The CKM Quark-Mixing Matrix in the Scale-Symmetric Theory

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Abstract: The masses and mixings of quarks have the origin in the Scale-Symmetric Theory (SST). They arise from the nuclear interactions of the source of them - it is the charge of the core of baryons (mass of the charge is 318.2955 MeV). There are the three dominating bosons: the loop with a mass of 67.54441 MeV (the neutral pions consist of two such loops), the boson that creates the Titius-Bode states for the nuclear strong-weak interactions (its mass is 750.28 MeV), and a Higgs-boson-type condensate with a mass of the bottom quark (its mass is 4190 MeV). The ratios of masses of these bosons to the mass of the source define the three mixing angles that lead to the Cabibbo-Kobayashi-Maskawa (CKM) matrix. Here we show that the SST interactions of the source of the nuclear strong interactions determine the strength of flavour-changing weak decays. Notice that contrary to SST, within the Standard Model we cannot calculate masses of quarks and the CKM-matrix mixing angles, Q(ij), from initial conditions. Within SST we obtain: Q(12) = 13.164, Q(13) = 0.212, and Q(23) = 2.357 degrees - obtained results are consistent with experimental data.

1. Introduction

Here, applying the Scale-Symmetric Theory (SST) [1], we calculated the three mixing angles, Q_{ij}, and the magnitudes, V_{ab}, that define the CKM quark-mixing matrix. Obtained results are consistent with experimental data [2]. Within SST, we calculated the masses of quarks from initial conditions [1A], [1D]. SST shows as well that the CPT symmetry is conserved [3]. The insignificantly broken T symmetry (so CP symmetry as well) follows from internal helicity of the main torus in each fermion – such tori produce jets in the spacetime [3]. Here we neglect the insignificant CP violation.

The SST shows that the succeeding phase transitions of the superluminal non-gravitating Higgs field during its inflation (the initial big bang) lead to the different scales of sizes/energies [1A]. Due to a few new symmetries, there consequently appear the superluminal binary systems of closed strings (entanglons) responsible for the quantum entanglement (it is the quantum-entanglement scale), stable neutrinos and luminal neutrino-antineutrino pairs which are the components of the luminal gravitating Einstein spacetime (it is the Planck scale), cores of baryons (it is the electric-charge scale), and the cosmicstructures/protoworlds (it is the cosmological scale) that evolution leads to the dark matter, dark energy and expanding universes (the "soft" big bangs) [1A], [1B]. The electric-charge scale leads to the atom-like structure of baryons [1A].

Among a thousand of calculated quantities within SST, which are consistent with experimental data, we calculated quantities that we use in this paper, i.e. the mass of the charge inside the core of baryons that is the source of the strong interactions X = 318.2955 MeV and the three dominating masses of bosons responsible for the nuclear strong interactions i.e. the mass of the large loop m_{LL} = 67.54441 MeV (neutral pions consist of two such loops), the mass of the boson responsible for creation of the Titius-Bode states m_{TB} = 750.28 MeV, and the Higgs-boson-type condensate with a mass equal to the mass of the bottom quark $m_{C\text{-}b}$ = 4190 MeV [1A], [1D].

2. The mixing angles, Q_{ij}, and magnitudes V_{ab} in the CKM-matrix from the Scale-Symmetric Theory

We can parameterize the CKM quark-mixing matrix, U, within the SST via the 3 mixing angles Q_{ij}.

$$s_{ij} = \sin Q_{ij} \qquad c_{ij} = \cos Q_{ij}$$

$$U_{SST} = \begin{bmatrix} c_{12}c_{13} & s_{12}c_{13} & s_{13} \\ -s_{12}c_{23} - c_{12}s_{23}s_{13} & c_{12}c_{23} - s_{12}s_{23}s_{13} & s_{23}c_{13} \\ s_{12}s_{23} - c_{12}c_{23}s_{13} & -c_{12}s_{23} - s_{12}c_{23}s_{13} & c_{23}c_{13} \end{bmatrix}$$

$$U_{SST} = \begin{bmatrix} V_{ud} = 0.97372 & V_{us} = 0.22774 & V_{ub} = 0.00370 \\ V_{cd} = -0.22769 & V_{cs} = 0.97287 & V_{cb} = 0.04113 \\ V_{td} = 0.00587 & V_{ts} = -0.04089 & V_{tb} = 0.99915 \end{bmatrix}$$

The CKM quark-mixing matrix in Scale-Symmetric Theory

We do not use the Wolfenstein parameterization because then the description of the origin of the parameters is much difficult.

The mixing angles we can calculate from three fundamental phenomena that took place inside the baryons.

A.

The first mixing angle is the ratio of the mass of the Higgs-boson-type Einstein-spacetime condensate with a mass of the bottom quark to the mass of the source of the nuclear strong interactions

$$A_{13}\ [^o] = m_{C\text{-}b} / X = \underline{13.164}. \tag{1}$$

B.

The second mixing angle is the ratio of the mass of the large loop responsible for the nuclear strong interactions to the mass of the source of the nuclear strong interactions

$$A_{12}\ [^o] = m_{LL} / X = \underline{0.212}. \qquad (2)$$

C.

The third mixing angle is the ratio of the mass of the boson that creates the Titius-Bode states for the nuclear-weak strong interactions to the mass of the source of the nuclear strong interactions

$$A_{23}\ [^o] = m_{TB} / X = \underline{2.357}. \qquad (3)$$

Calculated here mixing angles are consistent with experimental data [2].

3. Summary

Here we show that the Scale-Symmetric-Theory interactions of the source of the nuclear strong interactions determine the strength of flavour-changing weak decays. According to SST, separation of the nuclear weak from nuclear strong interactions is impossible. The nuclear strong interactions, which dominate, define the nuclear weak interactions, for example, via the CKM matrix.

The first mixing angle, A_{13}, is associated with the Higgs-boson-type Einstein-spacetime condensate with a mass of the bottom quark that is indirectly associated with the last Titius-Bode orbit for the strong-weak interactions (radius of this orbit is biggest: ~ 2.7 fm). The second mixing angle, A_{12}, is associated with the large loop responsible for strong interactions (radius of this orbit is smallest: ~ 0.465 fm). The third mixing angle, A_{23}, is associated with the boson that creates the Titius-Bode orbits/states for the strong-weak interactions.

We can see that the atom-like structure of baryons and the upper and lower limits for it lead to the CKM matrix that squared magnitudes determine probability of changing flavour of quarks in weak decays.

A symmetry violation does not follow from matter-antimatter asymmetry but from new physics that leads to the left-handed *internal* helicity of nucleons [1A] – the origin of such internal helicity of nucleons results from the initial left-handedness of the Higgs-field components that follows from the initial conditions of creation of the inner Cosmos, i.e. structures of a particle and its antiparticle are identical in consequence of the CPT transformation [1B], [1A], [3].

During the inflation, the initial asymmetry in the Higgs field transformed into the left-handedness of the Protoworld so there appeared much more p^+e^- pairs than p^-e^+ pairs and, then, much more neutrons than antineutrons.

Today, due to the left-handedness of nucleons, there should be created more π^+e^- than π^-e^+ or more μ^+e^- than μ^-e^+ i.e. more electron-neutrinos than electron-antineutrinos [5].

References

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