2	37.6
2	4.0	4	6	22.8	21.3	43.9	39.9
3	6.1	3	6	26.9	25.8	43.7	43.1
3	6.1	4	7	37.8	36.7	51.5	53.4
3	6.1	5	8	34.9	33.6	59.5	60.4
4	8.1	4	8	52.9	51.7	59.3	58.4
4	8.1	5	9	56.0	54.9	67.5	69.4
4	8.1	6	10	63.2	62.1	75.7	78.2
5	10.2	5	10	62.3	61.3	75.4	74.1
5	10.2	6	11	74.4	73.4	83.8	85.6
5	10.2	7	12	75.8	74.9	92.3	95.5
6	12.2	6	12	87.4	86.4	91.9	90.2
6	12.2	7	13	92.9	92.1	100.5	102.0
6	12.2	8	14	102.1	101.3	109.2	112.6
7	14.3	7	14	98.8	98.0	108.7	106.5
7	14.3	8	15	111.5	110.8	117.5	118.5
7	14.3	9	16	115.4	114.8	126.3	129.6
8	16.4	8	16	123.2	122.5	125.8	123.0
8	16.4	9	17	130.2	129.6	134.7	135.2
8	16.4	10	18	140.6	140.1	143.6	146.7
9	18.5	9	18	135.7	135.1	143.0	139.6
9	18.5	10	19	148.9	148.4	152.0	152.1
9	18.5	11	20	154.3	154.0	161.0	163.8
10	20.6	10	20	159.6	159.0	160.4	156.4
10	20.6	11	21	167.5	167.2	169.5	168.9
10	20.6	12	22	178.7	178.5	178.6	180.9
11	22.8	11	22	172.7	172.3	177.9	173.2
11	22.8	12	23	186.1	185.9	187.1	185.9
11	22.8	13	24	192.7	192.7	196.3	198.0
12	24.9	12	24	196.1	195.7	195.5	190.0
12	24.9	13	25	204.7	204.6	204.7	202.8
12	24.9	14	26	216.5	216.5	214.0	215.2
13	27.1	13	26	209.6	209.3	213.2	206.9
13	27.1	14	27	223.2	223.2	222.5	219.8
13	27.1	15	28	230.7	230.9	231.8	232.3
13	27.1	16	29	241.3	241.6	241.1	244.2
14	29.2	14	28	232.4	232.2	230.9	223.8
14	29.2	15	29	241.6	241.7	240.2	236.8
14	29.2	16	30	253.8	254.1	249.6	249.3
14	29.2	17	31	260.3	260.8	259.0	261.4
15	31.4	15	30	246.2	246.0	248.7	240.7

Z	A_S	$A-Z$	A	B_0	B_1	B_2	B_3
15	31.4	16	31	260.0	260.1	258.0	253.7
15	31.4	17	32	268.1	268.5	267.4	266.4
15	31.4	18	33	279.2	279.8	276.9	278.6
16	33.6	16	32	268.6	268.4	266.4	257.6
16	33.6	17	33	278.2	278.4	275.9	270.6
16	33.6	18	34	290.8	291.2	285.3	283.4
16	33.6	19	35	298.0	298.7	294.8	295.7
17	35.8	17	34	282.4	282.3	284.2	274.4
17	35.8	18	35	296.4	296.6	293.7	287.5
17	35.8	19	36	305.1	305.6	303.1	300.4
17	35.8	20	37	316.6	317.3	312.6	312.8
18	38.1	18	36	304.3	304.3	302.0	291.2
18	38.1	19	37	314.4	314.7	311.5	304.4
18	38.1	20	38	327.2	327.8	321.0	317.3
18	38.1	21	39	335.1	335.9	330.5	329.8
18	38.1	22	40	345.8	346.8	340.0	341.9
19	40.3	19	38	318.2	318.2	319.8	308.0
19	40.3	20	39	332.3	332.6	329.3	321.2
19	40.3	21	40	341.5	342.1	338.8	334.1
19	40.3	22	41	353.4	354.2	348.4	346.7
19	40.3	23	42	360.6	361.7	357.9	359.0
20	42.5	20	40	339.7	339.7	337.6	324.7
20	42.5	21	41	350.1	350.4	347.1	337.9
20	42.5	22	42	363.2	363.8	356.6	350.9
20	42.5	23	43	371.6	372.5	366.2	363.6
20	42.5	24	44	382.7	383.8	375.8	375.9
21	44.8	21	42	353.5	353.6	355.3	341.4
21	44.8	22	43	367.8	368.1	364.9	354.6
21	44.8	23	44	377.4	378.0	374.4	367.6
21	44.8	24	45	389.6	390.5	384.0	380.4
21	44.8	25	46	397.4	398.5	393.6	392.8
22	47.1	23	45	385.3	385.7	382.6	371.3
22	47.1	24	46	398.6	399.3	392.2	384.3
22	47.1	25	47	407.5	408.4	401.7	397.1
22	47.1	26	48	418.9	420.1	411.3	409.5
22	47.1	27	49	426.2	427.6	420.9	421.6
23	49.4	24	47	402.8	403.1	400.3	387.8
23	49.4	25	48	412.7	413.3	409.9	400.9
23	49.4	26	49	425.2	426.1	419.4	413.7
23	49.4	27	50	433.4	434.6	429.0	426.2
23	49.4	28	51	444.3	445.7	438.6	438.4
24	51.7	25	49	420.1	420.4	417.9	404.3

Z	A_S	$A-Z$	A	B_0	B_1	B_2	B_3
24	51.7	26	50	433.5	434.2	427.5	417.4
24	51.7	27	51	442.8	443.7	437.1	430.2
24	51.7	28	52	454.6	455.8	446.7	442.8
24	51.7	29	53	462.3	463.7	456.3	455.0
25	54.0	26	51	437.2	437.5	435.5	420.7
25	54.0	27	52	447.5	448.1	445.1	433.8
25	54.0	28	53	460.2	461.1	454.7	446.6
25	54.0	29	54	468.9	470.1	464.3	459.3
25	54.0	30	55	480.1	481.5	473.9	471.6
26	56.3	28	54	467.9	468.5	462.6	450.1
26	56.3	29	55	477.5	478.4	472.2	463.0
26	56.3	30	56	489.6	490.7	481.8	475.6
26	56.3	31	57	497.7	499.1	491.4	488.0
26	56.3	32	58	508.4	510.0	501.0	500.1
27	58.6	29	56	481.7	482.2	480.1	466.3
27	58.6	30	57	494.7	495.5	489.7	479.3
27	58.6	31	58	503.7	504.8	499.3	491.9
27	58.6	32	59	515.2	516.6	508.9	504.4
27	58.6	33	60	522.9	524.5	518.5	516.5
28	61.0	30	58	501.7	502.2	497.5	482.5
28	61.0	31	59	511.7	512.4	507.1	495.4
28	61.0	32	60	524.0	525.0	516.7	508.1
28	61.0	33	61	532.5	533.8	526.3	520.6
28	61.0	34	62	543.5	545.1	535.9	532.8
29	63.4	32	61	528.5	529.2	524.5	511.5
29	63.4	33	62	537.9	538.9	534.1	524.2
29	63.4	34	63	549.7	550.9	543.7	536.7
29	63.4	35	64	557.8	559.3	553.2	548.9
29	63.4	36	65	568.3	570.1	562.8	560.9
30	65.7	33	63	545.2	545.8	541.8	527.5
30	65.7	34	64	557.8	558.7	551.3	540.2
30	65.7	35	65	566.7	567.8	560.9	552.7
30	65.7	36	66	577.9	579.4	570.5	565.0
30	65.7	37	67	585.7	587.4	580.1	577.0
31	68.1	35	66	571.5	572.3	568.5	556.1
31	68.1	36	67	583.5	584.6	578.1	568.7
31	68.1	37	68	592.0	593.4	587.7	581.0
31	68.1	38	69	602.8	604.5	597.2	593.0
31	68.1	39	70	610.2	612.1	606.8	604.7
32	70.5	36	68	590.9	591.6	585.6	571.9
32	70.5	37	69	600.2	601.2	595.2	584.5
32	70.5	38	70	611.7	613.0	604.8	596.8

Z	A_S	$A-Z$	A	B_0	B_1	B_2	B_3
32	70.5	39	71	619.8	621.4	614.3	608.9
32	70.5	40	72	630.2	632.0	623.9	620.7
33	72.9	37	70	604.4	605.0	602.7	587.6
33	72.9	38	71	616.7	617.6	612.2	600.2
33	72.9	39	72	625.5	626.7	621.8	612.5
33	72.9	40	73	636.6	638.1	631.3	624.6
33	72.9	41	74	644.4	646.1	640.9	636.5
34	75.4	39	73	633.0	633.8	629.1	615.8
34	75.4	40	74	644.8	645.9	638.7	628.1
34	75.4	41	75	653.3	654.6	648.2	640.3
34	75.4	42	76	664.0	665.6	657.8	652.2
34	75.4	43	77	671.5	673.3	667.3	663.8
35	77.8	40	75	649.2	649.9	646.0	631.3
35	77.8	41	76	658.4	659.3	655.5	643.7
35	77.8	42	77	669.8	671.0	665.0	655.8
35	77.8	43	78	677.9	679.4	674.6	667.8
35	77.8	44	79	688.3	690.0	684.1	679.5
36	80.3	42	78	677.3	678.1	672.3	659.1
36	80.3	43	79	686.1	687.2	681.8	671.3
36	80.3	44	80	697.0	698.4	691.3	683.2
36	80.3	45	81	704.9	706.5	700.8	695.0
36	80.3	46	82	714.9	716.8	710.3	706.4
37	82.7	43	80	690.6	691.3	688.9	674.4
37	82.7	44	81	702.2	703.2	698.4	686.6
37	82.7	45	82	710.7	711.9	707.9	698.6
37	82.7	46	83	721.3	722.8	717.4	710.3
37	82.7	47	84	728.9	730.6	726.9	721.8
38	85.2	45	83	718.2	719.0	714.9	701.8
38	85.2	46	84	729.4	730.5	724.4	713.8
38	85.2	47	85	737.6	738.9	733.9	725.6
38	85.2	48	86	747.9	749.5	743.3	737.1
38	85.2	49	87	755.2	757.0	752.8	748.4
39	87.7	46	85	734.1	734.7	731.4	716.8
39	87.7	47	86	742.8	743.7	740.8	728.9
39	87.7	48	87	753.7	754.9	750.3	740.7
39	87.7	49	88	761.6	763.0	759.7	752.3
39	87.7	50	89	771.6	773.3	769.2	763.7
40	90.2	48	88	761.2	761.9	757.2	743.9
40	90.2	49	89	769.6	770.6	766.6	755.7
40	90.2	50	90	780.2	781.5	776.0	767.4
40	90.2	51	91	787.8	789.3	785.4	778.8
40	90.2	52	92	797.6	799.3	794.9	789.9

Z	A_S	$A-Z$	A	B_0	B_1	B_2	B_3
41	92.7	49	90	774.3	774.8	773.4	758.8
41	92.7	50	91	785.4	786.2	782.8	770.6
41	92.7	51	92	793.6	794.7	792.2	782.3
41	92.7	52	93	803.9	805.2	801.6	793.7
41	92.7	53	94	811.3	812.9	811.0	804.9
42	95.2	51	93	801.0	801.6	798.9	785.4
42	95.2	52	94	811.8	812.7	808.3	797.1
42	95.2	53	95	819.8	820.9	817.7	808.6
42	95.2	54	96	829.8	831.2	827.0	819.8
42	95.2	55	97	836.9	838.6	836.4	830.8
43	97.8	52	95	816.5	816.8	814.9	800.1
43	97.8	53	96	824.9	825.6	824.3	811.8
43	97.8	54	97	835.5	836.4	833.6	823.3
43	97.8	55	98	843.2	844.4	843.0	834.6
43	97.8	56	99	852.9	854.4	852.3	845.6
44	100.3	54	98	842.8	843.2	840.2	826.4
44	100.3	55	99	851.0	851.7	849.5	837.9
44	100.3	56	100	861.2	862.2	858.8	849.2
44	100.3	57	101	868.7	870.0	868.1	860.3
44	100.3	58	102	878.3	879.8	877.5	871.2
45	102.9	55	100	855.6	855.8	856.0	840.8
45	102.9	56	101	866.4	866.8	865.3	852.4
45	102.9	57	102	874.4	875.1	874.6	863.7
45	102.9	58	103	884.4	885.4	883.9	874.8
45	102.9	59	104	891.7	893.0	893.1	885.7
46	105.5	57	103	881.6	881.8	880.9	866.7
46	105.5	58	104	892.0	892.6	890.2	878.1
46	105.5	59	105	899.8	900.6	899.5	889.3
46	105.5	60	106	909.6	910.7	908.7	900.2
46	105.5	61	107	916.7	918.0	918.0	910.9
47	108.1	59	106	904.9	905.1	905.7	892.3
47	108.1	60	107	915.1	915.7	915.0	903.5
47	108.1	61	108	922.7	923.5	924.2	914.5
47	108.1	62	109	932.3	933.4	933.4	925.3
47	108.1	63	110	939.2	940.6	942.6	935.8
48	110.7	60	108	922.2	922.2	921.2	906.5
48	110.7	61	109	930.2	930.5	930.4	917.7
48	110.7	62	110	940.2	940.8	939.6	928.7
48	110.7	63	111	947.7	948.5	948.8	939.5
48	110.7	64	112	957.0	958.1	958.0	950.1
49	113.3	62	111	945.2	945.2	945.7	931.7
49	113.3	63	112	953.0	953.3	954.8	942.8

Z	A_S	$A-Z$	A	B_0	B_1	B_2	B_3
49	113.3	64	113	962.8	963.4	964.0	953.6
49	113.3	65	114	970.1	970.9	973.2	964.3
49	113.3	66	115	979.3	980.3	982.3	974.7
50	115.9	63	113	960.0	959.7	960.8	945.7
50	115.9	64	114	970.2	970.2	970.0	956.7
50	115.9	65	115	977.9	978.2	979.1	967.6
50	115.9	66	116	987.5	988.0	988.3	978.3
50	115.9	67	117	994.6	995.4	997.4	988.8
51	118.6	65	116	982.7	982.4	985.0	970.6
51	118.6	66	117	992.7	992.7	994.1	981.5
51	118.6	67	118	1000.2	1000.5	1003.2	992.2
51	118.6	68	119	1009.7	1010.2	1012.3	1002.7
51	118.6	69	120	1016.6	1017.4	1021.4	1013.0
52	121.2	67	119	1007.4	1007.1	1009.0	995.2
52	121.2	68	120	1017.3	1017.2	1018.1	1006.0
52	121.2	69	121	1024.6	1024.8	1027.2	1016.5
52	121.2	70	122	1033.8	1034.3	1036.2	1026.8
52	121.2	71	123	1040.6	1041.3	1045.3	1037.0
53	123.9	68	121	1021.9	1021.3	1023.8	1008.8
53	123.9	69	122	1029.7	1029.4	1032.9	1019.6
53	123.9	70	123	1039.4	1039.3	1041.9	1030.2
53	123.9	71	124	1046.5	1046.7	1051.0	1040.6
53	123.9	72	125	1055.6	1056.1	1060.0	1050.7
54	126.6	70	124	1046.3	1045.7	1047.5	1033.1
54	126.6	71	125	1053.9	1053.6	1056.5	1043.7
54	126.6	72	126	1063.4	1063.3	1065.5	1054.2
54	126.6	73	127	1070.5	1070.6	1074.5	1064.4
54	126.6	74	128	1079.4	1079.7	1083.5	1074.4
55	129.3	72	127	1068.4	1067.6	1071.0	1057.2
55	129.3	73	128	1075.8	1075.4	1080.0	1067.6
55	129.3	74	129	1085.1	1084.9	1089.0	1077.9
55	129.3	75	130	1092.0	1092.1	1097.9	1087.9
55	129.3	76	131	1100.8	1101.1	1106.9	1097.8
56	132.0	73	129	1082.6	1081.5	1085.4	1070.5
56	132.0	74	130	1092.3	1091.5	1094.4	1080.9
56	132.0	75	131	1099.6	1099.1	1103.3	1091.2
56	132.0	76	132	1108.7	1108.5	1112.2	1101.3
56	132.0	77	133	1115.5	1115.5	1121.2	1111.2
57	134.7	75	132	1104.4	1103.3	1108.6	1094.1
57	134.7	76	133	1113.9	1113.0	1117.5	1104.5
57	134.7	77	134	1121.1	1120.5	1126.4	1114.6
57	134.7	78	135	1130.1	1129.7	1135.3	1124.6

Z	A_S	$A-Z$	A	B_0	B_1	B_2	B_3
57	134.7	79	136	1136.7	1136.6	1144.2	1134.3
58	137.4	77	135	1128.0	1126.8	1131.6	1117.6
58	137.4	78	136	1137.4	1136.4	1140.5	1127.8
58	137.4	79	137	1144.4	1143.7	1149.4	1137.8
58	137.4	80	138	1153.3	1152.8	1158.2	1147.5
58	137.4	81	139	1159.8	1159.6	1167.0	1157.1
59	140.2	79	138	1149.4	1148.1	1154.5	1140.8
59	140.2	80	139	1158.6	1157.6	1163.3	1150.8
59	140.2	81	140	1165.6	1164.8	1172.1	1160.6
59	140.2	82	141	1174.3	1173.7	1180.9	1170.3
59	140.2	83	142	1180.7	1180.4	1189.7	1179.7
60	142.9	80	140	1165.4	1163.7	1168.3	1153.7
60	142.9	81	141	1172.7	1171.2	1177.1	1163.8
60	142.9	82	142	1181.7	1180.5	1185.9	1173.6
60	142.9	83	143	1188.5	1187.6	1194.6	1183.3
60	142.9	84	144	1197.1	1196.4	1203.4	1192.8
61	145.7	82	143	1186.5	1184.7	1190.8	1176.6
61	145.7	83	144	1193.7	1192.1	1199.5	1186.5
61	145.7	84	145	1202.6	1201.3	1208.3	1196.2
61	145.7	85	146	1209.3	1208.3	1217.0	1205.7
61	145.7	86	147	1217.8	1217.0	1225.7	1215.1
62	148.5	84	146	1209.5	1207.5	1213.1	1199.2
62	148.5	85	147	1216.5	1214.8	1221.8	1209.0
62	148.5	86	148	1225.3	1223.9	1230.5	1218.5
62	148.5	87	149	1231.9	1230.7	1239.2	1227.9
62	148.5	88	150	1240.2	1239.3	1247.8	1237.1
63	151.3	86	149	1230.3	1228.2	1235.2	1221.6
63	151.3	87	150	1237.2	1235.4	1243.9	1231.2
63	151.3	88	151	1245.9	1244.3	1252.5	1240.6
63	151.3	89	152	1252.4	1251.0	1261.1	1249.9
63	151.3	90	153	1260.6	1259.5	1269.8	1258.9
64	154.1	88	152	1252.8	1250.6	1257.1	1243.8
64	154.1	89	153	1259.7	1257.7	1265.7	1253.2
64	154.1	90	154	1268.2	1266.5	1274.3	1262.5
64	154.1	91	155	1274.6	1273.1	1282.9	1271.6
64	154.1	92	156	1282.7	1281.5	1291.5	1280.5
65	156.9	89	154	1264.4	1261.7	1270.2	1256.2
65	156.9	90	155	1273.3	1270.9	1278.8	1265.7
65	156.9	91	156	1280.0	1277.8	1287.4	1275.0
65	156.9	92	157	1288.4	1286.5	1295.9	1284.2
65	156.9	93	158	1294.8	1293.1	1304.5	1293.1
66	159.7	91	157	1286.7	1283.9	1291.8	1278.0

Z	A_S	$A-Z$	A	B_0	B_1	B_2	B_3
66	159.7	92	158	1295.5	1292.9	1300.3	1287.4
66	159.7	93	159	1302.1	1299.8	1308.9	1296.6
66	159.7	94	160	1310.4	1308.3	1317.4	1305.6
66	159.7	95	161	1316.7	1314.8	1325.9	1314.4
67	162.6	93	160	1307.0	1303.9	1313.2	1299.7
67	162.6	94	161	1315.6	1312.8	1321.6	1308.9
67	162.6	95	162	1322.1	1319.6	1330.1	1318.0
67	162.6	96	163	1330.4	1328.1	1338.6	1326.8
67	162.6	97	164	1336.5	1334.5	1347.0	1335.5
68	165.4	95	163	1328.9	1325.7	1334.3	1321.1
68	165.4	96	164	1337.5	1334.5	1342.8	1330.2
68	165.4	97	165	1343.9	1341.2	1351.2	1339.1
68	165.4	98	166	1352.0	1349.6	1359.6	1347.8
68	165.4	99	167	1358.1	1355.9	1368.0	1356.4
69	168.3	97	166	1348.8	1345.4	1355.3	1342.3
69	168.3	98	167	1357.3	1354.1	1363.7	1351.2
69	168.3	99	168	1363.7	1360.7	1372.1	1360.0
69	168.3	100	169	1371.7	1369.0	1380.4	1368.6
69	168.3	101	170	1377.7	1375.3	1388.8	1377.0
70	171.2	99	169	1370.5	1366.8	1376.1	1363.2
70	171.2	100	170	1378.8	1375.4	1384.4	1372.1
70	171.2	101	171	1385.1	1381.9	1392.7	1380.7
70	171.2	102	172	1393.0	1390.1	1401.1	1389.2
70	171.2	103	173	1399.0	1396.3	1409.4	1397.5
71	174.1	101	172	1390.1	1386.2	1396.6	1384.0
71	174.1	102	173	1398.3	1394.7	1404.9	1392.7
71	174.1	103	174	1404.5	1401.2	1413.2	1401.2
71	174.1	104	175	1412.4	1409.3	1421.5	1409.6
71	174.1	105	176	1418.3	1415.4	1429.8	1417.7
72	177.0	103	175	1411.4	1407.3	1417.0	1404.5
72	177.0	104	176	1419.5	1415.7	1425.2	1413.1
72	177.0	105	177	1425.7	1422.1	1433.5	1421.5
72	177.0	106	178	1433.5	1430.1	1441.7	1429.7
72	177.0	107	179	1439.3	1436.1	1449.9	1437.8
73	179.9	104	177	1424.2	1419.7	1428.9	1416.2
73	179.9	105	178	1430.7	1426.4	1437.2	1424.9
73	179.9	106	179	1438.8	1434.7	1445.4	1433.3
73	179.9	107	180	1444.8	1441.0	1453.6	1441.6
73	179.9	108	181	1452.6	1448.9	1461.7	1449.7
74	182.9	106	180	1445.3	1440.5	1448.9	1436.5
74	182.9	107	181	1451.7	1447.1	1457.1	1445.0
74	182.9	108	182	1459.6	1455.3	1465.3	1453.3

Z	A_S	$A-Z$	A	B_0	B_1	B_2	B_3
74	182.9	109	183	1465.7	1461.6	1473.4	1461.5
74	182.9	110	184	1473.3	1469.4	1481.5	1469.5
75	185.8	108	183	1464.4	1459.3	1468.7	1456.6
75	185.8	109	184	1470.7	1465.9	1476.9	1464.9
75	185.8	110	185	1478.6	1474.0	1485.0	1473.2
75	185.8	111	186	1484.6	1480.2	1493.1	1481.2
75	185.8	112	187	1492.1	1488.0	1501.2	1489.0
76	188.8	110	186	1485.1	1479.8	1488.3	1476.4
76	188.8	111	187	1491.4	1486.3	1496.4	1484.7
76	188.8	112	188	1499.2	1494.3	1504.5	1492.8
76	188.8	113	189	1505.1	1500.4	1512.5	1500.7
76	188.8	114	190	1512.6	1508.2	1520.6	1508.4
77	191.8	112	189	1504.0	1498.3	1507.7	1496.1
77	191.8	113	190	1510.2	1504.7	1515.8	1504.2
77	191.8	114	191	1517.9	1512.7	1523.8	1512.2
77	191.8	115	192	1523.7	1518.8	1531.8	1520.0
77	191.8	116	193	1531.2	1526.5	1539.7	1527.6
78	194.7	114	192	1524.4	1518.5	1526.9	1515.5
78	194.7	115	193	1530.5	1524.8	1534.9	1523.5
78	194.7	116	194	1538.2	1532.7	1542.9	1531.4
78	194.7	117	195	1544.0	1538.8	1550.8	1539.1
78	194.7	118	196	1551.3	1546.3	1558.7	1546.6
79	197.7	116	195	1543.0	1536.7	1545.9	1534.8
79	197.7	117	196	1549.0	1543.0	1553.8	1542.7
79	197.7	118	197	1556.6	1550.9	1561.7	1550.4
79	197.7	119	198	1562.4	1556.8	1569.6	1558.0
79	197.7	120	199	1569.7	1564.4	1577.5	1565.4
80	200.8	118	198	1563.1	1556.6	1564.7	1553.9
80	200.8	119	199	1569.1	1562.8	1572.5	1561.7
80	200.8	120	200	1576.7	1570.6	1580.4	1569.3
80	200.8	121	201	1582.3	1576.5	1588.2	1576.7
80	200.8	122	202	1589.6	1583.9	1596.1	1584.0
81	203.8	120	201	1581.4	1574.5	1583.2	1572.7
81	203.8	121	202	1587.4	1580.7	1591.1	1580.4
81	203.8	122	203	1594.8	1588.4	1598.9	1587.9
81	203.8	123	204	1600.5	1594.3	1606.7	1595.3
81	203.8	124	205	1607.7	1601.7	1614.4	1602.4
82	206.8	122	204	1601.3	1594.1	1601.6	1591.4
82	206.8	123	205	1607.2	1600.2	1609.4	1599.0
82	206.8	124	206	1614.6	1607.8	1617.1	1606.4
82	206.8	125	207	1620.2	1613.7	1624.9	1613.7
82	206.8	126	208	1627.3	1621.0	1632.6	1620.7

Z	A_S	$A-Z$	A	B_0	B_1	B_2	B_3
83	209.9	124	207	1619.3	1611.8	1619.7	1609.9
83	209.9	125	208	1625.2	1617.9	1627.5	1617.4
83	209.9	126	209	1632.5	1625.4	1635.2	1624.7
83	209.9	127	210	1638.1	1631.2	1642.9	1631.8
83	209.9	128	211	1645.1	1638.5	1650.5	1638.8
84	212.9	126	210	1638.9	1631.0	1637.7	1628.3
84	212.9	127	211	1644.7	1637.0	1645.3	1635.6
84	212.9	128	212	1652.0	1644.6	1653.0	1642.8
84	212.9	129	213	1657.5	1650.3	1660.6	1649.8
84	212.9	130	214	1664.5	1657.5	1668.3	1656.7
85	216.0	129	214	1662.4	1654.4	1663.0	1653.7
85	216.0	130	215	1669.7	1661.9	1670.6	1660.8
85	216.0	131	216	1675.2	1667.6	1678.2	1667.7
85	216.0	132	217	1682.1	1674.8	1685.8	1674.4
85	216.0	133	218	1687.3	1680.2	1693.3	1681.0
86	219.1	131	217	1681.7	1673.3	1680.5	1671.5
86	219.1	132	218	1688.9	1680.7	1688.0	1678.5
86	219.1	133	219	1694.3	1686.4	1695.6	1685.3
86	219.1	134	220	1701.2	1693.5	1703.1	1692.0
86	219.1	135	221	1706.4	1698.9	1710.6	1698.5
87	222.2	133	220	1699.2	1690.5	1697.7	1689.2
87	222.2	134	221	1706.4	1697.8	1705.2	1696.1
87	222.2	135	222	1711.7	1703.4	1712.7	1702.8
87	222.2	136	223	1718.6	1710.5	1720.2	1709.4
87	222.2	137	224	1723.7	1715.9	1727.6	1715.7
88	225.3	135	223	1718.2	1709.1	1714.8	1706.7
88	225.3	136	224	1725.3	1716.4	1722.2	1713.5
88	225.3	137	225	1730.7	1722.0	1729.6	1720.2
88	225.3	138	226	1737.5	1729.0	1737.1	1726.6
88	225.3	139	227	1742.6	1734.3	1744.5	1732.9
89	228.4	137	226	1735.5	1726.0	1731.6	1724.1
89	228.4	138	227	1742.5	1733.2	1739.0	1730.8
89	228.4	139	228	1747.8	1738.8	1746.4	1737.3
89	228.4	140	229	1754.6	1745.8	1753.7	1743.7
89	228.4	141	230	1759.7	1751.0	1761.1	1749.8
90	231.6	139	229	1754.2	1744.3	1748.2	1741.3
90	231.6	140	230	1761.2	1751.5	1755.6	1747.9
90	231.6	141	231	1766.5	1757.0	1762.9	1754.3
90	231.6	142	232	1773.2	1764.0	1770.2	1760.6
90	231.6	143	233	1778.3	1769.2	1777.5	1766.6
91	234.7	141	232	1771.3	1760.9	1764.6	1758.3
91	234.7	142	233	1778.2	1768.1	1771.9	1764.8

Z	A_S	$A-Z$	A	B_0	B_1	B_2	B_3
91	234.7	143	234	1783.5	1773.6	1779.2	1771.1
91	234.7	144	235	1790.2	1780.5	1786.4	1777.3
91	234.7	145	236	1795.2	1785.7	1793.7	1783.3
92	237.9	143	235	1789.8	1779.0	1780.8	1775.1
92	237.9	144	236	1796.7	1786.1	1788.0	1781.5
92	237.9	145	237	1801.9	1791.6	1795.3	1787.8
92	237.9	146	238	1808.5	1798.4	1802.5	1793.9
92	237.9	147	239	1813.5	1803.6	1809.7	1799.8
93	241.1	146	239	1813.4	1802.5	1804.0	1798.1
93	241.1	147	240	1818.6	1807.9	1811.1	1804.3
93	241.1	148	241	1825.2	1814.7	1818.3	1810.3
93	241.1	149	242	1830.2	1819.9	1825.4	1816.1
93	241.1	150	243	1836.6	1826.4	1832.6	1821.8
94	244.3	148	242	1831.6	1820.2	1819.7	1814.6
94	244.3	149	243	1836.8	1825.6	1826.8	1820.6
94	244.3	150	244	1843.4	1832.4	1833.9	1826.5
94	244.3	151	245	1848.3	1837.5	1841.0	1832.3
94	244.3	152	246	1854.6	1844.1	1848.1	1837.8
95	247.5	150	245	1848.2	1836.3	1835.2	1830.9
95	247.5	151	246	1853.3	1841.7	1842.2	1836.8
95	247.5	152	247	1859.9	1848.4	1849.3	1842.7
95	247.5	153	248	1864.8	1853.5	1856.3	1848.3
95	247.5	154	249	1871.1	1860.1	1863.3	1853.8
96	250.7	152	248	1866.1	1853.8	1850.5	1847.0
96	250.7	153	249	1871.2	1859.1	1857.5	1852.9
96	250.7	154	250	1877.8	1865.9	1864.5	1858.6
96	250.7	155	251	1882.6	1870.9	1871.4	1864.2
96	250.7	156	252	1888.9	1877.4	1878.4	1869.6
97	253.9	154	251	1882.5	1869.7	1865.5	1863.0
97	253.9	155	252	1887.5	1875.0	1872.5	1868.8
97	253.9	156	253	1894.0	1881.7	1879.4	1874.4
97	253.9	157	254	1898.9	1886.7	1886.3	1879.9
97	253.9	158	255	1905.1	1893.2	1893.3	1885.2
98	257.2	157	255	1905.2	1892.2	1887.3	1884.5
98	257.2	158	256	1911.7	1898.8	1894.2	1890.1
98	257.2	159	257	1916.5	1903.9	1901.0	1895.5
98	257.2	160	258	1922.7	1910.3	1907.9	1900.7
98	257.2	161	259	1927.3	1915.1	1914.7	1905.8
99	260.4	159	258	1921.3	1907.8	1901.9	1900.1
99	260.4	160	259	1927.7	1914.4	1908.7	1905.6
99	260.4	161	260	1932.5	1919.4	1915.5	1910.9
99	260.4	162	261	1938.7	1925.8	1922.3	1916.1

Z	A_S	$A-Z$	A	B_0	B_1	B_2	B_3
99	260.4	163	262	1943.3	1930.6	1929.1	1921.1
100	263.7	161	261	1938.8	1924.8	1916.2	1915.5
100	263.7	162	262	1945.2	1931.3	1923.0	1920.9
100	263.7	163	263	1949.9	1936.3	1929.8	1926.2
100	263.7	164	264	1956.1	1942.7	1936.5	1931.3
100	263.7	165	265	1960.7	1947.5	1943.2	1936.2
100	263.7	165	265	1960.7	1947.5	1943.2	1936.2

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