THE QUBIT MODEL: A PLATONIC AND EXCEPTIONAL QUANTUM THEORY

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Abstract. Recently, GUTs based on the exceptional Lie algebras attempt unification of interactions of the Standard Model as a gauge field theory, e.g. Garrett Lisi's $E8$-TOE. But the modern growing trend in quantum physics is based on the Quantum Information Processing paradigm (QIP).

The present proposal will develop the Qubit Model, a QIP analog of the Quark Model withing the SM framework.

The natural principle that "quantum interactions should be discrete", technically meaning the reduction of the gauge group to *finite subgroups* $G \subset SO(3)/SU(2)$, implies that *qubit-frames* in $SU(2) \to SO(3)$ (3D-pixels), playing the role of baryons, have the Platonic symmetries as their *Klein Geometry* (Three generations of flavors): T, O, I, and hence their "doubles", the *binary point groups* (behold!) are the root systems $E6, 7, 8$ of the exceptional Lie algebras, control their *Quantum Dynamics*.

The Qubit Model conceptually reinterprets the experimental heritage modeled into the SM, and has clear prospects of explainig the *mass spectrum* of elementary particles, consistent with the works of other researchers, including Mac Gregor and Palazzi regarding the quatization of mass (Elem. Particles), or Moon and Cook regarding the structure of the nucleus (Nuclear Phsyics).

Overall, the article is an open research proposal to design and implement a Quantum Computing and Category Theory based "Standard Model", ready for, and compliant with the needs, of the present era of Information Theory, Classical and Quantum.

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Introduction

Preamble

When two investigators, with two totally different research styles, coming from "opposite" directions, reach the same "crazy" idea of a TOE based on the exceptional Lie algebras ("Who ordered them!?" - to paraphrase physicist Rabi on the account of muons discovery, as "just" a replica of the electron[1]), then, the wise man should lend one ear (or two) ...

1. Introduction

In a nut-shell, the *Qubit Model* based the Quantum Computing framework (Quantum Information Networks prone to Category Theory as a mathematical language) is an implementation of the Quark Model of the Standard Model (Gauge Field Theory), with some *major conceptual "simplifications"*:

Universe is Locally Finite!

Axiom 1: **3D-Pixels.** Baryons are modeled as 3D-Qubit Frames (Quantum Space 3D-Pixels";[2]

Axiom 2: **Finite Interactions** A bounded Quantum System is discrete and finite, implying that a minimal math model will be discrete; in particular, in addition to Axiom 1, the possible z-axes in an interaction are finite, e.g. as in Stern-Gerlach

[1]... as if the mass difference is "just" more energy! It's a deeper clue towards understanding what mass is ;)

[2]Indeed for the author, "quantum" really means discrete!

experiment, justifying from the start the need to quantize angular momentum, and what "spin" is all-about; [3]

A) **Finite DATA**[4]. The "regular" qubits (steady-states) form a finite Klein Geometry, hence Platonic: the binary point groups T', O', I' (corresponding to $E6- >$ 8 root systems / Lie algebras);

B) **Finite INSTRUCTION SET**. The gates, and hence the gauge transformations/the connection 1-form from 3D-pixel to 3D-pixel, are finite subgroups of $SU(3)$, tentatively the *exceptional six subgroups* $\Sigma' s$ [10] (good source of modular categories for boundary CFTs).

Note that (B) goes beyond the current resurgent research on finite gauge groups G_f as *global symmetries*, in parallel to local gauge groups, as in $G_f \otimes SO(10)$ extension of the 1970s GUTs, beyond the (minimal) SM [11].

(1) Reunites the 3 quarks separated at birth (Gell-Mann's idea that they are "independent particles", leading to D. Gross Nobel Price for confinement and QCD) as a 3D-Pixel, dispensing of the corresponding role for QCD, and of the ad-hoc discrimination: particles are "white" (another "confinement", but not Nobel).

The main benefits are:

(i) **Why 3 quarks!?** The Platonic Geometry of the Qubit (foundational in Math-Physics via ADE-correspondence) hints to number of axes as $SU(2)$-quarks, predicting 3-Baryons with 3-axes (Type O/E_7: Cube / Octahedral Kremer-Wanier duality [12]), 4-Baryons/tetra-quarks with 4-axes (Type T/E_6 self-dual tetrahedron), and predicts 6-quark baryons (Type I/E_8: Ico/Dodecahedral dual)[5];

(ii) **Charged leptons as a 4th "color".** The qubit space $SU(2) \cong S^3$ is a Hopf fibration, with $U(1)$-generator playing the role of a charged "lepton" (corresponding to the appropriate generation: see iv), allowing for a quark-lepton unification;

(iii) **Three Generations.** The Platonic geometries T, O, I determine the "generations", in connection with "flavors" (see next), and (conceivably) dynamics (Lie groups from root systems $E6, E7, E8$; NOT for particle classification purposes!);

(iv) **Flavors**. The *six finite exceptional subgroups* $\Sigma \subset SU(3)$ of the **symmetries of the Harmonic Oscillator are candidates of FLAVORS** of "baryon cymatics" (modes of internal vibration" via groups of symmetry: finite spherical harmonics);

(v) **Spin-Flavor Interaction.** The Platonic Geometry of its Galois Groups $\Sigma \subset SU(3)$ acting on $SU(2)$, is a reasonable proposal for a model of **FLAVOR-SPIN interaction** (picture the 5 "Rubik solids for now, regarding how axes of spin-rotations implement angular momentum);

... and finally a "meta-argument":

[3]So the qubit space itself $SU(2)$, should be discrete: Coxeter-Dynkin type and its Wythoffian alterations, perhaps; and the quantum phase: algebraic!

[4]Thinking of the Universe as a Quantum Computer - see Lloyd a.a.

[5]The axes of course corresponds to R, G, B in a cubical case

(Goal) The above finite gauge groups, with McKay correspondence, and exceptionally (b/c of $E's$: see Lisi's TOE [13]) Beautiful theory (Platonic) meets The Beast (it's not a Monster!), with (seriously) heavy mathematical tools (Coxeter-Dynkin related, for computing a *QUANTIZED mass spectrum of elementary particles*, from experimental DATA (SM), conform the analysis done by Nambu (1954), MacGregor 1970s and Palazzi more recently (Not to mention some "numeralogy" attempts by barut, Koide, and formulas like Gall-Man-Okubo/Nihishima etc.).

Indeed internal "rest" mass is a measure of the quantity of information $m = \sum \log P$ to be stored in the (local) quantum register/qubit, as an automaton with the group of symmetries (its Klein geometry) as a transition table. Comparing the *Nambu parton numbers* [7] and Palazzi-MacGregor parton numbers with SM-masses, while keeping an eye on the "stoechiometric equations" of quark line diagrams for weak decay and strong productions, should do the job.

2. A bit of recent history

The present author got to the "big picture" that the Qubit Model based on Quantum Computing offers a better conceptual and computational framework[6] for Quantum Physics in general (not just for High Energy Physics), then the traditional $SU(n)$ gauge field theory [7], or any other *beyond* the Standard Model attempt for unification to date [8], because going "beyon" SM carries a heavy toll on the past "ad-hoc", yet satisfying solutions: quark hypothesis as independent "particles" that needed confionement (David Gross Nobel Prize), "weak interaction" hidden at small distances to acocunt for slow decay of fast production of resonant states, "color" to save Fermi's exclusion principle, yet an indirect "... but quarks do come in triples" (for baryons)[9] etc.

2.1. Main Goal: Mass Spectrum.

The main goal of the Qubit Model, and test of viability, is deriving the *mass spectrum* of the elementary particles, as the well known main "hush-hush" problem of Modern Physics [3], which is out-of-reach of the SM, beyond the various computationally working mass-formulas (Gell-Mann-Okubo, Barutt, Koide etc.), without clarifying what flavors and generations are.

Our Mach-like approach is based on a general principle (as Einstein would have probably requested): **quantization of the qubit**, or equivalently, requiring not just that Space-Time be "pixelated", but rather its pixels be discrete, i.e. be discrete, or globally put, the (co)tangent bundle be "pixelated".

[6]Heisenberg, Feynman, Manin, Lloyd, Kauffman, Ionescu etc.

[7]Einstein, Noether, Weyl, Feynman, Weinberg, Glashow-Salam, Georgi, Pati etc.

[8]Dixon, Lisi, Furey etc.

[9]A Galilean analog of "E pur si muove", denying that quarks are independent particles, and besides quark confinement, now introducing "colorless" as another kind of house rule.

In other words, the directions of interactions should be finitely many (e.g. the interaction of an electron with the Lab's magnetic field as in a Stern-Gerlach experiment), the pixel is not a "continuous" qubit $SU(2) \cong S^3$ (topologically), but a finite Klein geometry: the finite proper binary point groups in 4D.

As a byproduct this *"explains" the quantization of angular momentum*, i.e. makes the Theory of Spin a consequence of this principle [10].

2.2. **In a TOE quantize "everything" ... in One Postulate!** Now this happened during an investigation (comparing Quark Lines Diagrams of the Standard Model and Category Theory models for QFT / QC (Turaev Graphical Calculus and Temperley-Lieb Algebras), while having the DWT in the background[11], leading to the Platonic solids as candidates for quark flavors (in our qubit frame model), which was post-factum "confirmed" by finding in the literature the "crazy" idea of Prof. Moon that the nuclei are structures as imbricated Platonic solids.

The main idea was: "Everything" must be discrete (quantized)! If we adopt the "Meta-Axiom":

$$Universe\ is\ Locally\ Finite^{12}$$

then the gauge group $SU(N;k)$ (and quantum phase) must be finite somehow. The question was: use algebraic extensions $k = Q(\zeta)$ or finite subgroups $G \subset SU(N)$, e.g. *congruence subgroups*?

The "beauty" of it is, that "finite geometry" for qubits, i.e. finite subgroups $G \subset SO(3)$ are T, O, I, and their binary pull-backs $2T, 2I, 2O$ are *also* congruence subgroups $SU(3, F_3), SU(3, F_5)$! (see ADE-correspondence [4] and end-notes).

Finding that such an exceptionally Lie algebra based TOE exists (Lisi and back-track history: Furey, Dixon etc.), is a confirmation that "the solution is at hand", as it will be explained in a sketchy, yet technically precise terms, next.

2.3. **What is "Special" about this R & D Proposal.** The "novelty" of this proposal is the use of general conceptual foundations, which are simple, "natural", wide reaching and historically friendly, used as a guiding beacon for the top-down design of the Theory, leaving the technical implementation to a team of specialists (SM was built over roughly 100 years of hard work and trillion dollar investments!).

The "guarantee" of being on the right track is the *multiple confirmations of the line of thought and research of the author*, as mentioned above (Pauli's Group Theory solution of the H-atom, Moon's Model of the nucleus, Cook's FCC Model in Nuclear Physics, MacGregor and Palazzi's proof of quantization of mass, Lisi's E8-TOE), together with other preliminary investigations of finite gauge groups for SM, as early

[10]The result of a long historical journey: Bohr, Sommerfeld, Pauli, Schrodinger, Dirac, Feynman.

[11]Naming it DWT, and not TOE, is perhaps maybe less ambitious, yet realistic, since there are many aspects of reality not addressed.

[12]Yet maybe not bounded in size, and Network Fluctuations / reconfigurations, like are allowed: it's graph (co)homology.

as 1956 [5], as well as recent ones [6], yet "stuck" on the limited use as a classification tool, limited by the requirement to reproduce Gell-Mann's 8-fold way.

The main "advantage" of proposed research, is being consistent with the modern trends (Dominance of Information Theory in our grandchildren's Information Era), making it a long-term high-yield return investment.

As an important "collateral" to such an investment, is the author's broad education in Mathematics, Computer Science and Physics, with a high productivity and expertise for designing complex theories (e.g. Expert Systems in Computer Science), due to a "special evolution" during his carrier (see CV).

3. The Plan of Research and Development of the Qubit Model TOE

To place the present proposed research in the proper (dynamical) context, we recap the main stages of R&D of the PI.

3.1. **The Long Term Program of the Author.** The "functorial way" $Present : Past \to Future$, requires a quick inspection of the prior work of the PI.

... The PAST ...

• Phase I: Quantization Feynman Diagrams -¿ Category Theory and QC (1994-2007; DWT); see CV for details.

• Phase II: Periods and Amplitudes -¿ Categorification of the SM (2007-2017); includes various visits at IHES, as Prof. Maxim Kontsevich's guest, as the PI's research was linked to Kontsevich work on several and projects (deformation quantization, periods etc.), as well as with Prof. kreimer and Connes (Hopf algebras and renormalization).

... still *missing*: how to "quantize" the qubit!? (DWT requires finite "quantum digits"!).

The preliminary research (past year or so, leading to this proposal), being successful (as explained above), allows to state the Plan of R& D for the answer to the above main question (mass spectrum problem).

... The Present: this proposal ...

• Phase III: Quantizing The Qubit $\to$ "Platonic and Rubik (Quasi)-Solids"

3.2. **Intuitive Models as Guidelines.** Lord Kelvin's model of el;ements as knots in the ether, Maxwell's image of wheels to help understand EM, Bohr's solar system model of H-atom, or Moon's model of nucleus as a Kepler's Model of Solar system are not just useful intuitive models that guide the design of the "final, computational theory", but yield results way beyond the invested amount of technical knowledge used to build them.

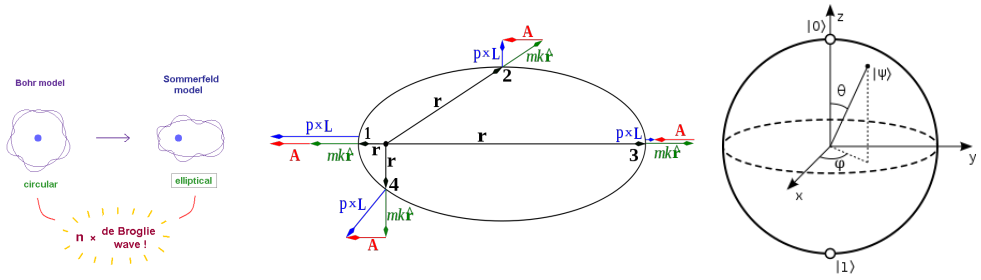

FIGURE 1. Angular momentum and spin: Bohr-Sommerfeld model and Kepler-Lenz Frame vs. Qubit Frame

Remark 3.1. Later on we will add another such pedagogical "gadget": the Rubik Platonic Solid, illustrating the connection between angular momentum (relative to one fixed z-axis) and flavor (The flavor's generation is determined by the finite set of possible z-axes: 3,4,6; corresponding to T, O, I point groups / $E_{6,7,8}$, in the ADE-correspondence).

In understanding the Qubit Model (QC) version of Quark Model (SM), the "unit of motion" is classically described by Kepler's Problem, while the quantum version, by Schrodinger Equation / Pauli Hamiltonian Solution / Qubit Frame (Bloch sphere in 3D / Hopf bundle in 3+1D). The correspondence is constructed using Laplace-Runge-Lenz conserved vector A, which yields 3D-frame to the Kepler Problem $(A, L, B = A \times L$ (here L is the angular momentum) to be considered analog to the Quabit Frame (J_x, J_y, J_z) in $so(3)$ $(\cong su(2))$ of generators of *qubit space*:

Bloch's sphere coordinates refer to $J_{x,y,z}$ basis of $su(2) - spin$ Lie algebra [13]

This allows to move between "old" Quantum Mechanics formulations (Schrodinger / Heisenberg with the Pauli's notable use of group theory), to extract the QC relevant guidelines.

3.3. **Quantizing The Qubit.** - This is an implementation of the *Parton Theory* from Theoretical and Experimental Physics (Feynman, Deep Inelastic Scattering etc.);

- Leads to the binary point groups $2T, 2T, 2O$, and hence to $E6- > E8$ exceptional Lie algebras; these in turn are "explained" via quaternions and octonions, "closing the circle" back to qubits and their interactions $(SL_2(C) \cong SU(2) \times SU(2)$ and octonions as a double of quaternions $SU(2))$;

- The qubit-frame $\{J_x, J_y, J_z\}$ (3D-pixel) is a basis of $su(2)$ (LIe algebra of the qubit-space $SU(2)$); interpreted as a 3D-Harmonic Oscillator, has $SU(3)$ as the symmetry group, which correspons to $SU(3) - color$ from SM (making absolete the "white baryon" requirement).

[13]Red,Green,Blue as "colors" of the wheels of the tri-gyro: the 3D-pixel of Quantum Space (baryons).

- Thus $SU(3) -$ "*color*" acts on $SU(2) - Mod$ (particles with spin), which have *modes of oscillation* (see Georgi for the 3-masses with 2D-degrees of freedom example and the corresponding analysis via irreducible representations of $SU(3)$), playing the role of "flavors";

- Relate these 3D-Harmonic Oscillator "flavors" of vibration (no wave equation needed: it's "just" harmonic analysis), to 3D-regular solids, i.e. Platonic Groups T, O, I (their doubles $E6 - 8$), and their rectifications and non-convex variants (see Coxeter-Dynkin diagrams and **Wythoffian operations**, as transitions between "maxima and minima of the modes of "vibration"; analogy with 3D-cymatics of a 3D-blob);

Remark 3.2. The R&D follows the well known methodology: DATA (Particle Data Group), Hypothesis (Qubit Model), Theory (Mass is Group Structure), Test (Mass Spectrum); e.g. the historical Brache-Kepler-Newton example.

3.4. **What is "mass"?** External mass refers to the momentum's equivalent mass, via Einstein's relation. The "internal rest mass" m_0, appearing as kinetic terms in the Lagrangean of a field theory, corresponds to size of the internal group of symmetry of the qubit-frame modeling the baryon, which accounts for the flavors of its three quarks (in the SM), as generators of the Lie algebra (adjoint rep; or partons in higher weight modules). The correspondence with SM is via the *generalized momentum* say for EM is $P = m_0 v + ieA$. More details are prepared in [14].

3.5. **Platonic Geometry and Mass Spectrum.** - The theoretical framework being set (Platonic Solids, Coxeter Groups, Dynkin diagrams, Wythoffian operations, Root Systems and E6-8), and the DATA together with its analysis being available (Mac Gregor and Palazzi: quantization of mass in units of $70MeV$, or electron mass m_e ("external states"/ finite structure constant, amplitudes and Multiple Zeta Values) and muon mass m_μ ("internal structure": mass as a measure of internal structure / Klein geometry / Markov System / Quantum Turing Automaton), one would start to look for a correspondece between *parton numbers* (Palazzi: m/m_μ), and sizes of symmetry groups T, I, O as flavors, combined with the theory of spin via representatiuons of the Lorentz group (conf. with the recent work by Varlamov [7], 2017);

- If (quantum) mass (Parton Number P) is a measure of the quantity of information (Shannon Theory and Markov Probability Models; e.g. a simple dice $P = 1/6$), with the Klein Geometry structure group (for e.g. Cube-Octahedron duality;

3.6. **The Three Generations.** . A working hypothesis to be tested, as a first example, is that the SM-*quark generations*, i.e. vibration modes of the 3D-Harmonic Osc. (the 3D-pixel/Qubit Frame), are the three Platonic Dualities (Poincare duality of the corresponding CW/Chain complexes; Euler-Poincare characteristic/ Homology-Cohomology):

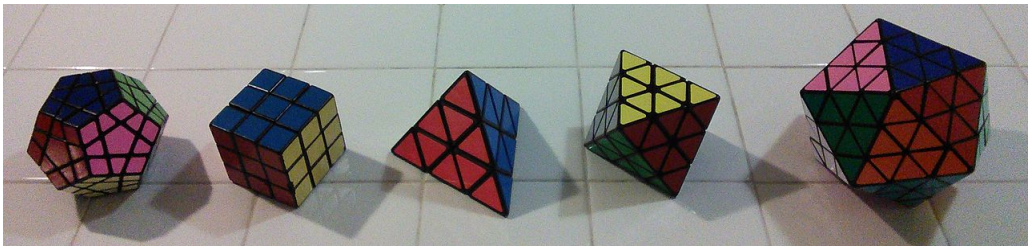

FIGURE 2. Platonic Rubik type p ($l = 1, dim\ V_l = 3$ "slices") solids illustrating the spin-flavor correlation; $SU(3)$-color acts on $SU(2) - Mod$ as a "Galois group" of equivariant transformations.

1) Tetrahedron (self-dual): $2T \quad <-> E_6$; u, d good isospin symmetry (Lorentz transversal vs. longitudinal mass correction factors; $z \sim t$ in the twistor model $p -> \zeta \otimes \zeta*$);
2) Cube-Octahedron: $2O \quad <-> E_7$; strange-charm s, c;
3) Iso-Dodecahedron: $2I \quad E_8$; bottom-top b, t.

Remark 3.3. T, O groups allow for tesselations of 3D (FCC model), while I (ico and dodeca), does not (stability related ...?).

3.7. **Spin-Flavor Coupling: the Rubik-Qubit Model.** . Spin of baryons is modeled via "slices" (number equals $dim = 2j + 1$, with j the total angular momentum) of Platonic versions of Rubik cube (Rubik solids):

Example 3.1. For example, from Palazzi (to be completed later on, in collaboration), the baryon Σ^0, member of the spin $\frac{1}{2}$ baryon octet, with quark structure uds in SM, has mass $m_\Sigma = 1189,37$, and parton number $P = ...$ (analog of atomic number in Mendeleev's Table), in units of $u = 35\ MeV$.

Varlamov's pair of angular momentum and total angular momentum is $(l, \dot{l}) = (48, 95/2)$ for this spin-line $s = 1/2$ of Lorentz representations [7], where $\dot{l} = l + s = j$, where spin $s = \frac{1}{2}$.

Similarly, and perhaps simpler to handle, the pseudo-scalar meson K^+, a member of the $SU(3) - flavor$ octet (SM classification), has mass $m = 497.57\ MeV$ ($m = 493.67\ MeV$ [7], p.13), parton number $P = 14$ (same unit $u = 35\ MeV$), and Varlamov's Lorentz coordinates $(61/2, 61/2)$.

Now some questions to be investigated:

Flavor related:
1) What "modes" from the $SU(3)$-symmetry theory of H. Oscillator corresponds to this "particle" Σ?

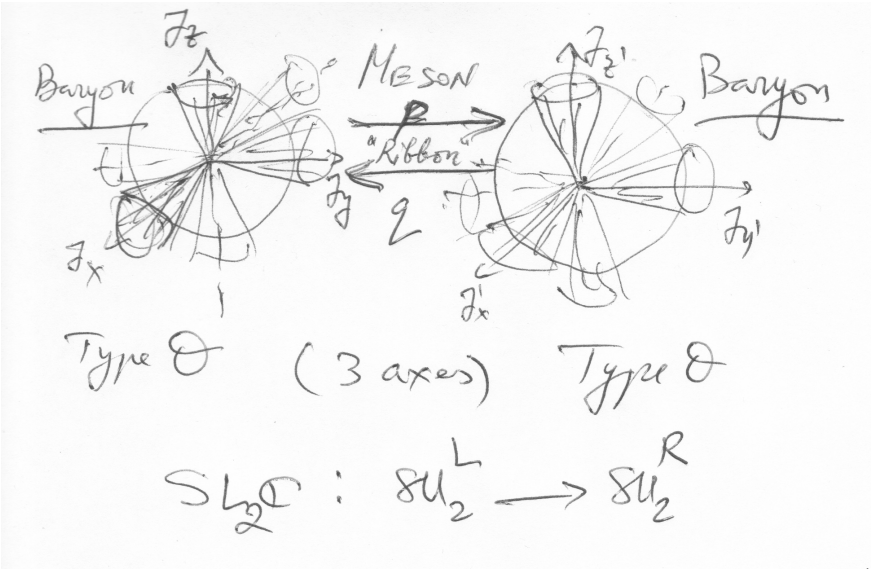

FIGURE 3. Exchange of geometry and momentum between baryons is achieved via mesons.

2) How does the meson mass reflects the "exchange" of modes, e.g. $K^+ = ud*$ can "replace" amnd d by an u in a mode of "vibration" of a baryon (correlation with the Electro-Weak Theory's heavy bosons, the "units" $W^{\pm}$; is their mass "on-shell" 80 GeV? Why so big for a light quark transition!?).

Spin related:

3) Is the corresponding Regge trajectory of higher angular momenta resonances compatible with our Rubik-Qubit Model of spin-flavor interaction?

3.8. **Mesons as Quantum Duplex Channels.** - Note that rotations $J's$ (generators of $su_2 \cong so(3)$) and boosts $K's$ in $SL2(C) = SU_2^L \times SU_2^R$ allow to interpret interactions as exchange of boosts at external DOFs level, while internal mass change may be modeled as geometry change (modes of "vibration"), via change of symmetry group T, O, I.

This later role can be attributed to mesons, as argued next.

- Genuine mesons $X = pq^*$, where $p \neq q$, like $K^+ = us^*$, i.e. not the quarkonium mesons (e.g. $\pi^0 = uu^* + dd^*$), are interpreted in the Qubit Model as *duplex channels of quantum information*, as is naturally suggested by the SM's Quark Line Diagrams, in the context of the Turaev Graphical calculus in Ribbon categories (or Temperley-Lieb recoupling theory, Topological Quantum Computing with anyons etc.). Their role is to exchange "modes of vibrations" of a qubit-frame (baryon), rather playing the original role ascribed by Yukawa Theory (That there is no need for Weak Force nor Strong Force, as gauge Theory "Forces", for many reasons, historically documented;

yet the analogy between Qubit Model and SM can be made at that level still). The mass spectrum of mesons and its analysis by Mac Gregor and Palazzi [2, 16] can be used to test the theory of transitions / interactions between qubit-frames (baryons), in the context of recoupling theory.

- One important technical point: the conversion between (internal) angular momentum and (external) linear momentum during an interaction via "light fermions/bosons" (electron and photon), is understood via $SL_2(C) = SU(2)^L \oplus SU(2)^R$ ($J's$/rotation, and $K's$/boosts, forming a basis of Lorentz group).

- Another point: "heavy fermions and bosons" (SM), carrying mass / "geometry change" are the mesons and heavy leptons (μ is essentially a pion: $\pi \to \mu + \nu_\mu$; similarly τ?); the distinction between "leptons" as carriers of whole charge and mass, but no "geometry", and mesons as similar but carrying "geometry" (quark lines / change of flavor in baryons), should be better understood in the Qubit Model.

3.9. **Unifying Leptons and Quarks: The Hopf Bundle.** - Note that there is a trend to unify leptons and quarks in E8-based GUTs;

- Note also that "leptons as a 4-th color" (ref.?), could have the following interpretation in the Qubit Model. The qubit space (H. Osc.) is the Hopf Bundle Frame $S^1 \to S^3 \to S^2$, and the Bloch sphere would correspond to the 3-frame Jx, Jy, Jz of $so(3) \cong su(2)$ Lie algebra (spin; a qubit is a tri-gyro./superposition of spin in all three "directions of interaction", relative to a frame/base), while Q the electric charge as a Noether charge generator, associated to $U(1)_{EM}$, would be the 4-th "color".

- Then the 4D-Harmonic Oscillator ("periodic vibrations" as 3+1-cobordisms), would have 4D-polychora as nodal configurations of max/min, with exactly 6 "shapes" (regular 4D-polychora): 5 (self-dual), 8/16 (Hurwitz quaternionic integers), 24=8+16 (self-dual), 120/600 (Caylay octonionic integers). This would require re-evaluating the "Three Generation Problem", within the same framework: $2T, 2O, 2I$ / $E6-8$, but in 4D. Note that "face-poking" Platonic solids, i.e. duality questions, leads to 3+1D anyways;

- Note that the "same" $2T, 2O, 2I$, i.e. E_6, E_7, E_8 govern the above 3+1 Flavors Theory, unifying indeed *leptons and quarks*, as the basic fermions; also the natural framework to understand them is that of quaternions and octonions (considering Platonic solids 2D-complexes as root systems E6-8).

- But the role of bosons from the Gauge Field Theory is played by mesons in the Graphical Calculus in Ribbon Categories, supplied by ribbons representing pair of quark lines from the SM).

... The Future ...

• Phase IV (Future):

- The Math-Physics Implementation means a mutual collaboration with SM experts to "import-export" the technical aspects, adapting them to the specifics of the language used (gauge theory of Fields, vs. QC on Networks and recoupling theory);

- Write the documentation; expository articles; finally, write some textbooks;

- Expand the academic curriculum, to include the Modern Mathematics (Category Theory and, e.g. TQFTs), Quantum Computing (and Topological Quantum Computing); applications to Quantum Physics: The Qubit Model.

4. The Project: Management and Resources

The PI envisions the accomplishment of this proposal as a large scale collaboration, with the PI's role as a Project Manager, benefiting from an extensive experience in such a role (conf. CV).

5. Management of the Project

Indeed, the Project is quite big and ambitious, requiring the contribution of a team of experts in two directions, to act as consultants for the Project:

Principal Collaborators/ DATA Analysis: Experts in the Quantization of Mass (NOt a SM aspect): Prof. Mac Gregor and Dr. Palazzi.

Secondary Collaborators/ Theory Consulting: 1) 3D-Platonic/ 4D-Regular polyhedra and Quaternions / Octonions: Prof. Baez; Profs. Corine Manogue and Tevian Dray;

2) From Point Groups to Exceptional Lie Algebras ($T, I, O- > E6-8$), and their connection to octonions and Physics: Baez, Furey, Lisi;

3) The Physics of the Standard Model: Prof. Griffith, Prof. David Gross; Lie Algebras and GUTs: Prof. Georgi.

The following tasks are carried out in parallel, as much as possible.

I) Establish a Cloud Based working environment (e.g. Poly-Physics analog of Poly-Math); work by email until then.

II) Finish 1st drafts of PI's articles: 1) On mass formulas and periods; 2) Quantizing The Qubit; 3) Qubit Model as an E6-8 TOE;

III) Explain the ideas and key Math-Phys-CS aspects in person: travel to meet the collaborators, or better, organize a Summer Workshop;

IV) Work on the Mass Problem:

- Match the parton numbers from the two main sources: from experiment (PDG) via MacGregor unit/ Palazzi work, and Varlamov Lorentz reps "coordinates", with the sizes of symmetry groups of the corresponding representations (clarify the role of finite geometries: Platonic solids / H. Oscillator nodes).

- Develop the theory of the 3D-H. Oscillator: group theory and reps theory (recoupling theory);

V) Understand the *dynamical role* of E6-8 Lie groups, NOT just as a classification tool; move away from the Gell-Mann interpretation of $SU(3)$-flavor, i.e. reinterpret charge as grading (see Baez's review), and "strangeness" as a "flavor" of oscillation mode (e.g. breathing mode of the 3D-H. Osc. with $SU(3)$ as a symmetry group);

etc.

5.1. **Resources needed: financial and human.** - PI's salary for 5 summers, i.e. 10 mo.: $10 \times 10,000 = 100K$;

- Main Collaborators: MacGregor and Palazzi, at 1 mo/year, for 5 years: $5 \times 10,000 = 50,000$;

- Secondary Collaborators (Baez etc.): 10 mo. at $10k/mo.$, i.e. $100,000$;

- Travel expenses: five trips at $2k$ per trip, total $10,000$; two workshops: $20k$.

Grand total for a 5 year period: $250,000$.

6. Conclusions

The *Qubit Model* is a Quantum Computing based model of Elementary Particle Physics, based on the experimental aspects captured by the Standard Model, without the actual solutions adopted by the Standard Model.

6.1. **Qubit Model: what is, and is not.** It is not a field theory; quarks are not initially "indepedent"; "colors" R,G,B are indexes of an $su(2)$-base, the qubit frame, with "Galois Group" $SU(3)$; "flavors" reflect the finite group geometry of the Qubit Frame, the 3D-pixel, and can be put in correspondence with finite gauge groups of the SM; isospin / fractional charge corresponds to grading; etc.

The main novelty is the "2nd quantization" Postulate:

$$\textit{Qubits have Finite Geometries}: \quad \textit{Platonic Groups } 2T, 2I, 2O = E_6, E_7, E_8.$$

In this way the mass problem can be meaningfully addressed, taking advantage of the DATA analysis of Mac Gregor and Palazzi.

In this framework, lepton-quark unification seams feasible via the Hopf bundle: 4th "color".

Spin-Flavor coupling is implemented via $SU(3)$ acting on $SU(2) - Mod$ (spin), as a Galois group, while identifying the said $SU(3)$ as the group of symmetries of the 3D-Harmonic Oscillator, the Qubit Frame ("3D-cymatics", similar to the 2D-drum modes used to understand atomic orbitals as Schrodinger solutions, or spherical harmonics / Laplacian and Group Theory: Pauli's solution; relate with Kepler-Lentz Frame, thinking of Bohr's intuitive model of the H-atom);

More importantly, the migration from Gauge Theory and Fields (especially the continuum aspects), represents a current trend: the future is that of Quantum Computing and Information Theory.

The discretization of models (lattice models, Spin Networks etc.) reflect the essence of Quantum Physics, at Low and High Energies. We know classical computers are finite; well, it seams that Quantum Computers are finite too!

6.2. **The New Paradigm: the needed for change.** As mentioned before, the *Standard Model* is an impressive achievement of 20th c. science and technology, based on the dominating Math-Physics paradigm "Group of symmetries correspond to conserved quantities" of Noether, leading to Weyl's Gauge Theory.

What needs to be abandoned are two "things":

Thing One: *Separation* between *sources and fields*, replaced by a *network models*, conform [8]; this includes the unification between fermions and bosons, but not in the way "traditional" supersymmetry is understood: at a much deeper, primordial conceptual level;

The aspects mentioned above are not the focus of this proposal, although are useful to be kept in the background.

The focus is on the following Meta-Axiom:

Thing Two: *The Continuum*! ... "The Universe is Finite" seams to yield much better conclusions (for a Quantum Theory that is), is computationally tractable (we couldn't build a continuum-handling Computer; Mathematica got quite close!), and the resulting "*Landscape*" is mandatory: there is only ONE instruction set! (Quantum Dice, Mr. Einstein!).

This prevents the continuum to creep-in, and proclaims the "legacy" of Platonic Groups and Solids T, O, I, which abstractly correspond to the ADE-correspondence [9]:

This in turn has implications in various directions, conceptual and technical:

1) $q\&p$ **Quantization.** The directions of interactions between two irreducible quantum systems (i.e. qubits), are finite; it justifies the quantization of angular momentum and its relation to $\frac{1}{2}$-spin (Stern-Gerlach experiment): mathematically speaking $SU(2) - Mod$; physically speaking, it explains the atomic orbitals via group theory, without Schroedinger Equation, leading to Pauli's solution.

2) **Qubits and Gates**[14]**.** Once the quark model is "simplified", with baryons as 3D-frames in $so(3)$ (or in qubit space $su(2)$), thought off as *tri-gyroscopes*, and corresponding in SM to the R,G,B colors of QCD (no longer needed as a "Force" to keep quarks confined: QCD role no.1), and *mesons as quantum duplex channels* (now playing the "other part" of the role of the "Strong Force"), the 3D-harmonic Oscillator theory can be used to derive the modes of "vibration" (Harmonic Analysis of corresponding finite groups), to understand flavor and its connection to spin, via $SU(3)$-Flavor as the symmetry group of 3D-H.Osc.

[14]Quantum Registers and Operators.

ADE classification

Dynkin diagram via McKay correspondence	Platonic solid	finite subgroups of SO(3)	finite subgroups of SU(2)	simple Lie group
A_n		cyclic group $\mathbb{Z}_{n+1}$	cyclic group $\mathbb{Z}_{n+1}$	special unitary group
D_{n+4}	dihedron, hosohedron	dihedral group D_{n+2}	binary dihedral group $2D_{n+2}$	special orthogonal group
E_6	tetrahedron	tetrahedral group T	binary tetrahedral group $2T$	E6
E_7	cube, octahedron	octahedral group O	binary octahedral group $2O$	E7
E_8	dodecahedron, icosahedron	icosahedral group I	binary icosahedral group $2I$	E8

FIGURE 4. ADE-classification: from Platonic Klein Geometry to Quantum Dynamics and Elementary Particles.

3) **Flavors.** Now these *modes* should correspond to *combinations of quark flavors* u, d, s, c, b, t from the $SU(3) - flavor$ classification of the SM, and the irred. representations of T, O, I, "should" lead to the understanding of the transitions via McKay correspondence, without the need of a "Weak Force" (playing its function; in QC there is only DATA, gates and channel capacity playing the role of the "propagator", which is based on a metric on a Space-Time). How $SU(3)$/8-Fold way via root systems corresponds to the T, O, I Klein geometries / Harmonic nodes and associated E_n-root systems (Lie Dynamics), remains to be investigated.

In other words, if we literally take "quantum" to mean discrete, for a Quantum Physics Theory "finite is the grease word". This entails it is Platonic, i.e. it is based on finite gauge groups, from which via ubiquitous ADE-classification does the job: root systems and E_n, finite type quiver representations, finite spectra of representations etc.

Since "Reality" seams to be quantum, in the sense that appears to be discrete (starting with Zeno, and ending with *Real Numbers, Real Jobs, Real Fish"*, we (many of us) claim: must be finite!

Then, behold! ... there is only one (*exceptional*) way: the Platonic Way! Period[15]!!

[15]How this relates with the "coincidence" between scattering amplitudes and MZVs as periods, becomes even more fascinating and enticing to study.

Even with such big changes, The Standard Model can be adapted easily to the new viewpoint, by adopting the "phylosophy" that quarks are basis elements in the fundamental representation of the particle, and "partons" correspond to higher dimensional representations, of a 3D-Frame (The Quantum Space Pixel).

It will still remains the "core" of Math-Physics modeling and experimental test scientific cycle.

There is, of course, the alternative "clean" formulation based on Quantum Computing (Information) framework and Category Theory mathematical language, which will develop as a dual, "modern" (young) approach, to the above classical and traditional (paternal) approach.

Epilog

Some say the Universe is a Quantum Computer (Lloyd, Musk etc.); well, it stands to reason that it has to have a finite set of instructions (quantum gates), and finite data types: it's *quantum*, right? ... Then there is only ONE CHOICE: IT's Platonic! (Plato would have loved this, I think :) ... (Wheeler too: IT from Bit ...?)

... and definitely *exceptional*: The Beauty and The Beast [16]:)

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