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NEW PHYSICS, W-BOSON MASS AND NON-RIEMANNIAN ZEROS OF THE ZETA FUNCTION

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Abstract. Contemporary definition of the New Physics proposed. Correction to the mass of the W-boson calculated. Non-Riemannian zeros of the zeta function proposed in [9] tested by direct calculations.

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In the Universe, matter has manly two type geometric structures, homogeneous isotropic, [1] and hierarchical, Russian-Doll-Like structures, [2]. The homogeneous structures are naturally described by real numbers with an infinite number of digits in the fractional part and usual archimedean metrics. The hierarchical structures are described by p-adic numbers with an infinite number of digits in the integer part and non-archimedean metrics, [3]. A discrete, finite, regularized, version of the homogenous structures are homogeneous lattices with constant steps and distance rising as arithmetic progression. The discrete version of the hierarchical structures is hierarchical lattice-tree with scale rising in geometric progression.

We say that we find **New Physics** (NP) when either we find a phenomenon which is forbidden by SM in principal - this is the qualitative level of NP - or we find a significant deviation between precision calculations in SM of an observable quantity and a corresponding experimental value. We believe that, beyond the SM regime, at higher energies, NP will show up. Precision experiments provide us an important tool to find its remnants already at todays energies. In 2017, the ATLAS Collaboration at CERN published the LHC's first measurement of the W-boson mass, giving a value of 80370±19 MeV. At the time, this measurement was the most precise single-experiment result, and was in agreement with the SM prediction and all other experimental results. Recently CDF collaboration has published [4] new measured value of the W-boson mass, $m_W = 80.4335 \pm 0.0094$ GeV=80433.5 ± 9.4 MeV, which is in excess of the SM prediction [5] $m_{SMW} = 80.375 \pm 0.006$ GeV=80375 ± 6 MeV, at 7σ level. Given the sizable difference in the W mass, the NP scale needs to be not too far above the TeV scale. Moreover, the NP could be at the electroweak scale if generating this discrepancy via loops. We discuss the possibility to explain the anomaly in the constituent Higgs-($m_H = 125$ GeV), W-($m_W = 80$ GeV) and Z-($m_Z = 91$ GeV) boson model. We propose a minimal supersimmetric constituent model with valense mass $m \sim 40$ Gev. In this model, W and H are bound states. Direct NP searches at the LHC and other experiments will certainly reveal or rule out the NP model candidates. Note that lead-208=$^{82}Pb^{126}_{208}$, the heaviest stable nucleus, contains 82 protons and 126 neutrons. The seven most widely recognized magic numbers are 2, 8, 20, 28, 50, 82, and 126. On the shell with angular momentum l

we have $2(2l+1)$ nucleons. The known doubly magic isotopes are helium-4, helium-10, oxygen-16, calcium-40, calcium-48, nickel-48, nickel-56, nickel-78, tin-100, tin-132, and lead-208=$^{82}Pb^{126}_{208}$. A simultaneous description of even-even and odd-A nuclei is possible through the introduction of a super-algebra, energy levels in both nuclei belonging to the same (super)multiplet, [6].

In the SM and its extensions the W-boson mass can be evaluated from, [7]

$$m_W^2(1-m_W^2/m_Z^2)=a(1+\delta)=A,\ a=\frac{\pi\alpha}{\sqrt{2}G_F}, \tag{1}$$

where G_F is the Fermi constant, α is the fine structure constant, and δ represents the sum of all non-QED loop diagrams to the muon-decay amplitude which itself depends on m_W as well. The relation (1) between the W-boson mass m_W, the Z-boson mass m_Z, the fine structure constant α, and the Fermi constant G_F, is of central importance for precision tests of the electroweak theory. We can solve the equation (1) as

$$m_W^2=(1\pm\sqrt{1-4A/m_Z^2})m_Z^2/2. \tag{2}$$

To the observed value of the m_W corrseponds

$$m_W^2=(1-\Delta)m_Z^2,\ \Delta=1-\frac{m_W^2}{m_Z^2}=(1-\sqrt{1-4A/m_Z^2})/2=0.223 \tag{3}$$

The second solution is

$$m_{W2}^2=\Delta m_Z^2,\ m_{W2}=\sqrt{\Delta}m_Z=43.0 m_W^2+m_{W2}^2=m_Z^2. \tag{4}$$

From the last equality in (4) the mass of the second particle is defined with precision $\delta m_{W2}\sim m_W/m_{W2}\delta m_W\sim 2\delta m_W$. We obtain the same result without introducing Δ in (3). The sum of the two solutions in (2) is equal to M_Z^2. One of the solutions corresponds to m_W^2, another solution gives m_{W2}^2, so we have the mass rule $m_W^2+m_{W2}^2=m_Z^2$ from which we define the value of m_{W2} and corresponding precision. The Eq. (2) predicts both values of mass. The value of the second mass is on the same precision as the first one and is good motivation for the experimental research.

A large group of dominant radiative corrections can be absorbed in the shift of the ρ parameter from its lowest order value $\rho_{Born}=1$. The result for the one-loop approximation

$$\begin{aligned}\delta\rho=3x_t=3\frac{G_Fm_t^2}{8\sqrt{2}\pi^2}\simeq 9.43\times10^{-3}\simeq10^{-2},\\ G_F=1.17\times10^{-5}GeV^{-2},\ m_t=173.2\pm0.7\end{aligned} \tag{5}$$

was first evaluated in [8]. The one-loop result δ_1 can be written as

$$\delta_1=\delta\alpha-\delta\rho/(m_Z^2/m_W^2-1)+\delta(m_H) \tag{6}$$

It involves large fermionic contributions from the shift in the fine structure constant due to light fermions, $\delta\alpha\sim\ln m_f$, and from the leading contribution to the ρ parameter $\delta\rho$.

The latter is quadratically dependent on the top-quark mass m_t (5) as a consequence of the large mass splitting in the isospin doublet. With the second mass,

$$\delta_1 = \delta\alpha - \delta\rho(m_Z^2/m_W^2 - 1 + 1/(m_Z^2/m_W^2 - 1)) + \delta(m_H)$$

Now the equation (1) gives correction ϵ on the right hand side

$$\begin{aligned}
&x(1-x) = A/m_Z^2(1+\delta_1-\epsilon),\ \epsilon = \delta\rho(m_Z^2/m_W^2 - 1),\\
&x = x_0 + \epsilon x_1,\ x_0(1-x_0) = A/m_Z^2(1+\delta_1),\\
&x_0 = m_W^2/m_Z^2,\ x_1 = A/m_Z^2(1+\delta_1)/(2x_0-1)\\
&= \frac{x_0(1-x_0)}{2x_0-1} = 0.139,\\
&\epsilon x_1 = 0.00137 \times 0.139 \simeq 2\times 10^{-4},\\
&m_W \simeq m_{W_0}(1 + m_{Z_0}^2/m_{W_0}^2 10^{-4}) = (80375+10)MeV.
\end{aligned}$$

Let us consider the following formula

$$\frac{1}{1-x} = (1+x)(1+x^2)(1+x^4)...,\ |x| < 1. \tag{7}$$

This formula can be used for the zeta function

$$\zeta(s) = \sum_{n\geq 1} n^{-s} = \prod_p (1-p^{-s})^{-1},\ Re\ s > 1, \tag{8}$$

when $x = x_n = p_n^{-s}$. We consider the following regularized form of the product (7)

$$\begin{aligned}
&p_k(x) \equiv (1+x+1/2^{k+1})(1+x^2)(1+x^4)...(1+x^{2^k}),\\
&p_k(-1) = 1/2,\ p_k(-1-1/2^{k+1}) = 0,\\
&|1/(1-x_k)|_2 = |\frac{2^{k+1}}{1+2^{k+2}}|_2 = 1/2^{k+1} \to 0,\ |0|_2 = 0,\ |2^n|_2 = 2^{-n},\\
&x = x_k = -1 - 1/2^{k+1} = -1-\epsilon_k \to -1,\ k \to \infty,\\
&s_k(p,l) = -\frac{\ln(1+\epsilon_k)}{\ln p} + i\frac{\pi(2l+1)}{\ln p} \to i\frac{\pi(2l+1)}{\ln p}
\end{aligned} \tag{9}$$

We have zeros (9) at $s = s_k(p_n) = (2k+1)\pi i/\ln(p_n), p_n$ is prime, k is an integer number, $|p^n|_p = p^{-n}$ is p-adic norm. The following integral representation allows to test these non-Riemannian zeros (NRZ),

$$\zeta(s) = \frac{\Gamma(1+s)^{-1}}{2^{1-s} - 2^{2(1-s)}} \int_0^\infty \frac{t^s dt}{\cosh^2 t}, \Re s > -1. \tag{10}$$

Let us estimate precision of the calculation,

$$I = \int_0^\infty \frac{dt}{\cosh^2 t} = 1,\ I > I. = \int_0^{100} \frac{dt}{\cosh^2 t} = 1.0000000000000049?! \tag{11}$$

The last integral calculated by Mathematica shows the typical error $O(10^{-15})$ in the following calculations, e.g. for the zero $s_3(2) = i7\pi/\log 2$

$$I = \int_0^{100} \frac{t^{s_3(2)} dt}{\cosh^2 t} = RI + iIm,\ |I| < 1,$$

$$RI = \int_0^{100} \frac{\cos(7\pi/\log 2 \log t)dt}{\cosh^2 t} = -8.37655 \times 10^{-16},$$
$$Im = \int_0^{100} \frac{\sin(7\pi/\log 2 \log t)dt}{\cosh^2 t} = -1.0894 \times 10^{-15} \tag{12}$$

For the zeros, $s(3)_4 = i9\pi/\log 3$

$$I = \int_0^{100} \frac{t^{s(3)_4}dt}{\cosh^2 t} = RI + iIm, \ |I| < 1,$$
$$RI = \int_0^{100} \frac{\cos(9\pi/\log 3 \log t)dt}{\cosh^2 t} = -3.64292 \times 10^{-16},$$
$$Im = \int_0^{100} \frac{\sin(9\pi/\log 3 \log t)dt}{\cosh^2 t} = -2.09728 \times 10^{-15},$$
$$s(3)_4 = i9\pi/\log 3 = 25.74i \tag{13}$$

All standard models of physics are of local type, are described by differential structures (Lagrangian and motion equations) and permit quantitative analysis by parallel algorithms and corresponding programs. Today multiprocessor supercomputers (e.g. Govorun, JINR Dubna) permit adaptation of the architecture to the algorithm of solution of a physical problem (e.g. for QCD hydrodynamic motion equations or lattice formulation of (non) equlibrium dynamics under NICA project) with the corresponding optimal control problem. Future supercomputers will probably contain also quantum processors with their intrinsic parallel processes.

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