Mass Model of Elementary Particles (Integrated Version)

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Abstract

Elementary particles can be classified according to their spin quantum numbers and electric charges. As the three features of elementary particles are spin, electric charge and mass, they could also be classified according to their masses. Our work hypothesized a model for the masses of elementary particles, in which a formula for the mass of an elementary particle in a set of modified atomic units (called Hartree-Chen atomic units) consists of a Time Factor (TF) times a Space Factor (SF) along with at least one Sub-space Factor (SSF) in the format of $m_{P/au}=[TF(SF\pm\Sigma 1/SSF)]^{2,-2}$. It seems that elementary particles should have two genders, i.e., Yang and Yin according to the ± symbols before 1/SSF-1st, and the Yang/Yin ratio of all quarks and leptons is 1/2. With the model, all masses of elementary particles (including neutrinos and the particle of dark matter) in Hartree-Chen atomic units were calculated, the mystery of three generations of quarks and leptons could be explained, the matter-antimatter asymmetry problem of the universe could be solved, and the composition of the universe could be interpreted. In the end, a picture and a table of mass model of elementary particles are presented.

Keywords: elementary particles, mass, atomic units, three generations, matter-antimatter asymmetry, dark matter, dark energy.

1. Introduction

In physics, a dimensionless physical constant, sometimes called a fundamental physical constant, is a physical constant that is dimensionless [1]. It has no units attached and has a numerical value that is independent on the system of units used, cannot be derived from any more fundamental theory and are determined only from measurements. Standard Model of physics requires 25 fundamental physical constants including the fine-structure constant α, 15 elementary particles to electron mass ratios and the others. The desire for a theory that would allow the calculation of the masses of elementary particles is a core motivation to the search for "physics beyond Standard Model". In this paper, we present a hypothetical model for the masses of elementary particles.

2. Natural Number Axis and Some of its Applications

In our previous papers [2], we defined the natural number axis (NNA) and gave some of its applications especially in the world of nuclides or the subatomic world.

2.1 Definition of the Natural Number Axis (NNA)

A natural number axis (NNA) is defined to be an axis with natural numbers sequentially located on it, but a specific natural number on it stands for a specific length of a line as follows (Figure 1).

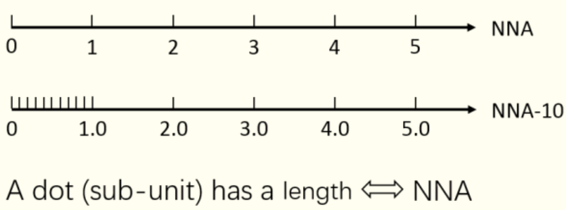


Figure 1. A natural number axis (NNA) and a 10-parts divided natural number axis (NNA-10)

On a NNA, a specific number such as 2 stands for a length from 1 to 2 or 0 to 2. Most importantly, NNA is continuous with no need to add any irrational numbers on it. And the length between two adjacent natural numbers on a NNA is called a unit of the NNA. For example, a unit of the above NNA has a length of 1.

Every unit of a NNA can be divided to a number of sub-units, for example, 10 or 100 equal parts. And hence the corresponding divided NNA can be called NNA-10 or NNA-100. A unit of a NNA-10 has a unit of 1.0 and a sub-unit of 0.1. A sub-unit of a NNA is defined as a dot of the NNA. A dot of a NNA has a length and even a width, and it can't be divided further. So if a place is located within a dot of a divided NNA, its value on this NNA must be the value of this dot no matter where it is exactly located in the dot. If a NNA-10 is amplified 10 times, its sub-unit will become a unit of a new NNA. So a dot with a length and a NNA with continuity are equivalent to each other.

2.2 A Square in a Natural Number Coordinate System with Diagonal length of a Rational Number

Use divided natural number axis x and y to compose a rectangular plane coordinate system which is called natural number coordinate system (NNCS), and a square is located in this coordinate system (Figure 2 and Figure 3).

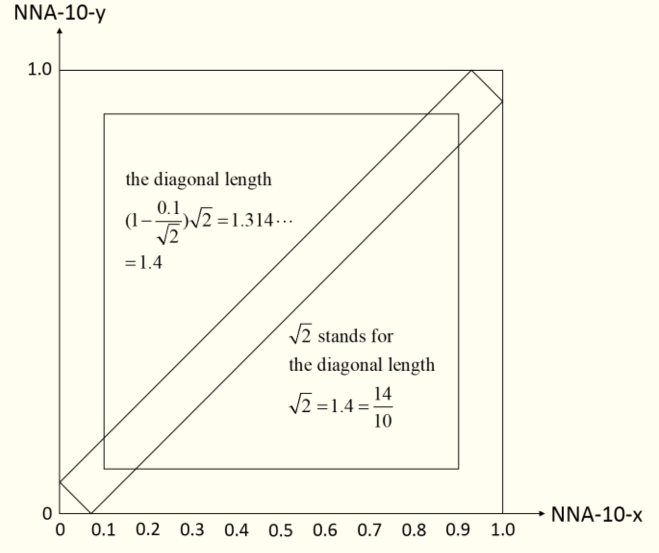


Figure 2. A square in NNCS-10 with a diagonal length of 1.4

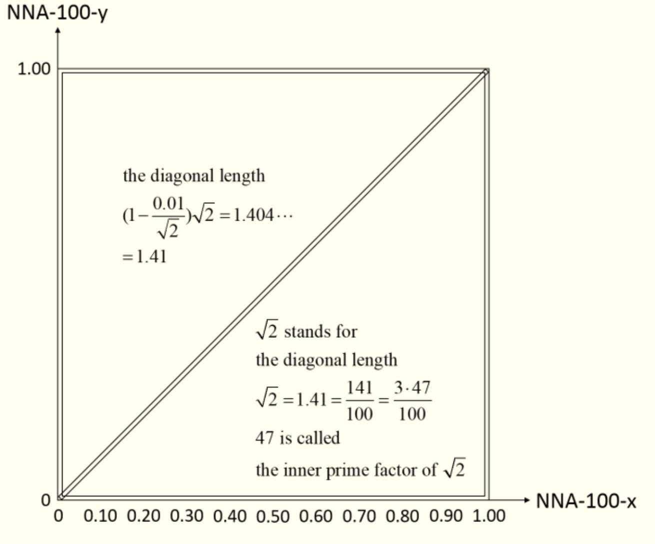


Figure 3. A square in NNCS-100 with a diagonal length of 1.41

The line length of these squares (l) is 1, and the line width of these squares (dl) is the sub-unit such as 0.1 or 0.01. Then the diagonal length of these squares would be 1.4 or 1.41 in the form of rational number especially in these natural number coordinate systems as the above.

So in divided natural number coordinate systems (NNCS), the diagonal length of the squares should be a series of rational numbers according to the ratios of width to length of the square lines (dl/l) as shown in Table 1.

NNCS	dl/l	Diagonal Length	Number
NNCS-10	0.1	1.4	rational
NNCS-100	0.01	1.41	rational
NNCS-1000	0.001	1.414	rational
NNCS-∞	1/∞	1.414…	irrational

Table 1. The diagonal lengths of the squares in NNCS

2.3 Relationships of the Square Root of 2, the Square Root of 3 and 2π with Nuclides

We found that a 100-parts divided natural number coordinate system (NNCS-100) should be the applicable coordinate system in the world of nuclides because in the subatomic world the dl/l value of a line should not be too small or too large. It seems that the centesimal system is also applicable in the world of nuclides like in human world. And these are rules of nature or stipulated by God. So in the world of nuclides, the square root of 2 must be a rational number such as 141/100 or its good approximate rational numbers such as 140/99 or 82/58 et al. The relationships between the square root of 2 and nuclides are shown as follows [2].

$$\sin\frac{\pi}{4}=\frac{\sqrt{2}}{2}=\frac{1.41}{2}=\frac{141}{2\cdot 100}\approx\frac{140}{2\cdot 99}\approx\frac{82}{2\cdot 58}$$

$${}^{140,142}_{58}Ce_{82,84} \quad {}^{141}_{59}\mathrm{Pr}_{82}$$

According to the above same reasons, in the world of nuclides, the square root of 3 must be a rational number such as 173/100 or its good approximate rational numbers such as 13/15 or 84/97. The relationships between the square root of 3 and nuclides are shown as follows [2].

$$\sin\frac{\pi}{3}=\frac{\sqrt{3}}{2}=\frac{1.73}{2}=\frac{173}{2\cdot 100}\approx\frac{13}{15}\approx\frac{84}{97}\approx\frac{97}{112}$$

$${}^{27}_{13}Al_{14} \quad {}^{31}_{15}P_{16} \quad {}^{56}_{26}Fe_{30} \quad {}^{97}_{42}Mo_{55} \quad {}^{168}_{68}Er_{100} \quad {}^{173}_{70}Yb_{103}$$

$${}^{13\cdot 19}_{97}Bk^{*}_{150} \quad {}^{264}_{103}Lr^{*}_{161} \quad {}^{15\cdot 19}_{112}Cn^{*}_{173} \quad {}^{2\cdot 173}_{137}Fy^{ie}_{209} \quad {}^{437}_{173}Ch^{ie}_{264}$$

According to the above same reason, in the world of nuclides, 2π must be a rational number such as 4×157/100 or its good approximate rational numbers such as 44/7 or 10×71/113. The relationships between 2π and nuclides are shown as follows [2-5].

$$2\pi=6.28=\frac{4\cdot 157}{100},\quad 2\pi=\frac{2\cdot 22}{7}=\frac{44}{7},\quad 2\pi=\frac{2\cdot 355}{113}=\frac{10\cdot 71}{113}$$

$${}^{48,49,50}_{22}Ti_{26,27,28} \quad {}^{100}_{44}Tm_{56} \quad {}^{157}_{64}Gd_{93} \quad {}^{257}_{100}Fm^{*}_{157} \quad {}^{4\cdot 71,22\cdot 13}_{113}Nh^{ie}_{171,173} \quad {}^{354}_{141}Ch^{ie}_{3\cdot 71} \quad {}^{400}_{157}Ch^{ie}_{243} \quad {}^{6\cdot 71}_{169}Ch^{ie}_{257}$$

2.4 The Square Root of 2 Plus the Square Root of 3 is Equal to π in the World of Nuclides

We found that 1.41+1.73=3.14 should not be a coincidence in the world of nuclides. In other words, the square root of 2 plus the square root of 3 is equal to π in the world of nuclides or in the subatomic world [2].

$$\text{We know: } \sin\frac{\pi}{4}=\frac{\sqrt{2}}{2}\approx\frac{1.41}{2},\ \sin\frac{\pi}{3}=\frac{\sqrt{3}}{2}\approx\frac{1.73}{2}$$

$$\text{and } 1.41+1.73=3.14,\ \pi\approx 3.14,\ \text{so: } \sqrt{2}+\sqrt{3}\approx\pi$$

However, in the subatomic world, especially when a centesimal natural number coordinate system (NNCS-100) is applicable,

the above $\approx$ should become $=$, so in the subatomic world:

$$\sqrt{2}+\sqrt{3}=\pi,\ \text{or}\ \frac{\sqrt{2}}{2}+\frac{\sqrt{3}}{2}=\frac{\pi}{2},$$

or $\sin\frac{\pi}{4}+\sin\frac{\pi}{3}=\frac{\pi}{2}$ (its geometric meaning is shown in Figure 4)

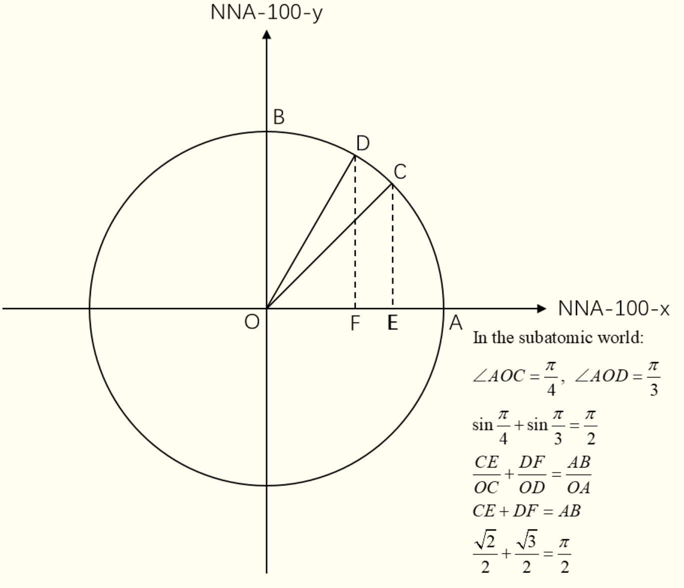


Figure 4. The square root of 2 plus the square root of 3 is equal to π in NNCS-100

3. The Formula of the Speed of Light in Atomic Units and its Relationships with the Square Roots of 2 and 3

In our previous papers [3-6], we gave 2π-e formula, the formulas of the fine-structure constant (α_1 and α_2) and the formula of the speed of light in atomic unites (c_{au}) as follows, and we found that there were 141=3×47 and 173 factors in the formula of c_{au} which should correspond to the square roots of 2 and 3.

$$2\pi-e\ \text{Formula: } (2\pi)_{Chen-k}=e^2\frac{e^2}{(\frac{2}{1})^3}\frac{e^2}{(\frac{3}{2})^5}\frac{e^2}{(\frac{4}{3})^7}\cdots\frac{e^2}{(\frac{k+1}{k})^{2k+1}}$$

$$\alpha_1=\frac{\lambda_e}{2\pi a_0}=\frac{36}{7(2\pi)_{Chen-112}}\frac{1}{112+\frac{1}{75^2}}=1/137.035999037435$$

$$\alpha_2=\frac{2\pi r_e}{\lambda_e}=\frac{13(2\pi)_{Chen-278}}{100}\frac{1}{112+\frac{1}{64\cdot 3\cdot 29}}=1/137.035999111818$$

$$\alpha_c=\frac{e^3}{4\pi\varepsilon_0\hbar c}=\frac{v_e}{c}=\frac{r_e}{a_0}=\sqrt{\alpha_1\alpha_2}=1/137.035999074626$$

$$c_{au}=\frac{c}{v_e}=\frac{1}{\alpha_c}=\frac{1}{\sqrt{\alpha_1\alpha_2}}=\sqrt{112(168-\frac{1}{3}+\frac{1}{12\cdot 47}-\frac{1}{14\cdot 112(2\cdot 173+1)})}$$
$$=137.035999074626$$

Note: $141=3\cdot 47$ and 173 should correspond to $\sqrt{2}$ and $\sqrt{3}$

c: the speed of light in vacuum

v_e: the line speed of the ground state electron of H atom in Bohr model

Relationship of the factors in the formula of c_{au} with nuclides:

$$ {}^{28}_{14}Si_{14} \quad {}^{56,58}_{26}Fe_{30,32} \quad {}^{83,84}_{36}Kr_{47,48} \quad {}^{100}_{44}Ru_{56} \quad {}^{103}_{45}Rh_{58} \quad {}^{107,109}_{47}Ag_{60,62} \quad {}^{112}_{48}Cd_{64} \quad {}^{126}_{52}Te_{74} $$

$$ {}^{136,137,138}_{56}Ba_{80,81,82} \quad {}^{140,142}_{58}Ce_{82,84} \quad {}^{141}_{59}\mathrm{Pr}_{82} \quad {}^{157,158}_{64}Gd_{93,94} \quad {}^{168}_{68}Er_{100} \quad {}^{169}_{69}Tm_{100} $$

$$ {}^{173}_{70}Yb_{103} \quad {}^{4\cdot 47}_{76}Os_{112} \quad {}^{209}_{83}Bi^{*}_{126} \quad {}^{209}_{84}Po^{*}_{125} \quad {}^{257}_{100}Fm^{*}_{157} \quad {}^{264}_{103}Lr^{*}_{161} \quad {}^{276}_{108}Hs^{*}_{168} \quad {}^{278}_{109}Mt^{*}_{169} $$

$$ {}^{285}_{112}Cn^{*}_{173} \quad {}^{2\cdot 57}_{126}Ch^{ie}_{4\cdot 47} \quad {}^{344,2\cdot\cdot 173,348}_{136,137,138}Fy^{ie}_{208,209,210} \quad {}^{6\cdot 59}_{141}Ch^{ie}_{213} \quad {}^{420}_{168}Ch^{ie}_{252} \quad {}^{437}_{173}Ch^{ie}_{264} $$

4. Hartree-Chen Atomic Units and the Exact Value of Planck's Constant

We suppose that Hartree atomic units (au) should have some drawbacks and could be redefined to a more scientific or more natural system which we would name Hartree-Chen atomic units (still abbreviated as au) as follows [7].

Hartree Atomic Units (au):

$$\hbar_{au} = e_{au} = a_{0/au} = m_{e/au} = 1$$

$$\hbar_{au} = \frac{h_{au}}{2\pi} = 1, \ h_{au} = 2\pi$$

Hartree-Chen Atomic Units (still abreviated as au):

$$\hbar_{au} = e_{au} = a_{0/au} = 1$$

$$m_{e/au} = 1 + \frac{1}{c_{au}{}^{4}}, \ m_{e^{+}/au} = 1 - \frac{1}{c_{au}{}^{4}}$$

$$\hbar_{au} = \frac{h_{au}}{(2\pi)_{au}} = 1, \ \ h_{au} = (2\pi)_{au} = \frac{4\times 157}{100} = 6.28$$

$$c_{au} = \frac{c}{v_e} = \sqrt{112(168 - \frac{1}{3} + \frac{1}{12\cdot 47} - \frac{1}{14\cdot 112(2\cdot 173+1)})}$$

$$= 137.035999074626$$

Note: in the subatomic world, $\sqrt{2}$, $\sqrt{3}$ and π express as rational numbers

$$(\sqrt{2})_{au} = \frac{3\times 47}{100} = 1.41, \ (\sqrt{3})_{au} = \frac{173}{100} = 1.73, \ (\pi)_{au} = \frac{2\times 157}{100} = 3.14$$

$$(\sqrt{2})_{au} + (\sqrt{3})_{au} = (\pi)_{au}, \ 1.41 + 1.73 = 3.14$$

$$(\frac{\sqrt{2}}{2})_{au} + (\frac{\sqrt{3}}{2})_{au} = (\frac{\pi}{2})_{au}, \ (\sin\frac{\pi}{4})_{au} + (\sin\frac{\pi}{3})_{au} = (\frac{\pi}{2})_{au}$$

$$\text{so: } (2\pi)_{au} = \frac{4\times 157}{100} = 6.28$$

Planck's constant h has the exact value of 6.62607015 J/Hz in SI units, and the reduced Planck's constant ħ is defined to be h/2π. In Hartree atomic units (au), the reduced Planck constant $\hbar_{au}$ is 1, so in Hartree atomic units the Planck constant h_{au} should be equal to 2π ($h_{au}=2\pi$). As atomic units should be the real scientific units, so $h_{au}=2\pi$ should be reasonable in the subatomic world. According to ordinary mathematical and physical concepts, $h_{au}=2\pi$ should be an irrational number. However, in our previous paper [2], we define the natural number axis (NNA) and the natural number coordinate system (NNCS), and suppose that in the world of nuclides or in the subatomic world, NNA-100 and NNCS-100 would be applicable, so in the subatomic world the square root of 2, the square root of 3 and π should become rational numbers of 1.41, 1.73 and 3.14 with the coincident proof of 1.41+1.73=3.14. So we hypothesize that the value of the Planck constant in Hartree-Chen atomic units should be exactly 6.28, i.e., h_{au}=6.28.

5. General Formulas for the Masses of Elementary Particles in Atomic Units

In our previous papers [3-6], we presented two series of formulas of the fine-structure constant giving two values of it (α_1 and α_2). With them, we accurately calculated the speed of light in vacuum in atomic units (c_{au}) as follows.

$$c_{au} = \frac{c}{v_e} = \frac{1}{\alpha_c} = \frac{1}{\sqrt{\alpha_1 \alpha_2}}$$

$$= \sqrt{112(168 - \frac{1}{3} + \frac{1}{12\cdot 47} - \frac{1}{14\cdot 112(2\cdot 173+1)})} = 137.035999074626$$

Note: $112 = 2\times 56$, $168 = 3\times 56$, $3\times 47 = 141$

56 is supposed to be the most stable number in nuclides

141 and 173 are related to $\sqrt{2}$ and $\sqrt{3}$ respectively

$c_{au} = \frac{1}{\sqrt{\alpha_1\alpha_2}}$ is consistent with Maxwell's formula $c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$

μ_0: magnetic permeability of vacuum; ε_0: electric permittivity of vacuum

So in the formula of c_{au}, we suppose:

112 is Magnetic Field Factor (MFF),

$168 - \frac{1}{3} + \frac{1}{12\cdot 47} - \frac{1}{14\cdot 112(2\cdot 173+1)}$ is Electric Field Factor (EFF).

In Hartree-Chen atomic units (au) and for an elementary particle,

Einstein's $E = mc^2$ equation should be as follows:

$$E_{au} = m_{P/au} c_{au}^{\ 2} \qquad (1)$$

$$m_{P/au} = \frac{m_P}{m_e / (1 + 1/c_{au}^{\ 4})} \qquad (2)$$

$$c_{au}^{\ 2} = 112(168 - \frac{1}{3} + \frac{1}{12\cdot 47} - \frac{1}{14\cdot 112(2\cdot 173+1)}) \qquad (3)$$

Considering $m_{P/au}$ might have the similar format as c_{au}, we hypothesized the general formula for the masses of elementary particles in Hartree-Chen atomic units ($m_{P/au}$) might have the following form (Eq. (4)), and hence we developed a model for the masses of elementary particles [8-10].

$$m_{P/au} = \frac{m_P}{m_e / (1 + 1/c_{au}^{\ 4})} = [TF(SF \pm \sum 1/SSF)]^{2,\ -2} \qquad (4)$$

TF: Time Factor (Wheel Factor)

SF: Space Factor (Gear Factor); SSF: Sub-space Factor (Cog Factor)

It is notable that according to Einstein's theory of general relativity, mass is correlated with time and space, so the general formula for the masses of elementary particles in Hartree-Chen atomic units ($m_{P/au}$) is supposed to consist of Time Factor (TF) and Space Factor (SF). And Time Factor is "tight" like time, Space Factor is "inclusive" like space.

6. Formulas and Values for the Masses of Elementary Particles in au

Based on Eq. (4), formulas and values for the masses of elementary particles in Hartree-Chen atomic units (au) are hypothesized in Table 2. The measured masses of elementary particles are adopted from Wikipedia or CODATA. The formulas and values for the masses of neutrinos are guessed out according to the already known conditions.

The formula and value for the mass of the particle of dark matter is guess out and will be explained in Section 8.10.

EP	Meassured Mass (MeV)	Measured m_{P}/m_{e}	Formulas of $m_{P/au}$	Calculated $m_{P/au}$
τ	1776.86(12)	3477.23(23)	$\{8[8-1+1/2-1/7+1/(72-13808/10^{10}]\}^2$	3477.25497631580
μ	105.6583755(23)	206.7682830(45)	$\{4[4-1/2+1/10-1/194+1/68786]\}^2$	206.768283056676
e	0.51099895000(15)	1	$\{1[1+1/(2c_{au}^4)]\}^2$ or $1+1/c_{au}^4$	1.00000000283571
t	$172.76(30)\times10^3$	$3.3808(59)\times10^5$	$[24(24+1/4-1/43]^2$	338074
b	$4.18(3)\times10^3$	$8.18(6)\times10^3$	$[10(10-1+1/23)]^2$	8178
c	1275(+35, -25)	2495(+68, -49)	$[7(7+1/7-1/116]^2$	2494
s	95(+9, -3)	186(+18, -6)	$[4(4-1+1/2-1/11)]^2$	186
u	2.01(14)	3.93(27)	$[1(2-1/56)]^2$	3.93
d	4.79(16)	9.37(31)	$[1(3+1/16)]^2$	9.38
ν_1			$1/\{66[68-1/3/(1-1/12)]\}^2$	5.01824×10^{-8}
ν_2			$1/[66(66-1/6)]^2$	5.29688×10^{-8}
ν_3			$1/\{55[55-1/2(1-1/56)]\}^2$	1.11334×10^{-7}
ν_e			$1/[66(62-1+1/5-1/194)]^2$	6.13031×10^{-8}
ν_μ			$1/\{66[57-1+1/2-1/(56+37/75)]\}^2$	7.19594×10^{-8}
ν_τ			$1/\{55[64-1/4+1/(21+13/38)]\}^2$	8.12225×10^{-8}
H	$125.35(15)\times10^3$	$2.4530(29)\times10^5$	$\{22[22+1-1/2+1/85-1/(16758+2/25)]\}^2$	245280.001934332
Z	$91187.6(21)\times10^3$	178450(4)	$\{20[22-1+1/8-1/(300+1/3126)]\}^2$	178449.921171171
W	80433.5(9.4)	157404(18)	$\{20[20-1/6+1/(222-4/17)]\}^2$	157415.999881172
D			$\{33[34+1/2-1/68+1/(79954-43/80)]\}^2$	1295078.41021327

Notes: 1. $1/c_{au}^4=(\alpha_1\alpha_2)^2=2.83571\times10^{-9}$; 2. In Measured Mass column, values for u and d are Lattice QCD calculated values; 3. D stands for the particle of dark matter.

Table 2. Formulas and values for the masses of elementary particle in Hartree-Chen atomic units

7. Factors in the Formulas for the Masses of Elementary Particles in au

We extract Time Factors (TF), Space Factors (SF) and Sub-space Factors (SSF) from the above formulas for the masses of elementary particles in Hartree-Chen atomic units (au) and try to look for their common rules (Table 3).

Particles	TF	SF	SSF-1st	SSF-2nd	SSF-3rd	SSF-4th
t	$24=3\times7+3$	24	4	43		
c	$7=2\times3+1$	7	7	116		
d	1	3	16			
e	1	1	$2c_{au}^4$			

b	10=2×4+2	10	1	23		
τ	8=2×4	8	1	2	7	$72-13808/10^{10}$
s	4=2×2	4	1	2	11	
μ	4=2×2	4	2	10	2×97	2×163(2×3×5×7-1)
u	1	2	56			
ν_1	66	68	3(1-1/12)			
ν_2	66	66	6			
ν_3	55	55	2(1-1/56)			
ν_e	66	62	1	5	2×97	
ν_μ	66	57	1	2	56+37/75	
ν_τ	55	64	4	21+13/38		
D	33	34	2	4×17	2×7(16×3×7×17-1)-43/80	
H	22=2×10+2	22	1	2	5×17	2×9×49×19+2/25
Z	20=2×10	22	1	8	300+1/[2×3×(2×9×29-1)]	
W	20=2×10	20	6	6×37-4/17		

Notes: Azure indicates Yang particle and positive SSF-1st;
Orange indicates Yin particle and negative SSF-1st.

Table 3. Factors in the formulas for the masses of elementary particles in au

8. Mass Model of Elementary Particles

8.1 Format of Formulas for the Masses of Elementary Particles

A Formula of the mass of an elementary particle in Hartree-Chen atomic units (au) basically consists of a Time Factor (TF) times a Space Factor (SF) and then totally squared or minus squared, and Space Factor is modified by reciprocals of some Sub-space Factors (SSF). For example, the formula for the Higgs boson mass in au is: $m_{H/au}=\{22[22+1/2-1/85+1/(16758+2/25)]^2=245280.001934332$, in which TF=SF=22, SSF-1st=+2 and so on. Time Factor is like a wheel, Space Factor is like a gear, Sub-space Factors (especially SSF-1st) are like cogs (convex and concave) on the gear.

8.2 Two Genders: Yang and Yin

According to the positive or negative features of 1/SSF-1st, elementary particles with mass can be classified into two types: Yang (+, Convex, azure), Yin (-, Concave, orange). And elementary particles without mass are Neutral (0, Smooth, white).

8.3 Yang to Yin Ratios

As shown in Table 3, in all elementary particles, fermion's Yang to Yin ratio is 1/2, and boson's Yang to Yin to Neutral ratio is 1/1/1. This can explain why quarks and leptons have three generations, it is because these 12 fermions (6 quarks plus 6 leptons) maintain Yang to Yin ratio to be 1/2 (4 Yang to 8 Yin) and also maintain the ratio of positive to negative total amount of electric charges to be +1/-2 (+2 charges to -4 charges for quarks and leptons totally).

8.4 Genders of Particles and Anti-particles

If elementary particles switch to their anti-particles, the Yang gender of electron changes to Yin gender of positron, the Yin gender of neutrinos change to Yang gender of anti-neutrinos, and those of other particles do not change. So the Yang to Yin ratio of anti-quarks and anti-leptons should be 1/1. The Yang to Yin ratio of quarks and leptons of 1/2 should be stable, and Yang to Yin ratio of anti-quarks and anti-leptons of 1/1 should be not stable, so there should be no anti-matter world or anti-matter universe.

8.5 Explanations to the Stability of Proton and Neutron

A proton consists of a u quark and two d quarks, the ratio of Yang to Yin in a proton is 1/2, the same as that for quarks and leptons, so proton is stable. A neutron consists of two d quarks and a u quark, the ratio of Yang to Yin in a neutron is 2/1, the opposite to that for quarks and leptons, so independent neutron is not stable.

8.6 The Mass Difference between Electron and Positron and the Matter-Antimatter Asymmetry Problem

In Hartree-Chen atomic units, the mass of an electron is defined as $\{1[1+1/(2\ c_{au}^4)]\}^2$ or $1+1/c_{au}^4$, and the mass of positron is defined as $\{1[1-1/(2\ c_{au}^4)]\}^2$ or $1-1/c_{au}^4$. So electron is Yang particle and positron is Yin particle. The reactions at the Big Bang of the universe and the subsequent annihilation could be expressed as follows [7].

$$2\gamma_0 \to e + e^+$$

$$e + e^+ \to (m_r + m_d)\ +\ 2\gamma_1$$

$$m_{e/au} = 1 + \frac{1}{c_{au}{}^4},\quad m_{e^+/au} = 1 - \frac{1}{c_{au}{}^4}$$

$$\left.\begin{aligned} m_r + m_d &= \frac{2}{c_{au}{}^4} \approx 5.671\times10^{-9} \\ \frac{m_r}{m_r+m_d} &= \frac{1}{(2\pi)_{au}} = \frac{1}{6.28} \end{aligned}\right\} \Rightarrow \frac{m_r}{m_d} \approx \frac{0.903\times10^{-9}}{4.768\times10^{-9}} = \frac{5.07\%}{26.78\%}$$

γ_0 : the original light of the universe to create electron and positron in the Big Bang

γ_1 : the subsequent light of the universe after annihilation of electron and positron

m_r : mass of regular matter

m_d : mass of dark matter

According to $E = h\nu$ and $E = mc^2$:

$$h_{au}\nu_{0/au} = \frac{m_{e/au} + m_{e^+/au}}{2} c_{au}{}^2,\quad h_{au}\nu_{1/au} = m_{e^+/au} \times c_{au}{}^2$$

$$h_{au}\nu_{0/au} = 1\times c_{au}{}^2,\quad h_{au}\nu_{1/au} = (1 - \frac{1}{c_{au}{}^4})\times c_{au}{}^2$$

ν_0: the frequence of γ_0; ν_1: the frequence of γ_1

$$\nu_{0/au} = \frac{1\times[112(168 - \frac{1}{3} + \frac{1}{12\cdot 47} - \frac{1}{14\cdot 112(2\cdot 173+1)})]}{4\cdot 157/100} = 2990.26513413709$$

Relationships with nuclides:

$${}^{83,84}_{36}Kr_{47,48}\quad {}^{100}_{44}Ru_{56}\quad {}^{103}_{45}Rh_{58}\quad {}^{107,109}_{47}Ag_{60,62}\quad {}^{112}_{48}Cd_{64}\quad {}^{136,137,138}_{56}Ba_{80,81,82}\quad {}^{140,142}_{58}Ce_{82,84}\quad {}^{141}_{59}\mathrm{Pr}_{82}$$

$${}^{157}_{64}Gd_{93}\quad {}^{168}_{68}Er_{100}\quad {}^{169}_{69}Tm_{100}\quad {}^{173}_{70}Yb_{103}\quad {}^{4\cdot 47}_{76}Os_{112}\quad {}^{209}_{83}Bi^{*}_{126}\quad {}^{209}_{84}Po^{*}_{125}\quad {}^{223}_{87}Fr^{*}_{136}\quad {}^{257}_{100}Fm^{*}_{157}\quad {}^{262}_{103}Lr^{*}_{159}$$

$${}^{276}_{108}Hs^{*}_{168}\quad {}^{285}_{112}Cn^{*}_{173}\quad {}^{2\cdot 157}_{126}Ch^{ie}_{4\cdot 47}\quad {}^{344,2\cdot\cdot 173,348}_{136,137,138}Fy^{ie}_{208,209,210}\quad {}^{6\cdot 59}_{141}Ch^{ie}_{213}\quad {}^{400}_{157}Ch^{ie}_{243}\quad {}^{420}_{168}Ch^{ie}_{252}\quad {}^{435}_{173}Ch^{ie}_{262}$$

$$\nu_{0/au} = [5(11 - \frac{1}{15} + \frac{1}{300} - \frac{1}{9(2\cdot 97\cdot 173+1) - \frac{2\cdot 5}{3\cdot 7}})]^2 = 2990.26513413709$$

$${}^{10,11}_{5}B_{5,6}\quad {}^{19}_{9}F_{10}\quad {}^{97}_{42}Mo_{55}\quad {}^{163}_{66}Dy_{97}\quad {}^{173}_{70}Yb_{103}\quad {}^{13\cdot 19}_{97}Bk^{*}_{150}\quad {}^{15\cdot 19}_{112}Cn^{*}_{173}\quad {}^{2\cdot 173}_{137}Fy^{*}_{11\cdot 19}\quad {}^{15\cdot 29}_{173}Ch^{ie}_{262}$$

$$\nu_{0/au}=[5(11-\frac{1}{15}+\frac{1}{300}-\frac{1}{2\cdot(90-1)(2\cdot 3(2\cdot 3\cdot 47+1)-1)+\frac{11}{3\cdot 7}})]^2$$

$$=2990.26513413709$$

$${}^{47}_{22}Ti_{25}\quad {}^{83}_{36}Kr_{47}\quad {}^{90}_{40}Zr_{50}\quad {}^{107,109}_{47}Ag_{60,62}\quad {}^{140,142}_{58}Ce_{82,84}\quad {}^{141}_{59}Pr_{82}\quad {}^{152}_{62}Sm_{90}\quad {}^{21\cdot 11,232}_{90}Th^{*}_{141,142}\quad {}^{6\cdot 59}_{141}Ch^{ie}_{213}$$

$$\nu_{1/au}=\frac{m_{e^+/au}c_{au}{}^2}{h_{au}}=\frac{(1-\frac{1}{c_{au}{}^4})c_{au}{}^2}{h_{au}}$$

$$=\frac{(1-\frac{1}{137.035999074626^4})\times[112(168-\frac{1}{3}+\frac{1}{12\cdot 47}-\frac{1}{14\cdot 112(2\cdot 173+1)})]}{4\cdot 157/100}$$

$$=2990.26512565757$$

$$\nu_{1/au}=[5(11-\frac{1}{15}+\frac{1}{300}-\frac{1}{2(2\cdot 3\cdot 5(2\cdot 3\cdot 5(2\cdot 83+1)+1)-1)+\frac{11}{47}})]^2$$

$$=2990.26512565757$$

$${}^{47}_{22}Ti_{25}\quad {}^{83}_{36}Kr_{47}\quad {}^{107,109}_{47}Ag_{60,62}\quad {}^{140,142}_{58}Ce_{82,84}\quad {}^{11\cdot 19}_{83}Bi^{*}_{126}\quad {}^{240}_{94}Pu^{*}_{146}\quad {}^{300}_{120}Ch^{ie}_{180}$$

$$\nu_{1/au}=[5(11-\frac{1}{15}+\frac{1}{300}-\frac{1}{47(4\cdot 3\cdot 13\cdot 41+1)-\frac{36}{47}})]^2$$

$$=2990.26512565757$$

$${}^{47}_{22}Ti_{25}\quad {}^{82,83}_{36}Kr_{46,47}\quad {}^{107,109}_{47}Ag_{60,62}\quad {}^{124,126}_{52}Te_{72,74}\quad {}^{140,142}_{58}Ce_{82,84}\quad {}^{141}_{59}\mathrm{Pr}_{82}\quad {}^{206,208}_{82}Pb_{124,126}\quad {}^{11\cdot 19}_{83}Bi^{*}_{126}$$

$$\nu_{0/au}=2\cdot 5\cdot 13\cdot 23+\frac{1}{3}-\frac{1}{14}+\frac{1}{3\cdot 103}-\frac{1}{3\cdot 5\cdot 31(2\cdot 157-1)-\frac{17}{19}}=2990.26513413709$$

$$\nu_{1/au}=2\cdot 5\cdot 13\cdot 23+\frac{1}{3}-\frac{1}{14}+\frac{1}{310}-\frac{1}{2\cdot 243(2\cdot 11\cdot 19+1)-\frac{3}{8}}=2990.26512565757$$

$${}^{27}_{13}Al_{14}\quad {}^{31}_{15}P_{16}\quad {}^{56}_{26}Fe_{30}\quad {}^{100}_{44}Ru_{56}\quad {}^{103}_{45}Rh_{58}\quad {}^{136,137,138}_{56}Ba_{80,81,82}\quad {}^{157}_{64}Gd_{3\cdot 31}\quad {}^{168}_{68}Er_{100}\quad {}^{169}_{69}Tm_{100}$$

$${}^{173}_{70}Yb_{103}\quad {}^{11\cdot 19}_{83}Bi^{*}_{126}\quad {}^{11\cdot 19}_{84}Po^{*}_{125}\quad {}^{243}_{95}Am^{*}_{148}\quad {}^{257}_{100}Fm^{*}_{157}\quad {}^{264}_{103}Lr^{*}_{7\cdot 23}\quad {}^{15\cdot 19}_{112}Ch^{*}_{173}\quad {}^{310}_{124}Ch^{ie}_{186}\quad {}^{2\cdot 157}_{126}Ch^{ie}_{188}$$

$${}^{344,2\cdot 173,346}_{136,137,138}Fy^{ie}_{16\cdot 13,11\cdot 19,210}\quad {}^{400}_{157}Ch^{ie}_{243}\quad {}^{19\cdot 23}_{173}Ch^{ie}_{264}$$

So in the universe after the Big Bang and the subsequent annihilation of electron and positron, 0.90×10^{-9} of regular matter and 4.77×10^{-9} of dark matter survived [7, 8].

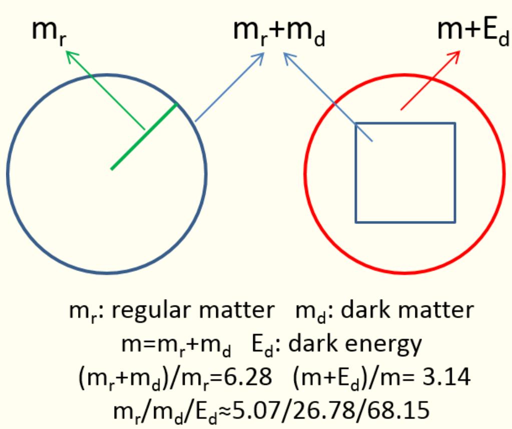


Figure 5. Composition of the Universe

This can explain the mystery of the matter and antimatter imbalance in the universe, and can explain the composition of regular matter and dark matter in the universe (Figure 5). And our results are consistent with the latest accurate measurements [11-16].

8.7 Determination of the Higgs Boson Mass

We use the general formula of mass model of the elementary particles (Eq. 4) to determine the Higgs boson mass in Hartree-Chen atomic units (au). It is also supposed that the factors in the formula for the Higgs boson mass in au are meaningful and related to nuclides [9].

Electron mass： $m_e = 0.51099895000(15)$ MeV

the CERN measured mass of the Higgs boson (2016)： $m_H = 125.35(15)$ GeV

The mass ratio of the Higgs boson to electron:

$$\frac{m_H}{m_e} = \frac{125.35(15)\times 10^3}{0.51099895000(15)} = 2.4530(29)\times 10^5 \ \ (245010 - 245597)$$

Based on our mass model of the elemetary particles, we constructed the following formulas for the Higgs boson mass in Hartree-Chen atomic units (au):

$$m_{H/au} = \frac{m_H}{m_e/(1+1/c_{au}{}^4)}$$

$$= [22(22+1-\frac{1}{2}+\frac{1}{5\cdot 17}-\frac{1}{2\cdot 9\cdot 49\cdot 19+\frac{2}{25}})]^2 = 32\cdot 3\cdot 5\cdot 7\cdot 73+\frac{1}{11\cdot 47-\frac{1}{39}}$$

$$= 245280.001934332$$

It is supposed that the integer part of the ratio having as many small prime factors as possible is special and more meaningful in their relationships with nuclides.

${}^{20,21,22}_{10}Ne_{10,11,12}$ ${}^{23}_{11}Na_{12}$ ${}^{24,25,26}_{12}Mg_{12,13,14}$ ${}^{27}_{13}Al_{14}$ ${}^{28,29,30}_{14}Si_{14,15,16}$ ${}^{31}_{15}P_{16}$ ${}^{32,33,34}_{16}S_{16,17,18}$ ${}^{35,37}_{17}Cl_{18,20}$

${}^{47,48,50}_{22}Ti_{25,26,28}$ ${}^{50,52,54}_{24}Cr_{26,28,30}$ ${}^{54,56,57,58}_{26}Fe_{28,30,31,32}$ ${}^{58,60,62}_{28}Ni_{30,32,34}$ ${}^{63,65}_{29}Cu_{34,36}$ ${}^{64,66,68}_{30}Zn_{34,36,38}$

${}^{70,72,73,74,76}_{32}Ge_{38,40,41,42,44}$ ${}^{79,81}_{35}Br_{44,46}$ ${}^{83.84}_{36}Kr_{47,48}$ ${}^{85,87}_{37}Rb_{48,50}$ ${}^{89}_{39}Y_{50}$ ${}^{90,92,94,96}_{40}Zr_{50,52,54,56}$ ${}^{100}_{44}Ru_{56}$

${}^{107,109}_{47}Ag_{60,62}$ ${}^{112}_{48}Cd_{64}$ ${}^{114,118,119,120}_{50}Sn_{64,68,69,70}$ ${}^{125,126}_{52}Te_{73,74}$ ${}^{136,137,138}_{56}Ba_{80,81,82}$ ${}^{140,142}_{58}Ce_{82,84}$

${}^{3\cdot 47}_{59}\mathrm{Pr}_{82}$ ${}^{143,144,145,146}_{60}Nd_{83,84,85,86}$ ${}^{145,146}_{61}Pm^{*}_{84,85}$ ${}^{154,156,157,158,160}_{64}Gd_{90,92,93,2\cdot 47,96}$ ${}^{168}_{68}Er_{100}$ ${}^{169}_{69}Tm_{100}$

${}^{173}_{70}Yb_{103}$ ${}^{180,181}_{73}Ta_{107,108}$ ${}^{4\cdot 47}_{76}Os_{112}$ ${}^{200}_{80}Hg_{120}$ ${}^{209}_{83}Bi^{*}_{126}$ ${}^{209}_{84}Po^{*}_{125}$ ${}^{210}_{85}At^{*}_{125}$ ${}^{223}_{87}Fr^{*}_{136}$ ${}^{235,14\cdot 17}_{92}U^{*}_{143,146}$

${}^{257}_{100}Fm^{*}_{157}$ ${}^{285}_{112}Cn^{*}_{173}$ ${}^{2\cdot 157}_{126}Ch^{ie}_{4\cdot 47}$ ${}^{344,2\cdot 173,348}_{137}Fy^{ie}_{208,209,210}$ ${}^{6\cdot 59}_{141}Ch^{ie}_{213}$ ${}^{370}_{146}Ch^{ie}_{224}$ ${}^{400}_{157}Ch^{ie}_{243}$ ${}^{435}_{173}Ch^{ie}_{262}$

Among the above nuclides, the following are more important and meaningful:

${}^{47,48,50}_{22}Ti_{25,26,28}$ ${}^{83.84,86}_{36}Kr_{47,48,50}$ ${}^{107,109}_{47}Ag_{60,62}$ ${}^{85,87}_{37}Rb_{48,50}$ ${}^{145,146}_{61}Pm^{*}_{84,85}$ ${}^{4\cdot 47}_{76}Os_{112}$ ${}^{209}_{83}Bi^{*}_{126}$

${}^{210}_{85}At^{*}_{125}$ ${}^{235,14\cdot 17}_{92}U^{*}_{143,146}$ ${}^{2\cdot 157}_{126}Ch^{ie}_{4\cdot 47}$ ${}^{370}_{146}Ch^{ie}_{224}$

So the exact value of the Higgs boson mass should be:

$$m_H = m_{H/au}\frac{m_e}{1+1/c_{au}{}^4} = 245280.001934332\times\frac{0.51099895000(15)}{1+1/137.035999074626^4}$$

$$= 125.33782309(4) \text{ GeV}$$

If a Higgs boson became a photon, what would be its frequency?

$$h_{au}\nu_{H/au} = m_{H/au}c_{au}{}^2$$

$$\nu_{H/au} = \frac{m_{H/au}c_{au}{}^2}{h_{au}} = \frac{245280.001934332\times 137.035999074626^2}{6.28} = 733452237.885311$$

$$\nu_{H/au} = 2(16\cdot 3\cdot 5\cdot 7\cdot 17-1)(8\cdot 3\cdot 5\cdot 107+1)-\frac{1}{8}+\frac{1}{97-\frac{1}{66}} = 733452237.885311$$

$$ {}^{32,33,34,36}_{16}S_{16,17,18,20} \quad {}^{35,37}_{17}Cl_{18,20} \quad {}^{56}_{26}Fe_{30} \quad {}^{58,60,61,62,64}_{28}Ni_{30,32,33,34,36} \quad {}^{64,66.68,70}_{30}Zn_{34,36,38,40} \quad {}^{75}_{33}As_{42} \quad {}^{85,87}_{37}Rb_{48,50} $$

$$ {}^{74,76,80,82}_{34}Se_{40,42,46,48} \quad {}^{96,97}_{42}Mo_{54,55} \quad {}^{99,100}_{44}Ru_{55,56} \quad {}^{107,109}_{47}Ag_{60,62} \quad {}^{112}_{48}Cd_{64} \quad {}^{116,118,119}_{50}Sn_{66,68,69} \quad {}^{136,137}_{56}Ba_{80,81} $$

$$ {}^{162,163}_{66}Dy_{96,97} \quad {}^{167,168}_{68}Er_{99,100} \quad {}^{180,181}_{73}Ta_{107,108} \quad {}^{188}_{76}Os_{112} \quad {}^{200}_{80}Hg_{120} \quad {}^{210}_{85}At^{*}_{125} \quad {}^{223,224}_{87}Fr^{*}_{136,137} \quad {}^{2\cdot137}_{107}Bh^{*}_{167} \quad {}^{285}_{112}Cn^{*}_{173} $$

8.8 Determination of the W Boson Mass

Before 2022, measurements of the W boson mass appeared to be consistent with the Standard Model. For example, in 2018, experimental measurements of the W boson mass were assessed to converge around 80379(12) MeV [17,18]. However, in April 2022, a new analysis of data that was obtained by the Fermilab Tevatron collider before its closure in 2011 determined the mass of the W boson to be 80433(9) MeV [17, 19, 20], which is seven standard deviations above that predicted by the Standard Model.

We use the general formula of mass model of the elementary particles (Eq. 4) to determine the W boson mass in Hartree-Chen atomic units (au). It is also supposed that the factors in the formulas for the W boson mass in au are meaningful and related to nuclides [10].

Electron mass： $m_e = 0.51099895000(15)$ MeV

the measured mass of the W boson (2018)： $m_W = 80379(12)$ MeV

the measured mass of the W boson (2022)： $m_W = 80433.5(9.4)$ MeV

The mass ratio of the W boson to electron:

$$ \frac{m_W}{m_e} = \frac{80433.5(9.4)\times10^3}{0.51099895000(15)} = 157404(18)\ (157386-157423) $$

$$ m_{W/au} = \frac{m_W}{m_e/(1+1/c_{au}{}^4)} = ? $$

$$ m_{W/au} = \frac{m_W}{m_e/(1+1/c_{au}{}^4)} = [20(20-\frac{1}{6}+\frac{1}{6\cdot37-\frac{4}{17}})]^2 = [20(20-\frac{1}{6}+\frac{1}{13\cdot17+\frac{13}{17}})]^2 $$

$$ =157415.999881172 $$

$$ m_{W/au} = 8\cdot3\cdot7(2\cdot7\cdot67-1)-\frac{1}{9\cdot5\cdot11\cdot17+\frac{13}{25}} = 8\cdot3\cdot7(8\cdot9\cdot13+1)-\frac{1}{9\cdot5\cdot11\cdot17+\frac{13}{25}} $$

$$ =157415.999881172 $$

Relationships with the nuclides:

$$ {}^{27}_{13}Al_{14} \quad {}^{28,29,30}_{14}Si_{14,15,16} \quad {}^{35,37}_{17}Cl_{18,20} \quad {}^{40}_{20}Ca_{20} \quad {}^{45}_{21}Sc_{24} \quad {}^{55}_{25}Mn_{30} \quad {}^{54,56,58}_{26}Fe_{28,30,32} \quad {}^{60,61,62,64}_{28}Ni_{32,33,34,36} $$

$$ {}^{64,66,67,68}_{30}Zn_{34,36,37,38} \quad {}^{75}_{33}As_{42} \quad {}^{85,87}_{37}Rb_{48,50} \quad {}^{98,99,100}_{44}Ru_{54,55,56} \quad {}^{112}_{48}Cd_{64} \quad {}^{9\cdot13,118}_{50}Sn_{67,68} \quad {}^{125,126}_{52}Te_{73,74} $$

$$ {}^{9\cdot17}_{55}Cs_{6\cdot13} \quad {}^{136,137,138}_{56}Ba_{80,81,82} \quad {}^{15\cdot11}_{67}Ho_{98} \quad {}^{166,168}_{68}Er_{99,100} \quad {}^{5\cdot37,11\cdot17}_{75}\mathrm{Re}_{110,112} \quad {}^{188}_{76}Os_{112} \quad {}^{208}_{82}Pb_{126} \quad {}^{209}_{83}Bi^{*}_{126} $$

$$ {}^{209}_{84}Po^{*}_{125} \quad {}^{210}_{85}At^{*}_{125} \quad {}^{6\cdot37}_{86}Rn^{*}_{8\cdot17} \quad {}^{223}_{87}Fr^{*}_{136} \quad {}^{276}_{108}Hs^{*}_{168} \quad {}^{285}_{112}Cn^{*}_{173} \quad {}^{24\cdot13}_{125}Ch^{ie}_{11\cdot17} \quad {}^{314}_{126}Ch^{ie}_{188} \quad {}^{344,2\cdot173,348}_{136,137,138}Fy^{ie}_{208,209,210} $$

So the mass of the W boson should be:

$$ m_W = m_{W/au}\frac{m_e}{1+1/c_{au}{}^4} = 157415.999881172\times\frac{0.51099895000(15)}{1+1/137.037999074626^4} $$

$$ =80439.410424(24)\ \text{MeV} $$

If a W boson became a photon, what would be its frequency?

$$ h_{au}\nu_{W/au} = m_{W/au}c_{au}{}^2 $$

$$ \nu_{W/au} = \frac{m_{W/au}c_{au}{}^2}{h_{au}} = \frac{157415.999881172\times137.035999074626^2}{6.28} = 470715575.999996 $$

$$ \nu_{W/au} = 8\cdot3\cdot19\cdot83[2\cdot9(4\cdot173-1)-1] = 8\cdot3\cdot19\cdot83[2\cdot9(2\cdot3\cdot5\cdot23+1)-1] = 470715576 $$

Relationships with the nuclides:

$$ {}^{19}_{9}F_{10} \quad {}^{39}_{19}K_{20} \quad {}^{56,57,58}_{26}Fe_{30,31,32} \quad {}^{66,68}_{30}Zn_{36,38} \quad {}^{69,71}_{31}Ga_{38,40} \quad {}^{82,83,84}_{36}Kr_{46,47,48} \quad {}^{88}_{38}Sr_{50} \quad {}^{102,104,106}_{46}Pd_{56,58,60} $$

$$ {}^{136,137,138}_{56}Ba_{80,81,82} \quad {}^{138}_{57}La_{81} \quad {}^{140,142}_{58}Ce_{82,84} \quad {}^{169}_{69}Tm_{100} \quad {}^{173}_{70}Yb_{103} \quad {}^{188,190}_{76}Os_{112,114} \quad {}^{11\cdot 19}_{83}Bi^{*}_{126} \quad {}^{11\cdot 19}_{84}Po^{*}_{125} $$

$$ {}^{223}_{87}Fr^{*}_{136} \quad {}^{226}_{88}Ra^{*}_{138} \quad {}^{257}_{100}Fm^{*}_{157} \quad {}^{24\cdot 11}_{103}Lr^{*}_{7\cdot 23} \quad {}^{15\cdot 19}_{112}Cn^{*}_{173} \quad {}^{2\cdot 157}_{126}Ch^{ie}_{188} \quad {}^{344,2\cdot 173,348}_{136,137,138}Fy^{ie}_{208,11\cdot 19,210} \quad {}^{19\cdot 23}_{173}Ch^{ie}_{24\cdot 11} $$

This frequency ($\nu_{W/au}$) could be called the characteristic frequency of the W boson in atomic units. It is notable that $\nu_{W/au}$ is miraculously very close to an integer number, so we suppose it should be an integer number (470715576) exactly. It means that in the atomic unit time (tau = 2.4188843265857(47) $\times 10^{-17}$ s [21]) the photon corresponding to the W boson would vibrate integer multiple times exactly (470715576). This amazing coincidence should be a very strong proof to our formulas and the value of the W boson mass because of the Sagan Standard “extraordinary claims require extraordinary evidence”, and it could be explained in analogy with Chinese poetry as follows.

1. W boson is analogous to Chinese characters 2. Atomic units is analogous to poetry which should be the most refined form of a language.	$\Leftrightarrow$	七绝·早发白帝城（唐·李白） 朝辞白帝彩云间，千里江陵一日还。 两岸猿声啼不住，轻舟已过万重山。

8.9 Determination of the Z Boson Mass

Compared to the complicated situations in the measurements of the W boson mass, the measurements of the Z boson mass are more steady and more accurate, the latest measurements determined the Z boson mass to be 91187.6(2.1) MeV [17, 18]. We use the general formula of mass model of the elementary particles (Eq. 4) to determine the Z boson mass in Hartree-Chen atomic units (au). It is also supposed that the factors in the formulas for the Z boson mass in au are meaningful and related to nuclides [10].

Electron mass： $m_e = 0.51099895000(15)$ MeV

the measured mass of the Z boson (2018)： $m_Z = 91187.6(2.1)$ MeV

The mass ratio of the Z boson to electron:

$$ \frac{m_Z}{m_e} = \frac{91187.6(2.1)\times 10^3}{0.51099895000(15)} = 178450(4)\ (178446 - 178454) $$

$$ m_{Z/au} = \frac{m_Z}{m_e/(1+1/c_{au}{}^4)} = ? $$

$$ m_{Z/au} = \frac{m_Z}{m_e/(1+1/c_{au}{}^4)} = [20(22-1+\frac{1}{8}-\frac{1}{300+\frac{1}{2\cdot 3(2\cdot 9\cdot 29-1)}})]^2 $$

$$ = 178449.921171171 $$

$$ m_{Z/au} = \frac{m_Z}{m_e/(1+1/c_{au}{}^4)} = 2\cdot 25\cdot 43\cdot 83 - \frac{1}{12} + \frac{1}{2\cdot 3\cdot 37} $$

$$ = 178449.921171171 $$

Relationships with the nuclides:

$$ {}^{35,37}_{17}Cl_{18,20} \quad {}^{40,42,43}_{20}Ca_{20,22,23} \quad {}^{46,47,48,50}_{22}Ti_{24,25,26,28} \quad {}^{55}_{25}Mn_{30} \quad {}^{56,58}_{26}Fe_{30,32} \quad {}^{63,65}_{29}Cu_{34,36} $$

$$ {}^{66,67}_{30}Zn_{36,37} \quad {}^{83}_{36}Kr_{47} \quad {}^{85,3\cdot 29}_{37}Rb_{48,50} \quad {}^{98,99}_{43}Tc^{*}_{55,56} \quad {}^{116,120}_{50}Sn_{66,70} \quad {}^{126}_{52}Te_{2\cdot 37} \quad {}^{140,142}_{58}Ce_{82,84} $$

$$ {}^{136,137,138}_{56}Ba_{80,81,82} \quad {}^{166,167}_{68}Er_{98,99} \quad {}^{180,181}_{73}Ta_{107,108} \quad {}^{184,186}_{74}W_{110,112} \quad {}^{200}_{80}Hg_{120} \quad {}^{209}_{83}Bi^{*}_{126} $$

$$ {}^{6\cdot 37}_{86}Rn^{*}_{136} \quad {}^{223,224}_{87}Fr^{*}_{136,137} \quad {}^{273}_{107}Bh^{*}_{166} \quad {}^{300}_{120}Ch^{ie}_{180} \quad {}^{2\cdot 157}_{126}Ch^{ie}_{188} \quad {}^{8\cdot 43,2\cdot 173,12\cdot 29}_{136,137,138}Fy^{ie}_{208,209,210} $$

So the mass of the Z boson should be:

$$ m_Z = m_{Z/au}\frac{m_e}{1+1/c_{au}{}^4} = 178449.921171171\times\frac{0.51099895000(15)}{1+1/137.037999074626^4} $$

$$ = 91187.722114(27)\ \text{MeV} $$

If a Z boson became a photon, what would be its frequency?

$$h_{au}\nu_{Z/au} = m_{Z/au}c_{au}^{\ 2}$$

$$\nu_{Z/au} = \frac{m_{Z/au}c_{au}^{\ 2}}{h_{au}} = \frac{178449.921171171 \times 137.035999074626^2}{6.28}$$

$$= 533612577.467664$$

$$\nu_{Z/au} = 3[2\cdot 3\cdot 11(8\cdot 9\cdot 5-1)(2\cdot 27\cdot 139+1)+1] + \frac{1}{2} - \frac{1}{30} + \frac{1}{17\cdot 59}$$

$$= 533612577.467664$$

Relationships with the nuclides:

$${}^{16,17,18}_{8}O_{8,9,10} \quad {}^{19}_{9}F_{10} \quad {}^{23}_{11}Na_{12} \quad {}^{32,33,34,36}_{16}S_{16,17,18,20} \quad {}^{35,37}_{17}Cl_{18,20} \quad {}^{46,48,49}_{22}Ti_{24,26,27} \quad {}^{59}_{27}Co_{32} \quad {}^{66}_{30}Zn_{36}$$

$${}^{82,84}_{36}Kr_{46,48} \quad {}^{105}_{46}Pd_{59} \quad {}^{113,115}_{49}In_{64,66} \quad {}^{138,139}_{57}La_{81,82} \quad {}^{138,140}_{58}Ce_{80,82} \quad {}^{141}_{59}\mathrm{Pr}_{82} \quad {}^{2\cdot 81}_{66}Dy_{96} \quad {}^{2\cdot 139}_{109}Mt^{*}_{169}$$

8.10 Estimation of the Mass of the Particle of Dark Matter

The particle of dark matter (D) should exist to maintain ratio of bosons to fermions in elementary particles to be 6/12 or 1/2 and to maintain Yang to Yin to Neutral ratio of bosons to be 1/1/1. This looks more reasonable.

We hypothesize there should be a relationship between the mass of Higgs boson and the mass of the particle of dark matter as follows (Figure 6). And hence, the mass of the particle of dark matter in Hartree-Chen atomic units (au) could be estimated out. In the following calculation, there are some factors which are supposed to relate to nuclides.

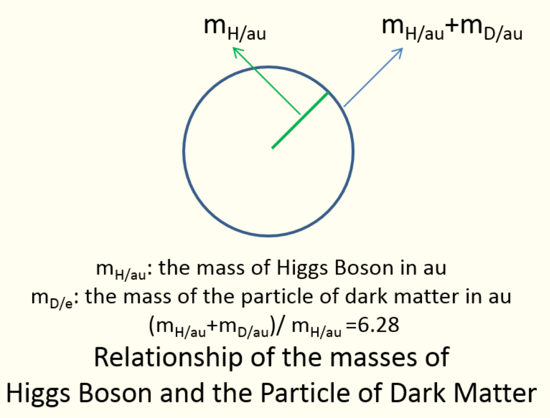


Figure 6. Relationship of the Masses of the Higgs Boson and the Particle of Dark Matter

Estimation of the mass of the particle of dark matter in au :

$$\frac{m_{H/au} + m_{D/au}}{m_{H/au}} = (2\pi)_{au}$$

$(2\pi)_{au} = 6.28$ in the subatomic world.

$$m_{D/au} = (6.28-1)m_{H/au} = 5.28 \times 245280.001934332 = 1295078.41021327$$

$$m_{D/au} = [33(34 + \frac{1}{2} - \frac{1}{68} + \frac{1}{2\cdot 7(16\cdot 3\cdot 7\cdot 17-1) - \frac{43}{80}}]^2 = 1295078.41021327$$

$$m_{D/au} = 2\cdot 19\cdot 173\cdot 197 + \frac{1}{2} - \frac{1}{11} + \frac{1}{81\cdot 11 - \frac{1}{50}} = 1295078.41021327$$

Relationships with the nuclides

$${}^{28,30}_{14}Si_{14,16} \quad {}^{35,37}_{17}Cl_{18,20} \quad {}^{32-34}_{16}S_{16-18} \quad {}^{39}_{19}K_{20} \quad {}^{45}_{21}Sc_{24} \quad {}^{60-62,64}_{28}Ni_{32-34,36} \quad {}^{68}_{30}Zn_{38} \quad {}^{69,71}_{31}Ga_{38,40} \quad {}^{75}_{33}As_{42}$$

$${}^{76,77,78,80,82}_{34}Se_{42,43,44,46,48} \quad {}^{84,86,88}_{38}Sr_{46,48,50} \quad {}^{98,99}_{43}Tc^{*}_{55,56} \quad {}^{99,100}_{44}Ru_{55,56} \quad {}^{112}_{48}Cd_{64} \quad {}^{118}_{50}Sn_{68} \quad {}^{136,137}_{56}Ba_{80,81}$$

$$ {}^{168}_{68}Er_{100} \quad {}^{173}_{70}Yb_{103} \quad {}^{188}_{76}Os_{112} \quad {}^{197}_{79}Au_{118} \quad {}^{209}_{83}Bi^{*}_{126} \quad {}^{209}_{84}Po^{*}_{125} \quad {}^{15\cdot 19}_{112}Cn^{*}_{173} \quad {}^{344,2\cdot 173}_{136,137}Fy^{ie}_{208,209} \quad {}^{437}_{173}Ch^{ie}_{24\cdot 11} $$

So the mass of the particle of the dark matter should be:

$$ m_D = m_{D/au}\frac{m_e}{1+1/c_{au}{}^4} = 1295078.41021327 \times \frac{0.51099895000(15)}{1+1/137.037999074626^4} $$

$= 661783.70591(9)$ MeV $= 661.78370591(9)$ GeV

If a particle of Dark Matter became a photon, what would be its frequency?

$$ \nu_{D/au} = \frac{m_{D/au}c_{au}{}^4}{h_{au}} = \frac{1295078.41021327 \times 137.035999074626^2}{6.28} = 3872627816.03443 $$

$$ \nu_{D/au} = 8\cdot 43(2\cdot 5\cdot 107-1)[4(8\cdot 7\cdot 47+1)-1] + \frac{1}{29+\frac{3}{68}} = 3872627816.03443 $$

Relationships with nuclides:

$$ {}^{56}_{26}Fe_{30} \quad {}^{63,65}_{29}Cu_{34,36} \quad {}^{83}_{36}Kr_{47} \quad {}^{99}_{43}Tc^{*}_{56} \quad {}^{100}_{44}Ru_{56} \quad {}^{107,109}_{47}Ag_{60,62} \quad {}^{136,137}_{56}Ba_{80,81} \quad {}^{140,142}_{58}Ce_{82,84} $$

$$ {}^{167,168}_{68}Er_{99,100} \quad {}^{169}_{69}Tm_{100} \quad {}^{179}_{72}Hf_{107} \quad {}^{4\cdot 47}_{76}Os_{112} \quad {}^{209}_{83}Bi^{*}_{126} \quad {}^{222}_{86}Rn^{*}_{136} \quad {}^{223,224}_{87}Fr^{*}_{136,137} \quad {}^{257}_{100}Fm^{*}_{157} $$

$$ {}^{2\cdot 137}_{107}Bh^{*}_{167} \quad {}^{285}_{112}Cn^{*}_{173} \quad {}^{2\cdot 157}_{126}Ch^{ie}_{4\cdot 47} \quad {}^{8\cdot 43,2\cdot 137}_{136,137}Fy^{ie}_{208,209} $$

8.11 Estimation of the Masses of Neutrinos

There are three flavors of neutrinos: electron, muon and tau neutrinos, i.e., ν_e, ν_μ and ν_τ. And there are also three different mass states of neutrinos: ν_1, ν_2, and ν_3. Each neutrino of a specific flavor is actually a combination of three different mass states of neutrinos. So firstly we hypothesized some formulas and values for these three mass states of neutrinos according to some already known conditions as follows.

$$ \text{Planck Satelite CMB Measurements}: \; m_{\nu_1} + m_{\nu_2} + m_{\nu_3} < 0.12\ eV $$

Neutrino Oscillation Measurements:

$$ m_{\nu_2}{}^2 - m_{\nu_1}{}^2 = 7.53 \pm 0.18 \times 10^{-5}\ (eV)^2 $$

$$ \left| m_{\nu_3}{}^2 - m_{\nu_2}{}^2 \right| = 2.51 \pm 0.50 \times 10^{-3}\ (eV)^2 $$

$$ m_{\nu_1/au} = \frac{1}{[66(68-\frac{1}{3(1-\frac{1}{12})})]^2} = \frac{1}{(36\cdot 124)^2} = 5.01824 \times 10^{-8} $$

$$ m_{\nu_2/au} = \frac{1}{[66(66-\frac{1}{6}]^2} = \frac{1}{(55\cdot 79)^2} = 5.29688 \times 10^{-8} $$

$$ m_{\nu_3/au} = \frac{1}{[55(55-\frac{1}{2(1-\frac{1}{56})})]^2} = \frac{1}{(81\cdot 37)^2} = 1.11334 \times 10^{-7} $$

$$ m_{\nu_1} = 5.01824 \times 10^{-8} \times \frac{m_e}{1+1/c_{au}{}^4} = 2.5643 \times 10^{-2}\ eV $$

$$ m_{\nu_2} = 5.29688 \times 10^{-8} \times \frac{m_e}{1+1/c_{au}{}^4} = 2.7067 \times 10^{-2}\ eV $$

$$ m_{\nu_3} = 1.11334 \times 10^{-7} \times \frac{m_e}{1+1/c_{au}{}^4} = 5.6891 \times 10^{-2} eV $$

$$ m_{\nu_1} + m_{\nu_2} + m_{\nu_3} = 0.1096\ eV $$

$$ m_{\nu_2}{}^2 - m_{\nu_1}{}^2 = 7.505 \times 10^{-5}\ (eV)^2; \; \left| m_{\nu_3}{}^2 - m_{\nu_2}{}^2 \right| = 2.504 \times 10^{-3}\ (eV)^2 $$

Secondly we should try to estimate the masses of neutrinos with different flavors by the following methods though these methods would be incorrect. And the neutrinos with flavors are also supposed to be Yin particles mainly because the formulas for the masses of the three mass states of neutrinos indicate they should be.

$$\begin{vmatrix} m_{\nu_e} & m_{\nu_\mu} & m_{\nu_\tau} \end{vmatrix} = \begin{vmatrix} \frac{m_{\nu_1}}{2} & \frac{m_{\nu_1}}{6} & \frac{m_{\nu_1}}{3} \\ \frac{m_{\nu_2}}{3} & \frac{m_{\nu_2}}{2} & \frac{m_{\nu_2}}{6} \\ \frac{m_{\nu_3}}{6} & \frac{m_{\nu_3}}{3} & \frac{m_{\nu_3}}{2} \end{vmatrix}$$

$$m_{\nu_e/au} = \frac{m_{\nu_1/au}}{2} + \frac{m_{\nu_2/au}}{3} + \frac{m_{\nu_3/au}}{6} = \frac{1}{2(36\times124)^2} + \frac{1}{3(55\times79)^2} + \frac{1}{6(81\times37)^2}$$

$$= \frac{1}{[66(62-1+\frac{1}{5}-\frac{1}{2\cdot97})]^2} = 6.13031\times10^{-8}$$

$$m_{\nu_\mu/au} = \frac{m_{\nu_1/au}}{6} + \frac{m_{\nu_2/au}}{2} + \frac{m_{\nu_3/au}}{3} = \frac{1}{6(36\times124)^2} + \frac{1}{2(55\times79)^2} + \frac{1}{3(81\times37)^2}$$

$$= \frac{1}{[66(57-1+\frac{1}{2}-\frac{1}{56+\frac{37}{75}})]^2} = 7.19594\times10^{-8}$$

$$m_{\nu_\tau} = \frac{m_{\nu_1/au}}{3} + \frac{m_{\nu_2/au}}{6} + \frac{m_{\nu_3/au}}{2} = \frac{1}{3(36\times124)^2} + \frac{1}{6(55\times79)^2} + \frac{1}{2(81\times37)^2}$$

$$= \frac{1}{[55(64-\frac{1}{4}+\frac{1}{21+\frac{13}{38}})]^2} = 8.12225\times10^{-8}$$

8.12 Mass Relationships of Elementary Particles

According to Tim Factors and Space Factors in Table 3, the masses of elementary particles except neutrinos should relate to the mass of Higgs boson, and the masses of neutrinos should relate to the mass of the particle of dark matter because their TF and SF seems to be related as shown in Table 3. This implies that neutrinos should be the bridge between regular matter and dark matter, and their masses would be derived from dark matter.

8.13 Conservation Law for Numbers of Yang and Yin

It seems there is a conservation law for numbers of Yang and Yin of elementary particles in some particle reactions, for examples:

$$2p + 2\gamma \to {}^2H^+ + e^+ + \nu_e$$

$$2(uud) + 2\gamma \to (uud)(uud) + e + e^+ \to (uud)(udd) + e^+ + \nu_e$$

$$n \to p + e + \bar{\nu}_e$$

$$(udd) \to (u\,u\,d) + e + e^+ + \bar{\nu}_e \to (uud) + e + \bar{\nu}_e$$

In the above reactions, it is supposed that 1 Yang and 1 Yin should neutralize each other or 1 Yang and 1 Yin should be created in pair simultaneously. So the net numbers of Yang and Yin before and after a particle reaction are conserved. But this kind of conservation is not always obeyed as follows. There should be some extra-restrictions.

$$\mu \to e + \bar{\nu}_e + \nu_\mu$$

$$\mu^+ \to e^+ + \nu_e + \bar{\nu}_\mu$$

9. Picture of Mass Model of Elementary Particles

We create a picture to briefly illustrate the above described mass model of elementary particles (Figure 7). We can see from the picture that although the masses of elementary particles in Hartree-Chen atomic units (au) range from 10^{-8} to 10^{6} order of magnitudes, they can be classified to Yang and Yin categories with reasonable Yang to Yin ratios. With the picture, why quarks and leptons have three generations, why there should be the particle of dark matter, why proton is stable but neutron is not stable independently, why there is only matter universe and other questions are understandable.

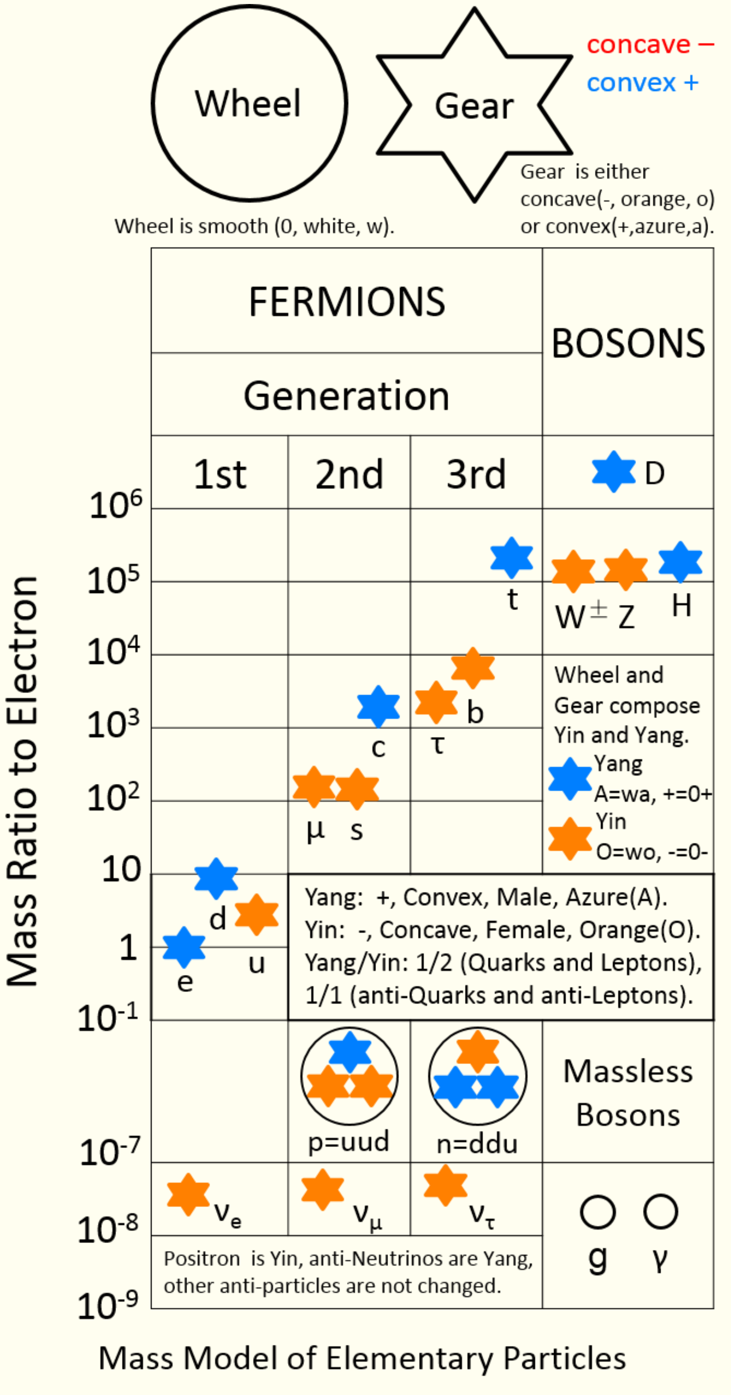
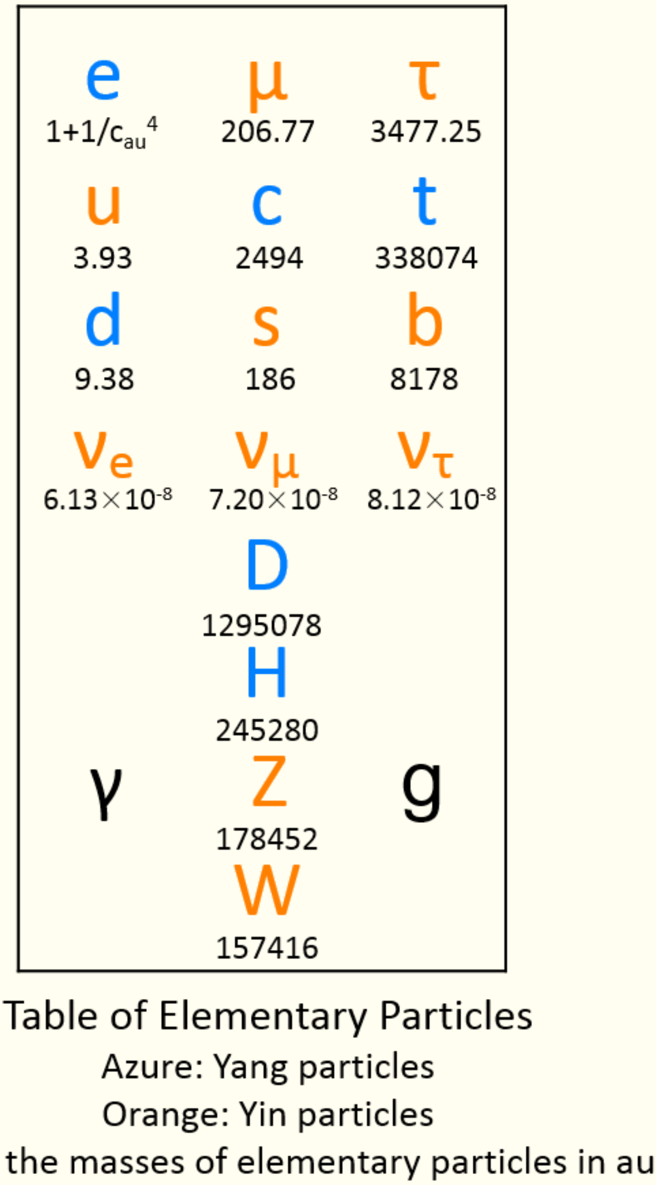


Figure 7. Picture of Mass Model of Elementary Particles

10. Table of Mass Model of Elementary Particles

To integrate the three features of elementary particles, i.e., spin quantum number, electric charge and mass gender (Yang and Yin), a new table of elementary particles is designed as follows (Figure 8).



e $1+1/c_{au}^4$	μ 206.77	τ 3477.25
u 3.93	c 2494	t 338074
d 9.38	s 186	b 8178
ν_e 6.13×10^{-8}	ν_μ 7.20×10^{-8}	ν_τ 8.12×10^{-8}
	D 1295078	
	H 245280	
γ	Z 178452	g
	W 157416	

Table of Elementary Particles
Azure: Yang particles
Orange: Yin particles
Values: the masses of elementary particles in au

Figure 8. Table of Elementary Particles

11. Why Quarks and Leptons Have Three Generations

Why quarks and leptons have three generations can be explained more intensively in Talble 4 and Table 5. For elementary particles, the number ratio of bosons to fermions is 6/12=1/2, the ratio of the total positive electric charges to the total negative charges of fermions is +2/-4=+1/-2, and even the ratio of the total electric charge of bosons (W, ±1) to the total neutralized electric charges of fermions (+2-4=-2) is also ±1/-2. So the ratio of Yang to Yin in quarks and leptons is 1/2 should be the most important reason for why they have three generations. In overall, the most important rule in elementary particles is the rule of 1/2.

Elementary Particles	Number	Electric Charges
Bosons	6	±1
Fermions	6+6=12	+2+(-4)=-2
Ratios	6/12=1/2	±1/-2

Table 4. Ratios of the Numbers and Electric Charges of Bosons and Fermions.

Quarks and Leptons	Electric Charges	Yang/Yin
ν_e, ν_μ, ν_τ	0	0/3
d, s, b quarks	3(-1/3)=-1	1/2
u, c, t quarks	3(+2/3)=+2	2/1
e, μ, τ	3(-1)=-3	1/2
Ratios	+2/-4=+1/-2	4/8=1/2

Table 5. Ratios of Electric Charges and Yang/Yin in Quarks and Leptons.

12. Why Quarks and Leptons Have Yang/Yin Ratio of 1/2

Why are the ratios of positive-negative electric charges and Yang-Yin particles in quarks and leptons 1/2, and why is the ratio of bosons to fermions also 1/2? The reason should be that elementary particles are "living" in time and space, time is of one dimension with only one piece of 2π in it, and space is of three dimensions with two pieces of 2π in it. The ratio of the pieces of 2π in time and space is 1/2, this should lead the above stated ratios to be 1/2 (Figure 9). In Figure 9, ±2π means one can move forwards and backwards in space, and +2π means one can only move forwards in time.

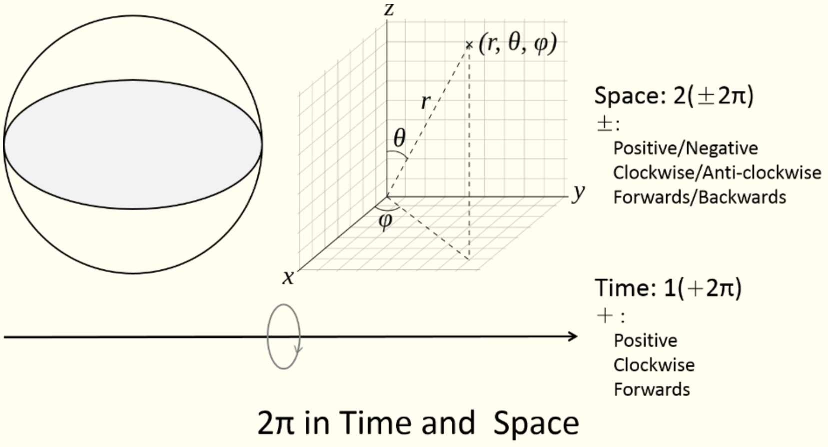


Figure 9. 2π in Time and Space

13. The Reason for the General Formula of the Masses of Elementary Particles

As stated in our previous papers [3-6], the ratio of Bohr radius of hydrogen atom to electron classic radius is as follows.

$$\frac{a_0}{r_e}=\frac{1}{\alpha_c^2}=\frac{1}{\alpha_1\alpha_2}=112(168-\frac{1}{3}+\frac{1}{12\cdot 47}-\frac{1}{14\cdot 112(2\cdot 173+1)})$$
$$=18788.8650423809$$

This formula should be supposed to correspond to a piece of 2π because it is related to radii of hydrogen atom and electron.

The general formula of elementary particles to electron mass ratios is as follows.

$$m_{P/au}=\frac{m_P}{m_e/(1+1/c_{au}{}^4)}=[TF(SF\pm\sum 1/SSF)]^{2,\ -2}$$

As the shape of an elementary particles should be spherical, so it is supposed that its mass should be proportional to their sphere volume in which there should be two pieces of 2π (Figure 9), and hence the general formula of the masses of elementary particles in Hartree-Chen atomic units (au) is assumed to be similar to that of Bohr radius to electron classic radius but usually squared or even minus squared. This is just a reasonable deduction rather than a proof.

14. Discussions and Conclusions

We have already given sufficient discussions and conclusions in the above sections. The followings are just some supplements.

Neutrinos seem to be the gender factors of other elementary particles with mass. Electron would contain neutrino but they should be integral and inseparable.

In the formulas of the masses of electron and positron in Hartree-Chen atomic units (au), $m_{e/au}=1+1/c_{au}^4$ and $m_{e+/au}=1-1/c_{au}^4$, there is $1/c_{au}^4$ term, and c_{au} is the speed of light in vacuum in au. It is noticed that there is also c^4 factor in Einstein's field equation of general relativity. So we suppose that there would be some subtle relationships of the masses of electron and positron with the theory of general relativity.

$$m_{e/au}=1+\frac{1}{c_{au}{}^4}\qquad m_{e^+/au}=1-\frac{1}{c_{au}{}^4}$$

c_{au}: the speed of light in vacuum in au

Einstein's Field Equation of General Relativity:

$$G_{\mu\nu}+g_{\mu\nu}\Lambda=\frac{8\pi G}{c^4}T_{\mu\nu}$$

For atomic nuclei, it seems there might be similar "time-space" model, for example, the four stable nuclides of Fe can be expressed as 26(30 / -2, 0, 1, 2). For atoms, the situation is analogous, Na^+ can be express as 11(11-1) and Cl^- can be expressed as 17(17+1). Genders of human beings are decided by X and Y chromosomes, and a family of mankind can be referred by Man(Woman+Children). These similarities in different areas indicate our mass model of elementary particles should be reasonable and has principle meanings.

In the end, we should present the core code in developing mass model of elementary particles and writing this paper, that is, in the world of elementary particles, a circle (2π) should be scientifically divided into 12 degrees and chirality (a pair of hands) should correspond to 24 degrees as follows. This should be the core reasons why elementary particles have 6 bosons and 12 fermions in three generations, why there is the key ratio of 1/2 and why the formula for the mass of the heaviest quark (t quark) has a factor of 24.

In the world of elementary particles:

$$2\pi=1(2\ 2)(3)^\circ=12^\circ$$

$$\text{Chirality}=\pm 2\pi=\pm 12^\circ=24^\circ$$

So we could say elementary particles live in a chiral time-space of 12 or 24 degrees. Something likes one year is divided to 12 months and one day is divided to 24 hours by human beings.

14. Supplements

14.1 Determination of the Muon Mass

We use the general formula of mass model of the elementary particles (Eq. 4) to determine the muon mass in Hartree-Chen atomic units (au). It is also supposed that the factors in the formula for the muon mass in au are meaningful and related to nuclides.

Electron mass： $m_e = 0.51099895000(15)$ MeV

the measured mass of the muon (Wikipedia)： $m_\mu = 105.6583755(23)$ MeV

The mass ratio of the muon to electron:

$$\frac{m_\mu}{m_e} = \frac{105.6583755(23)}{0.51099895000(15)} = 206.7682830(45)$$

$$m_{\mu/au} = \frac{m_\mu}{m_e/(1+1/c_{au}{}^4)} = ?$$

$$m_{\mu/au} = \frac{m_\mu}{m_e/(1+1/c_{au}{}^4)} = (4(4-\frac{1}{2}+\frac{1}{10}-\frac{1}{2\cdot 97}+\frac{1}{2\cdot 163(2\cdot 3\cdot 5\cdot 7+1)}))^2$$

$$= 206.768283056676$$

$${}^{97}_{42}Mo_{55}\quad {}^{163}_{66}Dy_{97}\quad {}^{2\cdot 97}_{78}Pt_{116}\quad {}^{247}_{97}Bk^*_{150}\quad {}^{268}_{105}Db^*_{163}\quad {}^{2\cdot 163}_{128}Ch^{ie}_{198}\quad {}^{2\cdot 163}_{129}Ch^{ie}_{197}\quad {}^{410}_{163}Ch^{ie}_{247}$$

$$m_{\mu/au} = 9\cdot 23-\frac{1}{4}+\frac{1}{2\cdot 27}-\frac{1}{31\cdot 137-\frac{2}{73}} = 206.768283056675$$

$${}^{50,51}_{23}V_{27,28}\quad {}^{69,71}_{31}Ga_{38,40}\quad {}^{137}_{56}Ba_{81}\quad {}^{173}_{70}Yb_{103}\quad {}^{146}_{61}Pm^*_{85}\quad {}^{169}_{69}Tm_{100}\quad {}^{223,224}_{87}Fr^*_{136,137}\quad {}^{238}_{92}U^*_{146}$$

$${}^{285}_{112}Cn^*_{173}\quad {}^{2\cdot 173}_{137}Fy^{ie}_{209}\quad {}^{370}_{146}Ch^{ie}_{224}$$

So the muon mass should be:

$$m_\mu = m_{\mu/au}\frac{m_e}{1+1/c_{au}{}^4} = 206.768283056676\times\frac{0.51099895000(15)}{1+1/137.035999074626^4}$$

$$= 105.65837524(3)\text{ MeV}$$

If a muon became a photon, what would be its frequency?

$$h_{au}\nu_{\mu/au} = m_{\mu/au}c_{au}{}^2$$

$$\nu_{\mu/au} = \frac{m_{\mu/au}c_{au}{}^2}{h_{au}} = \frac{206.768283056676\times 137.035999074626^2}{6.28}$$

$$= 618291.987669768$$

$$\nu_{\mu/au} = 4(4\cdot 3\cdot 11(4(4\cdot 73+1)-1)+1)-\frac{1}{81}+\frac{1}{32\cdot 7\cdot 17^2} = 618291.987669768$$

$${}^{60,61,62}_{28}Ni_{32,33,34}\quad {}^{78,80,82}_{34}Se_{44,46,48}\quad {}^{99,100}_{44}Ru_{55,56}\quad {}^{107,109}_{47}Ba_{60,62}\quad {}^{136,137}_{56}Ba_{80,81}\quad {}^{146}_{61}Pm^*_{85}\quad {}^{168}_{68}Er_{100}$$

$${}^{180,181}_{73}Ta_{107,108}\quad {}^{223,224}_{87}Fr^*_{136,137}\quad {}^{14\cdot 17}_{92}U^*_{2\cdot 73}\quad {}^{276}_{108}Hs^*_{168}\quad {}^{285}_{112}Cn^*_{173}\quad {}^{344,2\cdot 173}_{136,137}Fy^{ie}_{208,209}\quad {}^{370}_{146}Ch^{ie}_{224}$$

14.1 Determination of the Tauon Mass

We use the general formula of mass model of the elementary particles (Eq. 4) to determine the tauon mass in Hartree-Chen atomic units (au). It is also supposed that the factors in the formula for the tauon mass in au are meaningful and related to nuclides.

Electron mass： $m_e = 0.51099895000(15)$ MeV

the measured mass of the tauon (Wikipedia)： $m_\tau = 1776.86(12)$ MeV

The mass ratio of the tauon to electron:

$$\frac{m_\tau}{m_e} = \frac{1776.86(12)}{0.51099895000(15)} = 3477.23(23)$$

$$m_{\tau/au} = \frac{m_\tau}{m_e/(1+1/c_{au}{}^4)} = ?$$

$$m_{\tau/au} = \frac{m_\tau}{m_e/(1+1/c_{au}{}^4)} = (8(8-1+\frac{1}{2}-\frac{1}{7}+\frac{1}{72-\frac{32\cdot 27-1}{5^4\cdot 10^6}}))^2$$

$$= 3477.25497631580$$

$${}^{32}_{16}S_{16} \quad {}^{59}_{27}Co_{32} \quad {}^{72}_{32}Ga_{40} \quad {}^{122}_{50}Sn_{72} \quad {}^{180}_{72}Hf_{108}$$

$$m_{\tau/au} = 3\cdot 19\cdot 61+\frac{1}{3}-\frac{1}{12}+\frac{1}{200}-\frac{1}{2\cdot 3\cdot 31\cdot 227+\frac{6}{25}} = 3477.25497631580$$

$${}^{39}_{119}K_{20} \quad {}^{56,57}_{26}Fe_{30,31} \quad {}^{89}_{39}Y_{50} \quad {}^{138,139}_{57}La_{81,82} \quad {}^{149,150,152}_{62}Sm_{87,88,90} \quad {}^{200}_{80}Hg_{120} \quad {}^{227}_{89}Ac^*_{138} \quad {}^{376}_{149}Ch^*_{227}$$

So the tauon mass should be:

$$m_\tau = m_{\tau/au}\frac{m_e}{1+1/c_{au}{}^4} = 3477.25497631580\times\frac{0.51099895000(15)}{1+1/137.035999074626^4}$$

$$= 1776.8736367(6)\ \text{MeV}$$

If a tauon became a photon, what would be its frequency?

$$h_{au}\nu_{\tau/au} = m_{\tau/au}c_{au}{}^2$$

$$\nu_{\tau/au} = \frac{m_{\tau/au}c_{au}{}^2}{h_{au}} = \frac{3477.25497631580\times 137.035999074626^2}{6.28} = 10397914.3181818$$

$$\nu_{\tau/au} = 5\cdot 11\cdot 97(2\cdot 3\cdot 25\cdot 13-1)-1+\frac{1}{3}-\frac{1}{66} = 10397914.3181818$$

$${}^{55}_{25}Mn_{30} \quad {}^{66}_{30}Zn_{36} \quad {}^{75}_{33}As_{42} \quad {}^{78}_{34}Se_{44} \quad {}^{89}_{39}Y_{50} \quad {}^{97}_{42}Mo_{55} \quad {}^{116}_{50}Sn_{66} \quad {}^{133}_{55}Cs_{78} \quad {}^{163}_{66}Dy_{97} \quad {}^{2\cdot 97,15\cdot 13}_{78}Pt_{116,9\cdot 13}$$

$${}^{13\cdot 19}_{97}Bk^*_{150} \quad {}^{410}_{163}Ch^*_{13\cdot 19}$$

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Appendix I: Research and Writing History

Section	Page	Writing Period	Location	Version
Whole paper	1-21	2022/9/11-2023/2/11	Sichuan Shanghai	viXra:2302.0048v1
Supplement 14.1 Supplement 14.2 Revise the paper	1-23	2023/2/12 2023/2/17-18 2023/2/18-20	Shanghai	viXra:2302.0048v2

Note: date was recorded according to Beijing Time.