Insight into Quick Production and Slow Decay of Strange Particles from the New Quantum World

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I. New Four-Element Theory

Based on the new four-element theory, nature consists of four fundamental elements: radiation γ, mass M, electric charge Q, and color charge C [1-3]. Any known matter or particle is a combination of one or more of these four fundamental elements. For instances, a photon is radiation, a proton is a combination of mass and electric charge, a quark is a combination of mass, electric charge, and color charge, and so on. Radiation and mass are two forms of real energy, while electric and color charges are two forms of imaginary energy. Interactions between real energies are gravitational forces. Interactions between imaginary energies are gauge forces with three categories: the electromagnetic force between electric charges, the weak force between electric and color charges, and the strong force between color charges. Interactions between real and imaginary energies are imaginary forces, which have no direct observations but explain why charges are adhesive and always stick on mass. All these interactions can be classically unified as a single interaction between complex energies.

II. Two-Flavor Multi-Excitation Quark Model

The weak interaction is a force between electric and color charges, occurs within quark (Figure 1a), and causes quark excitation and decay, via absorbing or emitting a quark-antiquark pair (Figure 1b). Beta decays of nuclei/particles are resulted from quark-antiquark pair emissions and annihilations (Figure 1c). Leptons are products of decays rather than participants of weak interactions in the decays. Quarks do not change flavors. In the newly developed two-flavor (up & down quarks) multi-excitation (ground & excited states) model of quarks [4-5], the heavy flavor quarks (e.g.: charm, strange, top, and bottom) are considered as the second and third excited up and down quarks (Figure 1d). Combinations of quarks and antiquarks form eight types of particles via different levels of annihilations (Figure 1e). Combinations of three or more quarks and antiquarks, can form normal and exotic baryons and probably candidates of dark matter particles such as hexaquarks and nonaquarks.

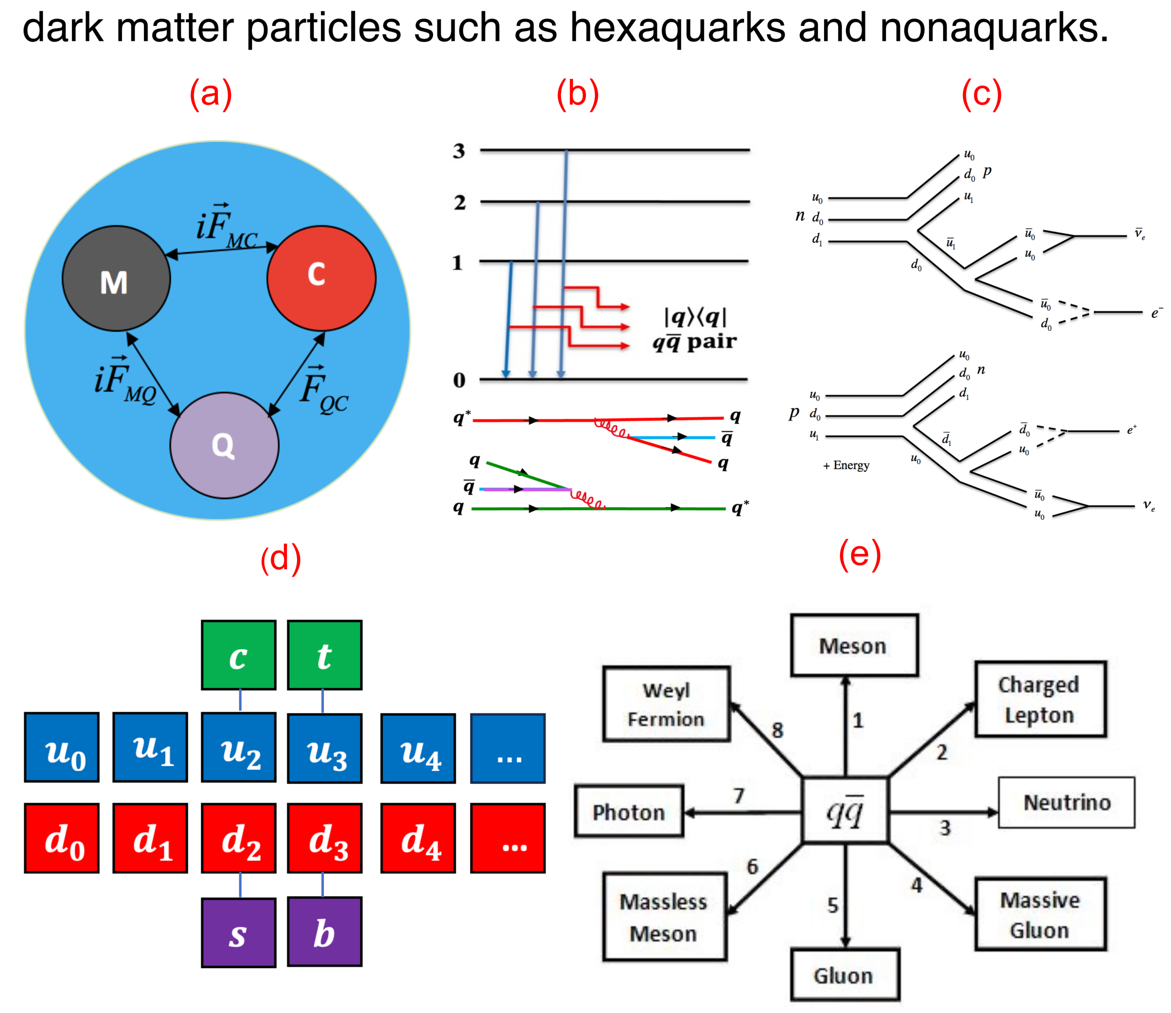

Figure 1: (a) Quark structure. (b) Quark excitation and decay. (c) Fine structures of Feynman diagrams for neutron decay and proton positron emission. (d) Two-flavor multi-excitation model of quarks. And (e) formation of particles from quark-antiquark combinations via various annihilations.

III. Formation of Baryons and Nonaquarks

A combination of a red (R) quark with a blue (B) quark and a green (G) quark forms a color neutral (R + B + G = 0) normal baryon (Figure 2a). A combination of a red quark with an antiblue antiquark and an antigreen antiquark forms a di-red (2R) super quark (Figure 2b). Similarly, we can have di-blue and di-green super quarks. According to their electric charges, super quarks have two types: antiup (-2e/3) and antidown (e/3). A combination of three super quarks with colors of di-red, di-blue, and di-green, respectively, forms a color neutral nonaquark (Figure 2c) [6]. Three two-type (up and down) quarks can form four types of normal baryons denoted by $\mathrm{P}^{+}, \mathrm{P}^{0}, \mathrm{P}^{-}, \text{and } \mathrm{P}^{++}$ (Figure 2d). Three two-type (antitup and antidown) super quarks can form four types of superhadron baryons or nonaquarks, denoted by $S^{0}, S^{-}, S^{+}, \text{and } S^{--}$ (Figure 2e).

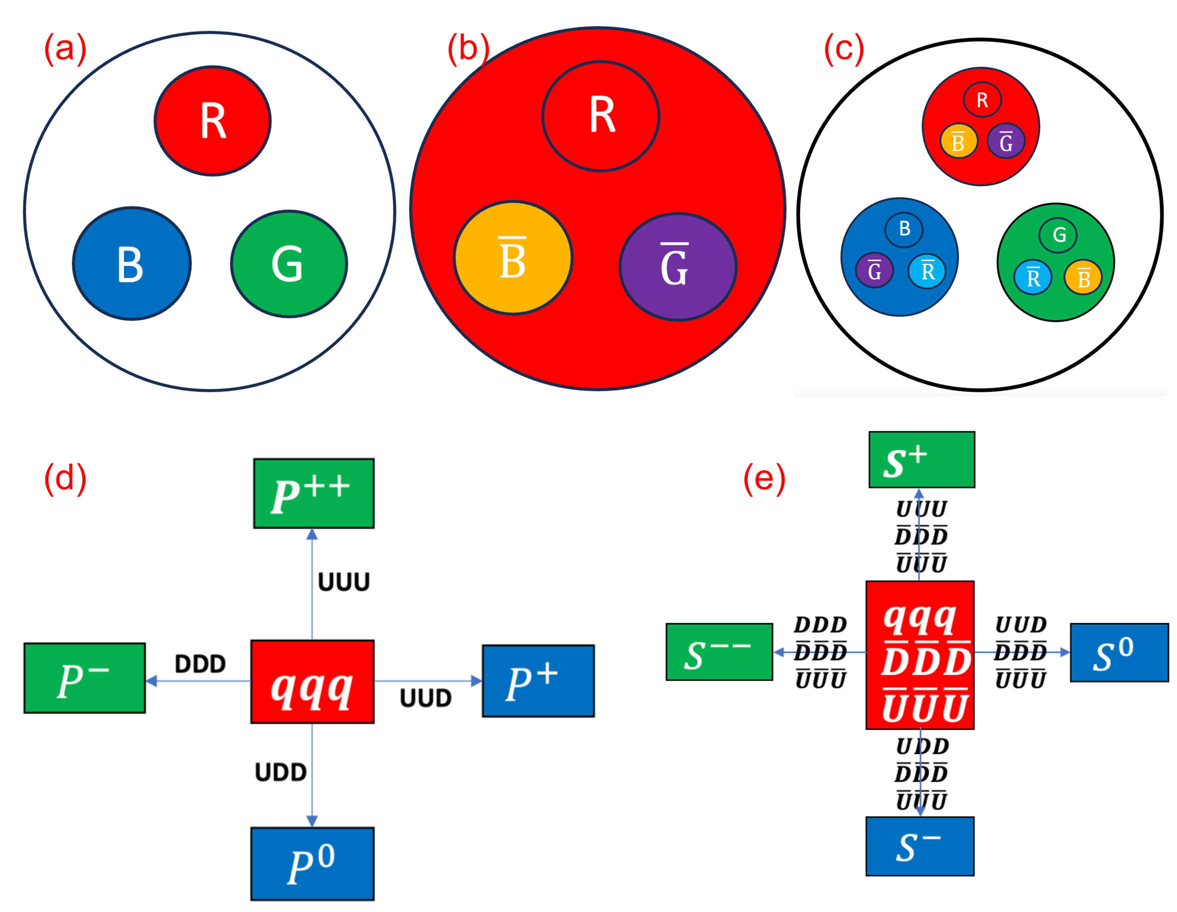

Figure 2: (a) Three quarks form a normal baryon. (b) One quark and two antiquarks form a super quark. (c) Three super quarks form a nonaquark. (d) Baryons have four types with charge states: +e, 0, -e, +2e. (e) Nonaquarks also have four types with charge states: 0, +e, -e, -2e.

Normal baryons have a stable (lowest state) particle: proton p = $(u_0 d_0 u_1)$ (Figure 3a). A free neutron n = $(u_0 d_0 d_1)$ has a lifetime of ~ 888 s and decays to proton as shown in Figure 1c. Nonaquarks have a stable (lowest state) particle: neutral superon $s^0 = (u_0\bar{d}_0\bar{u}_0,\ d_0\bar{d}_0\bar{u}_0,\ u_1\bar{d}_0\bar{u}_0)$ (Figure 3b). Its three quarks are those of a proton. It is structured via a two-level color-charge binding of three quarks with six antiquarks. It is neutral and hence does not have electromagnetic, weak and strong interactions, and only interacts with particles via the gravitational interaction. It is stable and hence does not decay. It can be considered as a candidate of dark matter particles. Formation of nonaquarks from consumptions of antiquarks in the early universe may explain why the present universe is significantly missing antimatter but is fully filled with dark matter.

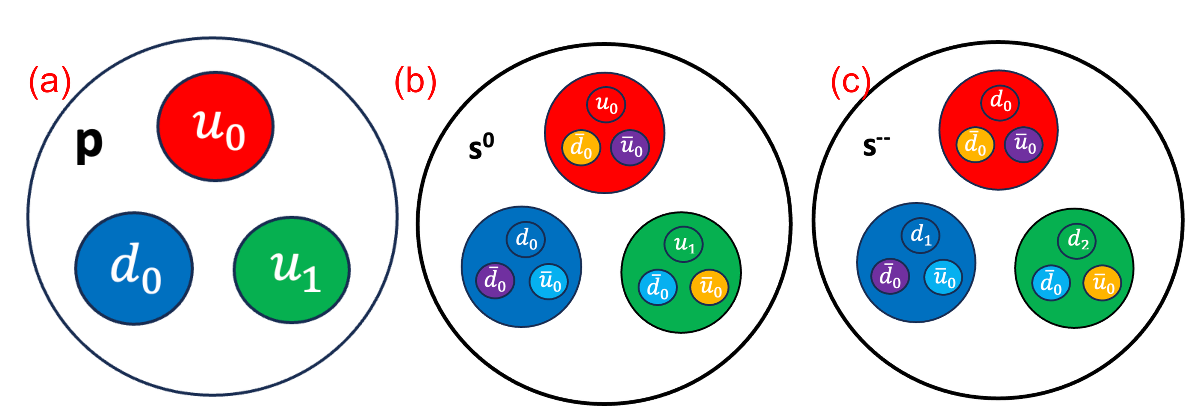

Figure 2: (a) A proton. (b) A neutral superon. (c) A doubly negatively charged superon with a strange quark (d_2).

IV. Decays of Strangeness Nonaquarks

The doubly negatively charged superon $s^{--} = (d_0\bar{d}_0\bar{u}_0,\ d_1\bar{d}_0\bar{u}_0,\ d_2\bar{d}_0\bar{u}_0)$ is a strangeness nonaquark. Its three quarks are those of $\Sigma^- = (d_0 d_1 d_2)$, containing a strange quark or the second excited down quark d_2 (Figure 3c). The decay of Σ^- into a neutron with π^- is resulted from the decay of the strange quark. The meson π^- further decays into an electron and an electron-type antineutrino. Figure 4a gives the fine structure of Feynman diagram (FSFD) for the decay of Σ^-. Figure 4b gives the FSFD for the strangeness antiup-type super quark in s^{--} to decay into the strange-less antidown-type super quark in s^-. Then, the decay of s^-, following the decay of a neutron, further gives a stable neutral superon s^0. Overall, the two beta decays of s^{--} give s^0, a candidate of dark matter particles.

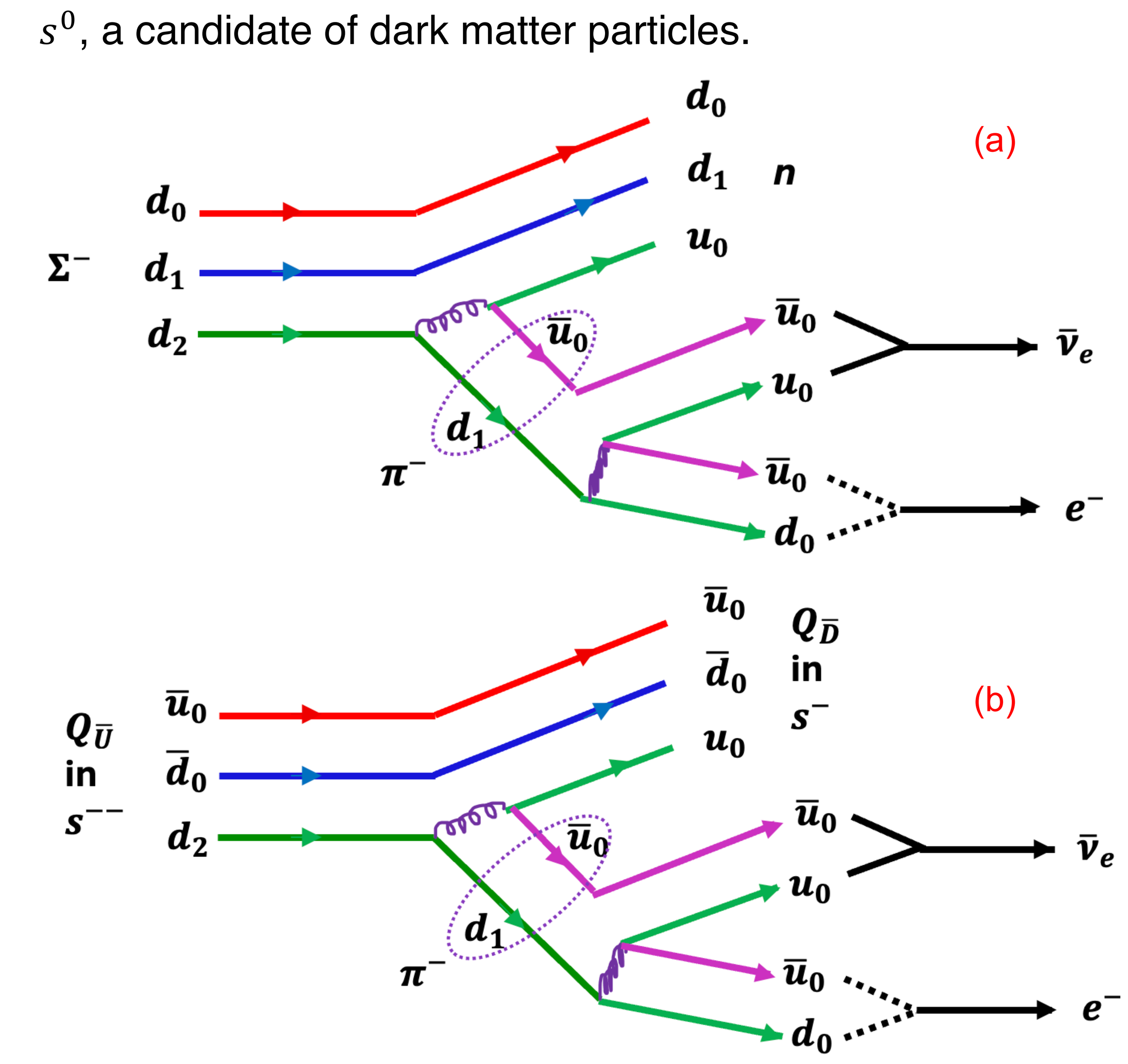

Figure 4: (a) FSFD for the decay of Σ^-. (b) FSFD for the decay of strangeness super quark in s^{--}.

V. Summary

We have briefly reviewed the author's well developed new four-element theory and new two-flavor multi-excitation quark model. We have illustrated the formation of nonaquarks for revealing the mysteries of antimatter and dark matter in the universe. We have explored the stability of nonaquarks, especially the decay of strangeness nonaquarks. The charged superon decay into the neutral one via beta decays. The doubly negatively charged superon contains a strange quark and decays into the neutral superon via two beta decays (one by d_2 and another by d_1).

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VI. References

1. Zhang T.X. (2008) Electric charge as a form of imaginary energy, Prog. Phys, 2, 79-83.
2. Zhang T.X. (2010) Fundamental elements and interactions of nature: a classical unification theory, Prog. Phys., 2, 36-42.
3. Zhang T.X. (2025) New four-element theory, Prog. Phys., 21, 137-146.
4. Zhang T.X. (2011) Quark annihilation and lepton formation versus pair production and neutrino oscillation: The fourth generation of leptons, Prog. Phys., 2, 20-26.
5. Zhang T.X. (2025) Two-flavor multi-excitation model of quarks, J. Mod. Phys., 16, 1243-1268.
6. Zhang T.X. (2026) Formation of nonaquarks and mysteries of antimatter and dark matter, J. Mod. Phys. Submitted.

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