Email: elicomay@post.tau.ac.il

Theoretical Contradictions of the

Klein-Gordon W, Z and Higgs Particles

A. The phase is an important quantum property because it affects interference. Being an argument of an exponential function, the phase must be a dimensionless quantity. In a relativistic theory it must also be a Lorentz scalar. These two requirements can be satisfied by the action (units where $\hbar = c = 1$ are used). This action must be derived from a Lagrangian density that is a Lorentz scalar having the dimension $[L^{-4}]$.

B. In a quantum theory, operators are used for a description of dynamical variables. In quantum mechanics operators operate on a Hilbert space and in quantum field theory they operate on the associated Fock space. These spaces are crucial elements of the theory and without them the operators become meaningless (see [1], pp. 20-22).

C. A Dirac particle is an elementary spin-1/2 massive particle. Properties of a free Dirac particle are derived from the following Lagrangian density (see [1], p. 54)

$$\mathcal{L} = \bar{\psi}(x^\nu)[\gamma^\mu \partial_\mu - m]\psi(x^\nu). \tag{1}$$

The operators of (1) have the dimension $[L^{-1}]$. Using **A**, one deduces that the dimension of a Dirac function ψ is $[L^{-3/2}]$. It means that the product $\psi^\dagger\psi$ has the dimension $[L^{-3}]$, which is the required dimension of density. As is well known, $\psi^\dagger\psi$ is indeed the expression for a Dirac particle density (see [1], p. 56). The following argument proves that a dimension of $[L^{-3/2}]$ is indeed a necessary condition for a function which is an element of the basis of a Hilbert space. The proof relies on the requirement stating that the dimension of an operator $\hat{\mathcal{O}}$ must be equal to the dimension of its expectation value $< \hat{\mathcal{O}} >= \int \psi^\dagger \hat{\mathcal{O}} \psi d^3x$.

D. Each of the Klein-Gordon, W, Z and Higgs are *massive* elementary particles that has a wave function whose dimension is $[L^{-1}]$. This property can be inferred from the term $\phi^\dagger m^2 \phi$ which is included in their Lagrangian density (see any textbook) and from the dimension $[L^{-4}]$ of any acceptable Lagrangian density. Therefore, due to item **C**, their wave function cannot be used for a construction of Hilbert and Fock spaces. For this reason they are unphysical ideas which cannot be used in an interpretation of experimental results.

The foregoing analysis proves that the Klein-Gordon, W, Z and the Higgs particles are *not* elementary pointlike particles which are described by field function which depend on a single set of 4 space-time coordinate, like $\phi(x^\mu)$. It means that they are composite particles. This fact is already known for the pion, which was the first Klein-Gordon candidate and is now known to be a quark-antiquark state. The most obvious candidates for the W, Z and the 125 GeV particle are mesons of the top quark. Further details can be found in [2,3]. The results obtained above prove that Dirac was right in his lifelong objection to the Klein-Gordon equation [4].

The following argument provides an indication concerning the correctness of the results obtained herein. Indeed, today, about 40 years have elapsed since the construction of the electroweak theory and there is still no *theoretical* expression for the interaction of the charged $W^\pm$ bosons with electromagnetic fields. For this reason calculations are relegated to an application of *effective* expressions [5,6]. Thus, the articles [5,6] have been cited many times and their *effective* electromagnetic interaction is still used in a collider data analysis [7] (see eq. (1) therein), [8] (see eq. (3) therein). As is well known, electromagnetic interaction depends on the 4-current and its 0-component represent density. The following statement can be said about the *W,Z* and the Higgs particles: The inability to construct a theoretically valid electromagnetic 4-current for these particles is related to the inability to use their wave function's density for constructing the Hilbert/Fock spaces.

References:

[1] J. D. Bjorken and S. D. Drell, *Relativistic Quantum Fields* (McGraw-Hill, New York, 1965).

[2] E. Comay, Prog. in Phys., **4**, 91 (2009). http://www.tau.ac.il/∼elicomay/MathPhys.pdf (Use the keyboard and replace the tilde.)

[3] E. Comay, Prog. in Phys., **4**, 9 (2012). http://ptep-online.com/index_files/2012/PP-31-03.PDF (Use the keyboard and replace the underscore.)

[4] P. A. M. Dirac, *Mathematical Foundations of Quantum Theory*, Ed. A. R. Marlow (Academic, New York, 1978). (See pp. 3,4).

[5] K. Hagiwara, R.D. Peccei, D. Zeppenfeld and K. Hikaso, Nuc. Phys. **B282**, 253 (1987).

[6] K. Hagiwara, J. Woodside, D. Zeppenfeld, Phys. Rev. **D41**, 2113 (1990).

[7] V.M. Abazov et al. (D0 collaboration), Phys. Lett. **B718**, 451 (2012)

[8] G. Aad et al. (ATLAS Collaboration), Phys. Lett. **B712**, 289 (2012).