Determination of the Masses of the W and Z Bosons

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Abstract

In our previous papers, we gave formulas of the fine-structure constant and their corresponding applications along with a model for the masses of the elementary particles. And in recent papers, we redefined Hartree atomic units to Hartree-Chen atomic units and gave formulas which determined the precise value of the mass of the Higgs boson. In this paper, we apply our mass model of the elementary particles and Hartree-Chen atomic units to determine the exact values of the masses of the W and Z bosons. Based on our hypothetical formulas, the masses of the W and Z bosons in Hartree-Chen atomic units should be 157415.999881172 and 178449.921171171 respectively, and the exact values of the masses of W and Z bosons should be 80439.410424(24) MeV and 91187.722114(27) MeV respectively. Compared to the latest and the most accurate values of 80433.5 ± 9.4 MeV and 91187.6 ± 9.4 MeV which were measured by the Detector Collidor at Fermilab (CDF) Collaboration and LEP respectively, our calculated values are almost absolutely precise if they are correct.

Keywords: masses, the W Boson, the Z boson, atomic units.

1. Introduction

The W and Z bosons are carrier particles that mediate the weak nuclear force, much as photon and gluon are the carrier particles for the electromagnetic force and the strong interaction respectively. These bosons are among the heavyweights of the elementary particles. With masses of 80.4 GeV/c2 and 91.2 GeV/c2, respectively, the W and Z bosons are almost 80 times as massive as the proton – heavier, even, than entire iron atoms. Their high masses limit the range of the weak interaction [1].

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 [1, 2]. 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 [1, 3], which is seven standard deviations above that predicted by the Standard Model.

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 mass of the Z boson to be 91187.6(2.1) MeV [1, 2].

In our previous papers, we gave formulas of the fine-structure constant and their corresponding applications [4-14] along with a model for the masses of the elementary particles [15]. In a recent paper [16], we redefined Hartree atomic units to Hartree-Chen atomic units. In another recent paper [17], we determined the mass of the Higgs boson to be 125.33782309(4) GeV. In this paper, we apply our mass model of the elementary particles and Hartree-Chen atomic units to determine the masses of the W and Z bosons.

2. Determination of the Mass of the W Boson

We use the general formula of our mass model of the elementary particles [6] to determine the mass of the W boson in Hartree-Chen atomic units. It is also supposed that the number factors in the formulas of the mass of the W boson in Hartree-Chen atomic units are meaningful and related to nuclides.

Hartree-Chen Atomic Units (au):

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

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

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

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

h_{au} : the Planck constant in Hartree-Chen atomic units

c_{au} : the speed of light in vacuum in Hartree-Chen atomic units

c: the speed of light in vacuum

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

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

the measured mass of the W boson (2018): $m_W = 80397(12)\ MeV$

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

The mass ratio of the W boson to electron:

$$\beta_{W/e} = \frac{m_W}{m_e} = \frac{80433.5(9.4)\times 10^3}{0.51099895000(15)} = 157404(18)\ (157386-157423)$$

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

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

$$m_{W/au} = \frac{m_W}{m_e/(1+1/c_{au}^{\ 4})} = [20(20-\frac{1}{6}+\frac{1}{6\cdot 37-\frac{4}{17}})]^2 = [20(20-\frac{1}{6}+\frac{1}{13\cdot 17+\frac{13}{17}})]^2$$

$$= 157415.999881172$$

$$m_{W/au} = 8\cdot 3\cdot 7\cdot(2\cdot 7\cdot 67-1)+\frac{1}{9\cdot 5\cdot 11\cdot 17+\frac{13}{25}} = 8\cdot 3\cdot 7\cdot(8\cdot 9\cdot 13+1)+\frac{1}{9\cdot 5\cdot 11\cdot 17+\frac{13}{25}}$$

$$= 157415.999881172$$

Relationships with the nuclides:

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

${}^{64,66,67,68}_{30}Zn_{34,36,37,38}$ ${}^{75}_{33}As_{42}$ ${}^{85,87}_{37}Rb_{48,50}$ ${}^{98,99,100}_{44}Ru_{54,55,56}$ ${}^{112}_{48}Cd_{64}$ ${}^{9\cdot 13,118}_{50}Sn_{67,68}$ ${}^{125,126}_{52}Te_{73,74}$

${}^{9\cdot 17}_{55}Cs_{6\cdot 13}$ ${}^{136,137,138}_{56}Ba_{80,81,82}$ ${}^{15\cdot 11}_{67}Ho_{98}$ ${}^{166,168}_{68}Er_{99,100}$ ${}^{5\cdot 37,11\cdot 17}_{75}\mathrm{Re}_{110,112}$ ${}^{188}_{76}Os_{112}$ ${}^{208}_{82}Pb_{126}$ ${}^{209}_{83}Bi^{*}_{126}$

${}^{209}_{84}Po^{*}_{125}$ ${}^{210}_{85}At^{*}_{125}$ ${}^{6\cdot 37}_{86}Rn^{*}_{8\cdot 17}$ ${}^{223,224}_{87}Fr^{*}_{136,137}$ ${}^{15\cdot 19}_{112}Cn^{*}_{173}$ ${}^{24\cdot 13}_{125}Ch^{ie}_{11\cdot 17}$ ${}^{314}_{126}Ch^{ie}_{188}$ ${}^{344,2\cdot 173,348}_{136,137,138}Fy^{ie}_{208,209,210}$

So the mass of the W boson should be:

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

$$= 80439.410424(24)\ MeV$$

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If a W boson became a photon, what would be its frequency in Hartree-Chen atomic units (au)?

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

$$\nu_{W/au} = \frac{m_{W/au}c_{au}^{\ 4}}{h_{au}} = \frac{157415.999881172\times 137.035999074626^2}{6.28} = 470715576$$

$$\nu_{W/au} = 8\cdot 3\cdot 19\cdot 83[2\cdot 9\cdot(4\cdot 173-1)-1] = 8\cdot 3\cdot 19\cdot 83[2\cdot 9\cdot(2\cdot 3\cdot 5\cdot 23+1)-1]$$

$$= 470715576$$

Relationships with the nuclides:

$^{56,57,58}_{26}Fe_{30,31,32}$ $^{66,68}_{30}Zn_{36,38}$ $^{69,71}_{31}Ga_{38,40}$ $^{83}_{36}Kr_{47}$ $^{88}_{38}Sr_{50}$ $^{102,104,106}_{46}Pd_{56,58,60}$ $^{126}_{52}Te_{74}$

$^{137,138}_{56}Ba_{81,82}$ $^{138,139}_{57}La_{81,82}$ $^{140,142}_{58}Ce_{82,84}$ $^{169}_{69}Tm_{100}$ $^{173}_{70}Yb_{103}$ $^{188}_{76}Os_{112}$ $^{11\cdot 19}_{83}Bi^{*}_{126}$

$^{226}_{88}Ra^{*}_{138}$ $^{227}_{89}Ac^{*}_{138}$ $^{257}_{100}Fm^{*}_{157}$ $^{15\cdot 19}_{112}Cn^{*}_{173}$ $^{2\cdot 157}_{126}Ch^{ie}_{188}$ $^{2\cdot 173,348}_{137,138}Fy^{ie}_{11\cdot 19,210}$ $^{435}_{173}Ch^{ie}_{262}$

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This frequency ($\nu_{W/au}$) could be called the essential frequency of the W boson in atomic units. It is notable that $\nu_{W/au}$ is miraculously an integer number. It means that in the atomic unit time (t_{au}) the photon corresponding to the W boson mass would vibrate integer multiple times exactly. This amazing coincidence should be a very strong proof to our formulas and the value for the mass of the W boson.

3. Determination of the Mass of the Z Boson

We use the general formula of our mass model of the elementary particles [6] to determine the mass of the Z boson in Hartree-Chen atomic units. It is also supposed that the number factors in the formulas of the mass of the Z boson in Hartree-Chen atomic units are meaningful and related to nuclides.

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:

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

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

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

$$=178449.921171171$$

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

$$=178449.921171171$$

Relationships with the nuclides:

$^{35,37}_{17}Cl_{18,20}$ $^{40,42,43}_{20}Ca_{20,22,23}$ $^{46,47,48,50}_{22}Ti_{24,25,26,28}$ $^{55}_{25}Mn_{30}$ $^{56}_{26}Fe_{30}$ $^{66,67}_{30}Zn_{36,37}$ $^{83}_{36}Kr_{47}$

$^{85,3\cdot 29}_{37}Rb_{48,50}$ $^{98,99}_{43}Tc^{*}_{55,56}$ $^{120}_{50}Sn_{70}$ $^{126}_{52}Te_{2\cdot 37}$ $^{136,137,138}_{56}Ba_{80,81,82}$ $^{136,138,140,142}_{58}Ce_{78,80,82,84}$

$^{180}_{80}Hg_{120}$ $^{209}_{83}Bi^{*}_{126}$ $^{6\cdot 37}_{86}Rn^{*}_{136}$ $^{223,224}_{87}Fr^{*}_{136,137}$ $^{300}_{120}Ch^{ie}_{180}$ $^{2\cdot 157}_{126}Ch^{ie}_{188}$ $^{8\cdot 43,2\cdot 173,12\cdot 29}_{136,137,138}Fy^{ie}_{208,209,210}$

So the mass of the Z boson should be:

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

$$= 91187.722114(27)\ MeV$$

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If a Z boson became a photon, its frequency in Hartree-Chen atomic units would be:

$$\nu_{Z/au} = \frac{m_{Z/au}c_{au}{}^4}{h_{au}} = \frac{178449.921171171\times 137.035999074626^2}{6.28}$$

$$= 533612577.467664$$

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

$$= 533612577.467664$$

Relationships with the nuclides:

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

$^{82,84}_{36}Kr_{46,48}$ $^{105}_{46}Pd_{59}$ $^{138,140}_{58}Ce_{80,82}$ $^{141}_{59}\mathrm{Pr}_{82}$ $^{2\cdot 139}_{109}Mt^{*}_{169}$

2023/1/28–29

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Appendix I: Research and Writing History

Section	Page	Writing Period	Location	Version
Whole paper	1-6	2023/1/29-31	Shanghai	viXra:2301.????v1

Note: date was recorded according to Beijing Time.