Ontogenesis, Part 1

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In the beginning was the Word
John 1:1
And the Word became flesh, and dwelt among us
John 1:14

There are two complementary [1] science domains, irreconcilable in popular beliefs: quantum theory and classical laws. Yet quantum[1], i.e., particle-like, features only arise upon measurement, i.e., upon extraction of classical information. Quantum theory *assumes* the dynamics of insinuated *quantum state* between measurements is unitary, i.e., wavelike[2], commonly expressed via Schrödinger equation. Unitarity ensures conservation of information, as mandated by objectivity [2]. If, in Stern-Gerlach device oriented along z-axis, an atom was detected in spin ↿ state, a subsequent measurement with Stern-Gerlach device oriented along z-axis would again detect that atom in spin ↿ state [3]. The output from second device is same as the output from first, i.e., preparation device. To account for this, the *evolution* $\boldsymbol{\psi} \rightarrow (\boldsymbol{\psi}' = \boldsymbol{U}\boldsymbol{\psi})$ of quantum state between measurements has to be unitary and diagonal in measuring device eigenbasis[3]: $[\boldsymbol{U}\boldsymbol{X}] = 0$; $\boldsymbol{X}$ being an operator representing measuring device. Transformation $\boldsymbol{U}$, commuting with $\boldsymbol{X}$, conserves extracted by first measurement information, i.e., conserves knowledge that atom is in spin ↿ state. A natural question arises, how can measuring device impose transformation $\boldsymbol{U}$ on quantum state *prior to measurement*? After initial measurement, how does atom know next measurement will be with commuting operator, and not with some other, non-commuting with $\boldsymbol{U}$ operator? There is no sensible answer to this question compatible with quantum state concept. Admittedly, the notion of quantum state is a delusion. Not only it is logically malformed[4], it contradicts empirical evidence, e.g., Alain Aspect's [4] and similar experiments, that proved quantum state does not exist prior to measurement. What does not exist can't be said to evolve. Transformation has to be ascribed to measuring device [eigenbasis] rather than to quantum state. The notion of quantum state is a misleading abstraction responsible for the conundrum of so-called "interpretations" of quantum mechanics. Unlike delusive quantum state, the *device* is a tangible and straightforward concept. The *Heisenberg picture* is the meaningful one, not Schrödinger's.

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[1] The numerous misconceptions in quantum mechanics may have a lot to do with buzzword abuse. The word *quantum* obfuscates the fact that it refers to discrete, yet classical, outcomes of the measurement. The domain of quantum mechanics deals with correlation of classical information extracted in different measurements. More appropriately it should be called *knowledge mechanics* (KM) [16]

[2] The century-old fallacy of "wave-particle duality" immediately falls apart, as particle-like properties relate strictly to outcomes of measurement, i.e., to an output of measuring device, while wave-like behavior relates to unitary dynamics before the measurement, i.e., at no point they co-exist as properties of any entity

[3] Were transformation $\boldsymbol{U}$ diagonal instead in eigenbasis of preparation device, then $\boldsymbol{\psi}' = \boldsymbol{U}\boldsymbol{\psi} = e^{i\varphi}\boldsymbol{\psi}$. Here φ is a real-valued parameter; $\boldsymbol{\psi}$ is the preparation device output eigenstate. Multiplication by a phase factor would result in probability of finding object in initial state $P = |\langle\boldsymbol{\psi}|\boldsymbol{\psi}'\rangle|^2 \equiv 1$, i.e., there would be no detectable dynamics. If $\boldsymbol{U}$ is diagonal in measuring device eigenbasis $\{\boldsymbol{k}\}$, then $\boldsymbol{\psi}' = \boldsymbol{U}\boldsymbol{\psi} = \boldsymbol{U}\sum_{\boldsymbol{k}}|\boldsymbol{k}\rangle\langle\boldsymbol{k}|\boldsymbol{\psi}\rangle = \sum_{\boldsymbol{k}} e^{i\varphi_k}|\boldsymbol{k}\rangle\langle\boldsymbol{k}|\boldsymbol{\psi}\rangle$; $P = |\langle\boldsymbol{\psi}|\boldsymbol{\psi}'\rangle|^2 = \sum_{\boldsymbol{k},\boldsymbol{j}} P_k P_j \cos(\varphi_k - \varphi_j)$, where $P_k = |\langle\boldsymbol{k}|\boldsymbol{\psi}\rangle|^2$. In this case, we get the expected dynamics by parameters $\{\varphi_k\}$

[4] Assuming the existence of quantum state presupposes classical information (fact of existence), with no measurement

For a meaningful measurement, as that with mutually exclusive outcomes, device must be represented by a Hermitian operator with distinct eigenvalues. It ensures real-valued device readings (eigenvalues), and orthogonality of corresponding device output states (eigenstates), constituting device eigenbasis. Some challenges arise in this context:

1. What drives unitary transformation of eigenbasis? Or, in orthodox formulation, unitary transformation of quantum state? Transformation in a real physical sense, rather than just mathematical substitution with no underpinning physics[5]
2. Measurement converts quantum information[6] into classical. The objective reality is represented by classical information, which can only be extracted by measurement. What effectuates the measurement and associated *transition* of information, that creates objective reality? Unitary dynamics, represented by, e.g., Schrödinger equation, does not involve transition, since unitarity preserves both quantum and classical information. The popular but deceitful math trick [5], to consider system entangled to environment, with subsequent tracing environment out, doesn't answer this question. Tracing out environment implies measurement [of the environment part of the whole system] [6]. This challenge relates to so-called *measurement problem* [7], albeit orthodox formulation of the latter is based on the notion of wave function (quantum state) collapse, which derails understanding of the problem from get-go. The challenge is part of ancient question [8]: *why is there something rather than nothing*?
3. Let M be the cardinality of measurement outcomes in defining [9] representation of measurement operator. So far, no one has put a warrantable limit[7] on M. Yet objectivity mandates measurement outcome to be encoded in $O = 2$ observation basis, homomorphic to $3D$ information space, in order to represent objective reality [10]. How do outcomes of measurements in M-cardinality bases build up to $3D$ objective reality?

The analysis of above challenges shall lay the foundation for a coherent picture of *ontogenesis*.

I shall start with conceptual overview of measurement. Measurement is the extraction of classical information, by reading output of measuring device. The fact of reading is the *measurement event*. Device reading, a distinct real number, is the *eigenvalue*. The corresponding device output state is the *eigenstate*. Eigenstates are only distinguished by eigenvalues. Eigenstates are usually represented as M-dimensional eigenvectors, where M is the cardinality of device readings. Input interface of measuring device is quantum[8], and output interface is classical.

Hermitian operator $\boldsymbol{X}_M$, representing device with output cardinality M, is defined by M^2 real parameters. Of which, M parameters are eigenvalues, independent of device input. The rest $(M^2 - M\ )$ are input parameters, defining device input state.

[5] New variables and new basis vectors must be de-facto measured observables and actual device outputs, in order to signify a real physical transformation

[6] As defined elsewhere [13], quantum information is the *potential* information, which could be materialized as real, i.e., classical information, by measurement

[7] There has not been a formal justification for confinement of standard model to $U(1) \times SU(2) \times SU(3)$ symmetry group. Rather, it came up through efforts to fit experimental results, similar to the story with QED [17]

[8] The adjective *quantum* simply indicates there is no reading (extraction of classical information) at input interface

The expression for device eigenvalues and eigenvectors via M^2 parameters is derived from Gell-Mann decomposition [9] of device operator. I shall first consider cardinality $M = 2$ (qubit) operator. For $M = 2$, eigenvalues ϵ_u, ϵ_v, and normalized eigenvectors $\boldsymbol{u}, \boldsymbol{v}$ are:

$$[\epsilon_u \;;\; \epsilon_v] = [t + r \;;\; t - r] \quad ; \quad r = \sqrt{x^2 + y^2 + z^2}$$

$$\boldsymbol{u} = \left(\frac{r+z}{2r}\right)^{1/2} \cdot e^{i\varphi_u} \cdot \left[1 \;;\; \frac{x+iy}{r+z}\right] \quad ; \quad \boldsymbol{v} = \left(\frac{r+z}{2r}\right)^{1/2} \cdot e^{i\varphi_v} \cdot \left[-\frac{x-iy}{r+z} \;;\; 1\right] \qquad (1)$$

, where $(t, \boldsymbol{r}) = (t, x, y, z)$ are 4 real parameters of operator $\boldsymbol{X}_{M=2}$ in Gell-Mann decomposition:

$$\boldsymbol{X}_2 = t \cdot \boldsymbol{I}_2 + (\boldsymbol{r} \cdot \boldsymbol{\sigma}) = \begin{pmatrix} t+z & x-iy \\ x+iy & t-z \end{pmatrix} = \epsilon_u |\boldsymbol{u}\rangle\langle\boldsymbol{u}| + \epsilon_v |\boldsymbol{v}\rangle\langle\boldsymbol{v}| \qquad (2)$$

, where $\boldsymbol{\sigma}$ are Pauli matrices, and $\boldsymbol{I}_2 = |\boldsymbol{u}\rangle\langle\boldsymbol{u}| + |\boldsymbol{v}\rangle\langle\boldsymbol{v}|$. Eigenvalues ϵ_u, ϵ_v are co-measurable with commuting observables t, r. In discussed above spin measurement, observable t is correlative of time, and r is correlative of location along z-axis where atom registers. Generally, for an operator of cardinality M there are M commuting observables, same as number of eigenvalues. Commuting observables and eigenvalues are complementary sets of measurement parameters.

A commuting with $\boldsymbol{X}_2$ unitary transformation $\boldsymbol{U}_2$ is enacted by $e^{i\varphi_u}$, $e^{i\varphi_v}$ factors in (1), where φ_u, φ_v are real functions of measurement parameters. $\boldsymbol{U}_2$ has particularly simple form in $\boldsymbol{X}_2$ eigenbasis:

$$\boldsymbol{U}_2 = \begin{pmatrix} U_u & 0 \\ 0 & U_v \end{pmatrix} = \begin{pmatrix} e^{i\varphi_u} & 0 \\ 0 & e^{i\varphi_v} \end{pmatrix} = e^{i\varphi_u} |\boldsymbol{u}\rangle\langle\boldsymbol{u}| + e^{i\varphi_v} |\boldsymbol{v}\rangle\langle\boldsymbol{v}|$$

Outputs of measuring device, i.e., device eigenstates, are only distinguished by device readings. Therefore, eigenstate only transforms with corresponding eigenvalue, i.e., φ_u, φ_v are functions of:

$$\varphi_u = \varphi_u(\epsilon_u) = \varphi_u(t + r) \quad ; \quad \varphi_v = \varphi_v(\epsilon_v) = \varphi_v(t - r) \qquad (3)$$

Expressions (3) answer first challenge: unitary transformation is effectuated by reading device output [2]. It may seem self-contradictory, since unitarity is mutually exclusive with measurement. The contradiction vanishes once unitary transformation is only viewed as mathematical interpolation from output state of preparation to output state of measuring device. There are no devices and no states in between. Out of infinitely many unitary transformations between two states, measuring device enacts transformation, which commutes with its eigenbasis [11], and has device readings as transformation parameters. Device readings only acquire definite values with measurement. Device itself is the generator of unitary transformation:

$$\boldsymbol{U}_2 = exp(i\boldsymbol{X}_2) = e^{i\epsilon_u} |\boldsymbol{u}\rangle\langle\boldsymbol{u}| + e^{i\epsilon_v} |\boldsymbol{v}\rangle\langle\boldsymbol{v}| \qquad (4)$$

, i.e., functions $\varphi_u(\epsilon_u) \equiv \epsilon_u$; $\varphi_v(\epsilon_v) \equiv \epsilon_v$. Any other form of these functions requires additional information, beyond what is read from device output.

Maximum amount of information which can be extracted from qubit per measurement event[9] is 1 bit [12], if output state $\boldsymbol{\rho}_p$ of preparation is orthogonal to output state $\boldsymbol{\rho}_m$ of measuring device. The orthogonality condition $Tr(\boldsymbol{\rho}_p \boldsymbol{\rho}_m) = 0$ implies output of measuring device is not correlated[10]

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[9] Not to mix in so-called superdense coding [15] schemes which actually involve two-or-more qubit measurement
[10] The scalar product of [normalized] vectors, has a meaning of correlation coefficient

with output of preparation device, i.e., no information is shared between devices, which signifies *unconditional measurement*. Otherwise, the amount of information extracted from output of measuring device is reduced by the amount of shared information[11]; their sum in any case not to exceed 1 $bit/event$. In measuring device eigenbasis:

$$\boldsymbol{\rho}_p = (\boldsymbol{\rho}_p)_{uu}|\boldsymbol{u}\rangle\langle\boldsymbol{u}| + (\boldsymbol{\rho}_p)_{vu}|\boldsymbol{u}\rangle\langle\boldsymbol{v}| + (\boldsymbol{\rho}_p)_{uv}|\boldsymbol{v}\rangle\langle\boldsymbol{u}| + (\boldsymbol{\rho}_p)_{vv}|\boldsymbol{v}\rangle\langle\boldsymbol{v}|$$

$$\boldsymbol{\rho}_m = \boldsymbol{U}_2^{\dagger}\boldsymbol{\rho}_p\boldsymbol{U}_2 =$$
$$= (\boldsymbol{\rho}_p)_{uu}|\boldsymbol{u}\rangle\langle\boldsymbol{u}| + e^{i(\epsilon_v-\epsilon_u)}\cdot(\boldsymbol{\rho}_p)_{vu}|\boldsymbol{u}\rangle\langle\boldsymbol{v}| + e^{i(\epsilon_u-\epsilon_v)}(\boldsymbol{\rho}_p)_{uv}|\boldsymbol{v}\rangle\langle\boldsymbol{u}| + (\boldsymbol{\rho}_p)_{vv}|\boldsymbol{v}\rangle\langle\boldsymbol{v}|$$

$$Tr(\boldsymbol{\rho}_p\boldsymbol{\rho}_m) = (\boldsymbol{\rho}_p)_{uu}^2 + (\boldsymbol{\rho}_p)_{vv}^2 + 2(\boldsymbol{\rho}_p)_{uv}(\boldsymbol{\rho}_p)_{vu}\cos(\epsilon_u-\epsilon_v)$$

Given $0 \le \left[det(\boldsymbol{\rho}_p) = (\boldsymbol{\rho}_p)_{uu}(\boldsymbol{\rho}_p)_{vv} - (\boldsymbol{\rho}_p)_{uv}(\boldsymbol{\rho}_p)_{vu}\right] \le 1/4$; $-1 \le \cos(\epsilon_u-\epsilon_v) \le 1$, for $Tr(\boldsymbol{\rho}_p\boldsymbol{\rho}_m) = 0$, one must have: $det(\boldsymbol{\rho}_p) = 0$; $(\boldsymbol{\rho}_p)_{uu} = (\boldsymbol{\rho}_p)_{vv} = 1/2$; and $\cos(\epsilon_u-\epsilon_v) \equiv \cos(2r) = -1$; with two principal solutions: $r = \pm\pi/2$, corresponding to output eigenstates $\boldsymbol{u}, \boldsymbol{v}$, of standard nomenclature *spin* $\pm 1/2$. The extraction of 1 bit from a qubit is co-measurable to observable r acquiring absolute value $\pi/2$ $radians$, i.e., 1 $bit \equiv \pi/2$ $radians$. Bit is the natural unit of an observable value. $Radian$ only appeared because of the choice of exponent base in (4).

Entropy is the amount of extracted classical information. The amount of information extracted by measuring device is the difference in entropies of measuring and preparation device outputs:

$$\mathcal{L} = H_m - H_p \qquad (bits/event) \tag{5}$$

For measuring device to extract 1 $(bit/event)$ from a qubit, the preparation device output has to have entropy $H_p = 0$,[12] and measuring device output has to have entropy $H_m = -Tr(\boldsymbol{\rho}_m \log_2 \boldsymbol{\rho}_m) = 1$ $(bit/event)$, i.e., the output of measuring device has to be a mixed state with equal outcome probabilities: $(\boldsymbol{\rho}_m)_{uu} = (\boldsymbol{\rho}_m)_{vv} = 1/2$ [12], and zero off-diagonal terms.

Before I proceed to second challenge, to answer what effectuates the measurement itself, I have to emphasize distinction between the verbs *effectuate* vs. *cause*. The former looks for a definite value of observable, whose operator encodes the fact of measurement. The latter asks for information pre-determining the fact of measurement. If no prior measurement produced that information, the *cause* has no objective answer. Conversely, a definite value of observable whose operator encodes the fact of prior measurement, would signify the *cause*.

The measurement is not *fait accompli* unless obtained information persists in some [encoded] form. Device $\boldsymbol{X}_2$ does not encode[13] observable t, reflecting empirical fact that one can't determine object's age from object itself. That information is encoded separately, in some form of historical record. Hilbert space of a device, which encodes t, thus producing historical record, has to include, and extend beyond, the Hilbert space of $\boldsymbol{X}_2$. In terms of observables (t, r):

$$\boldsymbol{X}_2 = r\cdot(|\boldsymbol{u}\rangle\langle\boldsymbol{u}| - |\boldsymbol{v}\rangle\langle\boldsymbol{v}|) + t\cdot(|\boldsymbol{u}\rangle\langle\boldsymbol{u}| + |\boldsymbol{v}\rangle\langle\boldsymbol{v}|) = r\cdot\boldsymbol{R} + t\cdot\boldsymbol{I}_2 \tag{6}$$

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[11] One can show that in conditional measurement $Tr(\boldsymbol{\rho}_p\boldsymbol{\rho}_m) \neq 0$

[12] Which means the output $\boldsymbol{\rho}_p$ of preparation device has to be one of its eigenstates

[13] Operator $t\cdot\boldsymbol{I}_2$ in (2) does not encode observable t because $t\cdot\boldsymbol{I}_2$ output is same for any input. The value of t can only be encoded by an operator, whose output is correlative of the fact of measurement, and the fact of no measurement by $t\cdot\boldsymbol{I}_2$ operator

, where $\boldsymbol{R} = |\boldsymbol{u}\rangle\langle\boldsymbol{u}| - |\boldsymbol{v}\rangle\langle\boldsymbol{v}|$. Observable t is encoded by device $\boldsymbol{X}_{M=3}$, with $(\boldsymbol{u}, \boldsymbol{v}, \boldsymbol{w})$ eigenbasis:

$$\boldsymbol{X}_3 = r \cdot \boldsymbol{R} + t \cdot \boldsymbol{T} + \gamma \cdot \boldsymbol{I}_3 \quad ; \quad where \quad \boldsymbol{I}_3 = \boldsymbol{I}_2 + |\boldsymbol{w}\rangle\langle\boldsymbol{w}| \tag{7}$$

The part of $\boldsymbol{X}_3$, which encodes t, is traceless operator $\boldsymbol{T} = \boldsymbol{I}_2 - 2|\boldsymbol{w}\rangle\langle\boldsymbol{w}|$, orthogonal to $\boldsymbol{R}$: $Tr(\boldsymbol{RT}) = 0$. The positive $+1$ eigenvalue of operator $\boldsymbol{T}$ in (7), corresponding to eigenstates $\boldsymbol{u}, \boldsymbol{v}$, indicates the completed measurement by $\boldsymbol{X}_2$. The negative -2 eigenvalue of operator $\boldsymbol{T}$, corresponding to eigenstate $\boldsymbol{w}$, indicates no measurement by $\boldsymbol{X}_2$.

Orthogonality $Tr(\boldsymbol{\rho}_p \boldsymbol{\rho}_m) = 0$ of output $\boldsymbol{\rho}_p$ of preparation, and output $\boldsymbol{\rho}_m$ of measuring device, expressed in terms of output states $|\boldsymbol{\psi}_p\rangle = u \cdot |\boldsymbol{u}\rangle + v \cdot |\boldsymbol{v}\rangle + w \cdot |\boldsymbol{w}\rangle$; $|\boldsymbol{\psi}_m\rangle = \boldsymbol{U}_3 |\boldsymbol{\psi}_p\rangle = u \cdot e^{i(t+r)} \cdot |\boldsymbol{u}\rangle + v \cdot e^{i(t-r)} \cdot |\boldsymbol{v}\rangle + w \cdot e^{-2it} \cdot |\boldsymbol{w}\rangle$, with[14] $|u|^2 = |v|^2 = |w|^2 = 1/M = 1/3$, leads to the following conditions on definite values of observables t, r:

$$\langle \boldsymbol{\psi}_p | \boldsymbol{\psi}_m \rangle = \langle \boldsymbol{\psi}_p | \boldsymbol{U}_3 | \boldsymbol{\psi}_p \rangle = 0 \quad \Longrightarrow \quad e^{i(t+r)} + e^{i(t-r)} + e^{-2it} = 0 \quad \Longrightarrow$$
$$2\cos(r) + \cos(3t) = 0 \quad ; \quad \sin(3t) = 0 \tag{8}$$

Three principal solutions[15] of (8), corresponding to output eigenstates $\boldsymbol{u}, \boldsymbol{v}, \boldsymbol{w}$, are: $(t, r)_u = (\pi/3, \pi/3)$; $(t, r)_v = (\pi/3, -\pi/3)$; $(t, r)_w = (-\pi/3, \sim\pi/3)$, where $\sim$ is undefined sign, with special algebra rules[16]. The undefined sign of an observable occurs when eigenvalue does not include that observable. E.g., $\epsilon_w = -2t$ does not include r. The element of $(t, r)_w$, corresponding to observable r, has absolute value $\pi/3$ known from (8), and undefined sign. The sign is undefined because ϵ_w device reading is mutually exclusive with outputs $\boldsymbol{u}, \boldsymbol{v}$ which determine the sign of r. Eigenvalue is the sum of elements of principal solution[17]: $\epsilon_u = \pi/3 + \pi/3 = 2\pi/3$; $\epsilon_v = \pi/3 - \pi/3 = 0$; $\epsilon_w = -\pi/3 + \sim\pi/3 = -2\pi/3 \ radians$, or $(\epsilon_u, \epsilon_v, \epsilon_w) = (4/3, 0, -4/3) \ bits$.

The measurement event by $\boldsymbol{X}_3$ device, in unconditional measurement, sets absolute value of observable r to $\pi/3 \ radians$, not $\pi/2 \ radians$ as does measurement event by $\boldsymbol{X}_2$ device in (6). This is because operator $r \cdot \boldsymbol{R}$ in (7) acts in 2 out of 3 measurement events. The amount H_r of information, extracted per event by $r \cdot \boldsymbol{R}$ operator in (7), is $2/3$ of the amount extracted by $r \cdot \boldsymbol{R}$ operator in (6), i.e.:

$$H_r = (2/3) \cdot \pi/2 = \pi/3 \ radians/event = 2/3 \ bits/event$$

The amount of information extracted by $t \cdot \boldsymbol{T}$ operator in (7), from Shannon's [12] formula, is:

$$H_t = -\frac{2}{3}\log_2\frac{2}{3} - \frac{1}{3}\log_2\frac{1}{3} = \left(\log_2 3 - \frac{2}{3}\right) \ bits/event$$

The amount of information extracted by $\gamma \cdot \boldsymbol{I}_3$ operator in (7) is $H_\gamma = 0$. As expected, from Shannon's entropy [12], the amount of information extracted by $\boldsymbol{X}_3$ device in unconditional measurement is: $H_3 = H_r + H_t + H_\gamma = \log_2(M = 3) \ bits/event$.

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[14] Unconditional measurement mandates equal probability of device outputs

[15] Other solutions, e.g., $(2\pi/3, 2\pi/3)$; $(0, 2\pi/3)$ are obtained by adding or subtracting principal solutions: $(2\pi/3, 2\pi/3) = (t, r)_u + (t, r)_u$; $(0, 2\pi/3) = (t, r)_u + (t, r)_w = (t, r)_u - (t, r)_v$; $(0, -2\pi/3) = (t, r)_v + (t, r)_w$

[16] The rules are: $\forall\, t \geq 0, r \geq 0$: $t + \sim r = t + r$; $-t + \sim r = -t - r$; $t - \sim r = t - r$; $-t - \sim r = -t + r$. Variable with undefined sign acquires sign of preceding variable in addition and subtraction expressions

[17] In standard nomenclature, eigenvalues of $\boldsymbol{X}_3$ would be expressed as: $\epsilon = \pi \cdot (Y + I_3 \cdot 2/3) \ radians$, where I_3 is *isospin* and Y is *hypercharge* [19]; $(Y, I_3)_u = (1/3, 1/2)$; $(Y, I_3)_v = (1/3, -1/2)$; $(Y, I_3)_w = (-2/3, 0)$. Another quantum number called *charge* is defined as $Q = I_3 + Y/2$

Just as $\boldsymbol{X}_2$ device does not encode observable t, device $\boldsymbol{X}_3$ does not encode γ. The value of γ would be encoded by device $\boldsymbol{X}_4$, with eigenbasis $(\boldsymbol{u},\boldsymbol{v},\boldsymbol{w},\boldsymbol{q})$:

$$\boldsymbol{X}_4 = r\cdot\boldsymbol{R} + t\cdot\boldsymbol{T} + \gamma\cdot\boldsymbol{\Upsilon} + \lambda\cdot\boldsymbol{I}_4 \quad ; \quad where \ \ \boldsymbol{I}_4 = \boldsymbol{I}_3 + |\boldsymbol{q}\rangle\langle\boldsymbol{q}| \tag{9}$$

Observable γ is encoded by traceless operator $\boldsymbol{\Upsilon} = \boldsymbol{I}_3 - 3\cdot|\boldsymbol{q}\rangle\langle\boldsymbol{q}|$, orthogonal to $\boldsymbol{R}$ and $\boldsymbol{T}$: $Tr(\boldsymbol{R\Upsilon}) = 0$; $Tr(\boldsymbol{T\Upsilon}) = 0$. Orthogonality $Tr(\boldsymbol{\rho}_p\boldsymbol{\rho}_m) = 0$ for $\boldsymbol{X}_4$, expressed in terms of output states $|\boldsymbol{\psi}_p\rangle = u\cdot|\boldsymbol{u}\rangle + v\cdot|\boldsymbol{v}\rangle + w\cdot|\boldsymbol{w}\rangle + q\cdot|\boldsymbol{q}\rangle$; $|\boldsymbol{\psi}_m\rangle = \boldsymbol{U}_4|\boldsymbol{\psi}_p\rangle = u\cdot e^{i(\gamma+t+r)}\cdot|\boldsymbol{u}\rangle + v\cdot e^{i(\gamma+t-r)}\cdot|\boldsymbol{v}\rangle + w\cdot e^{\gamma-2it}\cdot|\boldsymbol{w}\rangle + q\cdot e^{-3i\gamma}\cdot|\boldsymbol{q}\rangle$, with $|u|^2 = |v|^2 = |w|^2 = |q|^2 = 1/M = 1/4$ leads to the following conditions on definite values of observables γ, t, r:

$$\langle\boldsymbol{\psi}_p|\boldsymbol{\psi}_m\rangle = \langle\boldsymbol{\psi}_p|\boldsymbol{U}_4|\boldsymbol{\psi}_p\rangle = 0 \quad \Longrightarrow \quad e^{i(\gamma+t+r)} + e^{i(\gamma+t-r)} + e^{i(\gamma-2t)} + e^{-3i\gamma} = 0 \quad \Longrightarrow$$
$$2\cos(r) + \cos(3t) + \cos(t+4\gamma) = 0 \quad ; \quad \sin(3t) + \sin(t+4\gamma) = 0 \tag{10}$$

The principal solutions of (10), corresponding to output eigenstates $\boldsymbol{u},\boldsymbol{v},\boldsymbol{w},\boldsymbol{q}$, are: $(\gamma,t,r)_u = (\pi/4\,,\pi/4\,,\pi/4)$; $(\gamma,t,r)_v = (\pi/4\,,\pi/4\,,-\pi/4)$; $(\gamma,t,r)_w = (\pi/4\,,-\pi/4\,,\sim\pi/4)$; $(\gamma,t,r)_q = (-\pi/4\,,\sim\pi/4\,,\sim\pi/4)$. The corresponding eigenvalues are[18]: $(\epsilon_u,\epsilon_v,\epsilon_w,\epsilon_q) = (3\pi/4\,,\pi/4,-\pi/4,-3\pi/4)\ radians$, or $(\epsilon_u,\epsilon_v,\epsilon_w,\epsilon_q) = (3/2\,,1/2,-1/2,-3/2)\ bits$.

The measurement event by $\boldsymbol{X}_4$ device, in unconditional measurement, sets absolute value of observable r to $\pi/4\ radians$, not $\pi/2\ radians$ as does measurement event by $\boldsymbol{X}_2$ device in (6). This is because operator $r\cdot\boldsymbol{R}$ in (9) acts in 2 out of 4 measurement events, so the amount H_r of information extracted per event by $r\cdot\boldsymbol{R}$ operator in (9) is $1/2$ of the amount extracted by $r\cdot\boldsymbol{R}$ operator in (6), i.e.:

$$H_r = (1/2)\cdot\pi/2 = \pi/4\ radians/event = 1/2\ bits/event$$

The amount of information extracted by $t\cdot\boldsymbol{T}$ operator in (9) is $3/4$ of the amount extracted by $t\cdot\boldsymbol{T}$ operator in (7), because operator $t\cdot\boldsymbol{T}$ in (9) acts in 3 out of 4 measurement events:

$$H_t = \frac{3}{4}\cdot\left(\log_2 3 - \frac{2}{3}\right)\ bits/event$$

The amount of information extracted by $\gamma\cdot\boldsymbol{\Upsilon}$ operator in (9), from Shannon's formula, is:

$$H_\gamma = -\frac{3}{4}\log_2\frac{3}{4} - \frac{1}{4}\log_2\frac{1}{4} = \left(2 - \frac{3}{4}\log_2 3\right)\ bits/event$$

The amount of information extracted by $\lambda\cdot\boldsymbol{I}_4$ operator in (9) is $H_\lambda = 0$. As expected, from Shannon's entropy [12], the amount of information extracted by $\boldsymbol{X}_4$ device in unconditional measurement is $H_4 = H_r + H_t + H_\gamma + H_\lambda = \log_2(M=4) = 2\ bits/event$.

In general, for $\boldsymbol{X}_M$ device, the principal solutions for definite values of commuting observables are of the form $(\dots,\gamma,t,r) = (\dots,\pi/M\,,-\pi/M\,,\sim\pi/M\,,\dots)$. Device readings take discrete values from $-\pi(M-1)/M$ to $\pi(M-1)/M$ with interval $2\pi/M\ radians$. Amount of information extracted by $\boldsymbol{X}_M$ device in unconditional measurement is $H_M = \log_2(M)\ bits/event$.

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[18] With quantum numbers from standard nomenclature, eigenvalues of $\boldsymbol{X}_4$ would be expressed as: $\epsilon = \pi\cdot(\mathbb{C} + Y\cdot 3/4 + I_3/2)\ radians$, where $\mathbb{C}$ could be called *hypercurrent*, related to $charm\ C = \mathbb{C} + 1/4$; $(\mathbb{C},Y,I_3)_u = (1/4\,,1/3\,,1/2)$; $(\mathbb{C},Y,I_3)_v = (1/4\,,1/3\,,-1/2)$; $(\mathbb{C},Y,I_3)_w = (1/4\,,-2/3\,,0)$, $(\mathbb{C},Y,I_3)_q = (-3/4\,,0{,}0)$

Operator $t \cdot \boldsymbol{T}$ in (7) creates historical record of measurement by $r \cdot \boldsymbol{R}$ operator. In discussed above spin measurement, the extracted by $t \cdot \boldsymbol{T}$ information is encoded as, e.g., position of clock hands pointing to time of spin measurement. Without this knowledge, the extracted by $r \cdot \boldsymbol{R}$ information would represent an undated still picture, e.g., of the spots, where spin-separated atomic beams hit detector in Stern-Gerlach apparatus.

Similarly, operator $\gamma \cdot \boldsymbol{\Upsilon}$ in (9) encodes the fact of creation by $t \cdot \boldsymbol{T}$ of historical record of measurement. The extracted by $\gamma \cdot \boldsymbol{\Upsilon}$ information represents the *passage of time* knowledge. Without this knowledge, the extracted information is like timestamped movie frame, showing a proverbial *Zeno's arrow* frozen in flight[19]. The device's $\gamma \cdot \boldsymbol{\Upsilon}$ operator effectuates the motion, i.e., it extracts information conveying knowledge that, in fact, the object is moving.

The answer on the second posed challenge is: measurement is effectuated by acquisition of a definite value by an observable, whose definite value signifies the fact of measurement[20].

Observable t acquiring definite value effectuates the measurement by device $\boldsymbol{X}_2$. The value of t is encoded by $t \cdot \boldsymbol{T}$ operator of encompassing $\boldsymbol{X}_3$ device. E.g., photodetector $r \cdot \boldsymbol{R}$ registers a photon at location r at time t, recorded by a clock $t \cdot \boldsymbol{T}$. The fact of registration of a photon, recorded by the clock $t \cdot \boldsymbol{T}$, effectuates the measurement by photodetector $r \cdot \boldsymbol{R}$. To find out what effectuates the measurement by the clock $t \cdot \boldsymbol{T}$, i.e., to find out if registration of photons takes place, we do not need to know time t of photon registration. We only need to know current in photodetector circuit. The *facts of measurement* by clock $t \cdot \boldsymbol{T}$ manifest as current in photodetector circuit, i.e., measurement by $\boldsymbol{X}_3$ device is effectuated by the current, encoded by $\gamma \cdot \boldsymbol{\Upsilon}$ operator of encompassing $\boldsymbol{X}_4$ device as observable γ. In turn, the facts of measurement by $\boldsymbol{X}_4$ device manifest as a thing to be called *current of currents,* encoded by encompassing $\boldsymbol{X}_5$ device as observable λ.

Information extracted by device $\boldsymbol{X}_M$ can't tell if there is a measurement by encompassing device $\boldsymbol{X}_{M+1}$. The derived earlier principle [13] states, no finite set of objective facts can explain itself. The above adds to this principle: no finite set of objective facts can tell, if there exists an explanation of these facts outside of the set. The second addition to principle [13] is: no finite set of objective facts can explain the fact of its own existence. An answer to old question *why is there something rather than nothing*[21] is bound to involve circular reasoning.

The fact of measurement by device $\boldsymbol{X}_M$, i.e., the fact of existence of classical information produced by $\boldsymbol{X}_M$, is encoded by encompassing device $\boldsymbol{X}_{M+1}$. As transpired above with examples of $\boldsymbol{X}_2$, $\boldsymbol{X}_3$, $\boldsymbol{X}_4$ devices, the encoding of the fact of measurement by device $\boldsymbol{X}_M$ is done by an operator of device $\boldsymbol{X}_{M+1}$, whose eigenvalues signify the fact of measurement, and the fact of no measurement by $\boldsymbol{X}_M$. Consequently, the fact of *existence of a thing* can only be encoded as classical information by encompassing measurement if there is also "*the thing does not exist*" outcome.

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[19] Zeno of Elea: "*What is in motion moves neither in the place it is nor in one in which it is not*". (Diogenes Laertius *Lives of Famous Philosophers*, ix.72. Knowing arrow's coordinates, one can't tell if arrow is moving

[20] To determine if the measurement took place we do not need to know where did atom hit detector in Stern-Gerlach apparatus. We only need to know time t when detector clicked. Definite value of t signifies the fact of measurement

[21] The question presumes the existence of classical information representing answer, i.e., it presupposes the existence of *something*. Conversely, if there was nothing, rather than something, the question *why is there nothing* would be ill-posed, as it looks for information under condition that no information exists

I now proceed to third challenge. I shall show how $\boldsymbol{X}_3$ and $\boldsymbol{X}_4$ device outputs are encoded in, respectively, 2-qubit and 3-qubit basis, with generalization to $\boldsymbol{X}_M$ device and $(N = M - 1)$-qubit states. I also show the encoding in N-qubit basis ($3D$ space) is the only possibility for extracted information to persist/be conserved.

Hilbert space of N-qubit has subspaces, invariant under $SU(2)$ transformation [14]. The N-qubit which encodes output of $\boldsymbol{X}_M$ device has cardinality of its largest invariant subspace matching cardinality of $\boldsymbol{X}_M$ device [10]:

$$M = \frac{(N + 2 - 1)!}{N! \cdot (2 - 1)!} = N + 1$$

The largest invariant subspace of N-qubit is that of a completely symmetric multiplet. The complete symmetry is required, because encoding by N-qubit has to be independent of qubit order, as output of measuring device does not contain qubit ordering information.

Eigenstates $\boldsymbol{u}, \boldsymbol{v}, \boldsymbol{w}$ of $\boldsymbol{X}_3$ device are projected onto $(N = 2)$-qubit eigenstates as:

$$\begin{pmatrix} \boldsymbol{u} \\ \boldsymbol{v} \\ \boldsymbol{w} \end{pmatrix} \Rightarrow \begin{pmatrix} \mathbf{00} \\ (\mathbf{01} + \mathbf{10})/\sqrt{2} \\ \mathbf{11} \end{pmatrix} \qquad (11)$$

, where $\mathbf{0}$ and $\mathbf{1}$ are single qubit eigenstates. From group theory: $2 \otimes 2 = 3 \oplus 1$, i.e., Hilbert space of 2-qubit has two invariant subspaces, of cardinality 3 and 1 [14]. Cardinality 3 subspace (triplet) with eigenstates on the right side of (11) matches cardinality of $\boldsymbol{X}_3$ device. Cardinality 1 subspace is spawned by singlet $(\mathbf{01} - \mathbf{10})/\sqrt{2}$ with eigenvalue $\epsilon_{01} = \epsilon_{10} = 0$. The amount of information which can be extracted from singlet is $\log_2 1$=0. There are no transitions within singlet's subspace. With a basis change singlet transforms into itself:

$$\mathbf{0} = (\boldsymbol{A} + \boldsymbol{B})/\sqrt{2} \quad ; \quad \mathbf{1} = (\boldsymbol{A} - \boldsymbol{B})/\sqrt{2} \qquad \Rightarrow$$

$$(\mathbf{01} - \mathbf{10})/\sqrt{2} = [(\boldsymbol{AA} - \boldsymbol{AB} + \boldsymbol{BA} - \boldsymbol{BB})/2 - (\boldsymbol{AA} + \boldsymbol{AB} - \boldsymbol{BA} - \boldsymbol{BB})/2]/\sqrt{2} = (\boldsymbol{BA} - \boldsymbol{AB})/\sqrt{2}$$

, i.e., singlet is same in new $\boldsymbol{A}, \boldsymbol{B}$ basis, as in old $\mathbf{0}, \mathbf{1}$ basis. On other hand, any state of the triplet on the right side of (11) transform into superposition of triplet's states:

$$\mathbf{00} = (\boldsymbol{AA} + \boldsymbol{AB} + \boldsymbol{BA} + \boldsymbol{BB})/2 = \left[(\boldsymbol{AA} + \boldsymbol{BB})/\sqrt{2} + (\boldsymbol{AB} + \boldsymbol{BA})/\sqrt{2}\right]/\sqrt{2}$$

$$(\mathbf{01} + \mathbf{10})/\sqrt{2} = [(\boldsymbol{AA} - \boldsymbol{AB} + \boldsymbol{BA} - \boldsymbol{BB})/2 + (\boldsymbol{AA} + \boldsymbol{AB} - \boldsymbol{BA} - \boldsymbol{BB})/2]/\sqrt{2} = (\boldsymbol{AA} - \boldsymbol{BB})/\sqrt{2}$$

$$\mathbf{11} = (\boldsymbol{AA} - \boldsymbol{AB} - \boldsymbol{BA} + \boldsymbol{BB})/2 = \left[(\boldsymbol{AA} + \boldsymbol{BB})/\sqrt{2} - (\boldsymbol{AB} + \boldsymbol{BA})/\sqrt{2}\right]/\sqrt{2}$$

The condition on definite value of observable r, signifying transition between orthogonal states of the triplet, results in:

$$e^{ir}e^{ir} + e^{ir}e^{-ir} + e^{-ir}e^{-ir} = 0 \quad \Rightarrow \quad 2\cos(2r) + 1 = 0 \quad \Rightarrow \quad r = \pm\pi/3 \ radians$$

and eigenvalues: $(\epsilon_{00}, (\epsilon_{01} = \epsilon_{10}), \epsilon_{11}) = (2r, (r - r), -2r) = (2\pi/3, 0, -2\pi/3)$. Eigenvalues of triplet match eigenvalues $(\epsilon_u, \epsilon_v, \epsilon_w)$ of $\boldsymbol{X}_3$ device, obtained from (8). Classical information extracted from output of $\boldsymbol{X}_3$ device is identical to information extracted from triplet on the right side of (11), as device outputs are only distinguished by device readings.

As noted in the beginning, the number of input parameters (input cardinality) of $\boldsymbol{X}_M$ device is $M^2 - M$. Therefore, $\log_2(M^2 - M)\ bits$ is needed to encode [the input state of] $\boldsymbol{X}_M$ device, i.e.,

$\log_2(M^2 - M)\, bits$ is the amount of [quantum] information $\boldsymbol{X}_M$ device stores internally. $\boldsymbol{X}_2$ (qubit) input cardinality $2^2 - 2 = 2$ is same as output cardinality. Amount of information ($\log_2 2 = 1\ bit/event$) which can be extracted from qubit in unconditional measurement is same as amount needed to encode it. This conclusion also applies to N-qubit, as input cardinality $M = N + 1$ of N-qubit is same as its output cardinality. The amount of information, extracted from $\boldsymbol{X}_3$ device in unconditional measurement $H_3 = \log_2 3\ bits/event$ matches $\log_2(N+1) = \log_2 3\ \ bits$ which can be encoded in, and extracted from, 2-qubit.

Continuing to $\boldsymbol{X}_4$ device: it takes $(N = M - 1 = 3)$-qubit to encode output of $\boldsymbol{X}_4$ device, within cardinality 4 (quadruplet) invariant subspace. The condition on definite value of observable r, acquired in transition between orthogonal states of quadruplet, is

$$e^{ir}e^{ir}e^{ir} + e^{ir}e^{ir}e^{-ir} + e^{ir}e^{-ir}e^{-ir} + e^{-ir}e^{-ir}e^{-ir} = 0 \quad \Longrightarrow$$
$$\cos(3r) + \cos(r) = 0 \quad \Longrightarrow \quad r = \pm\pi/4\ radians$$

Similar to (11), eigenstates of $\boldsymbol{X}_4$ device project onto quadruplet's eigenstates as:

$$\begin{pmatrix} \boldsymbol{u} \\ \boldsymbol{v} \\ \boldsymbol{w} \\ \boldsymbol{q} \end{pmatrix} \Longrightarrow \begin{pmatrix} \mathbf{000} \\ (\mathbf{001} + \mathbf{010} + \mathbf{100})/\sqrt{3} \\ (\mathbf{011} + \mathbf{101} + \mathbf{110})/\sqrt{3} \\ \mathbf{111} \end{pmatrix}$$

The quadruplet eigenvalues are $(3\pi/4\,, \pi/4\,, -\pi/4\,, -3\pi/4)$. They match eigenvalues of $\boldsymbol{X}_4$ device obtained from (10). Eigenvalues $\epsilon_{000} = 3\pi/4$ and $\epsilon_{111} = -3\pi/4$ are non-degenerate, while $\epsilon_{001} = \epsilon_{010} = \epsilon_{100} = \pi/4$, and $\epsilon_{011} = \epsilon_{101} = \epsilon_{110} = -\pi/4$ have degeneracy 3. The invariant subspaces of 3-qubit are:

$$2 \otimes 2 \otimes 2 = 4 \oplus 2 \oplus 2 \qquad \Longleftrightarrow \quad \begin{pmatrix} 3\pi/4 \\ \pi/4 \\ -\pi/4 \\ -3\pi/4 \end{pmatrix} \oplus \begin{pmatrix} \pi/4 \\ -\pi/4 \end{pmatrix} \oplus \begin{pmatrix} \pi/4 \\ -\pi/4 \end{pmatrix}$$

Since input and output cardinality of 3-qubit is 4, the amount of information which can be encoded in, and extracted from, 3-qubit, is $\log_2 4 = 2\ bits$, same as amount of information extracted from output of $\boldsymbol{X}_4$ device in unconditional measurement. Matching eigenvalues make information, extracted from output of $\boldsymbol{X}_4$ device and encoded in quadruplet, identical to information extracted from quadruplet. Generally, information extracted from output of $\boldsymbol{X}_M$ device would be encoded in cardinality M invariant subspace of $(N = M - 1)$-qubit.

The amount of [quantum] information $\boldsymbol{X}_M$ device stores internally, in its input state, is $\log_2(M^2 - M)\, bits$. Of which, up to $\log_2 M\ bits/event$ are extracted and converted into classical information by measurement. The remaining $\log_2(M^2 - M) - \log_2 M = \log_2(M - 1)$ $bits$ are unavailable for extraction. The only possibility for all stored information to be extractable, is to encode it in $M = 2$ basis, i.e., in a qubit. It follows, only $\boldsymbol{X}_2$ device, and its N-qubit variants, can be represented by extracted classical information. The state of $\boldsymbol{X}_{M>2}$ device is not represented by information extracted from its output, as $\boldsymbol{X}_{M>2}$ device contains $\log_2(M - 1)\ bits$ unavailable for extraction.

A search for an example of $\boldsymbol{X}_{M>2}$ device points toward living organisms. There are features of living organisms which fit the disclosed properties of $\boldsymbol{X}_{M>2}$ device:

1. The measurement of living organism cannot extract all the information. Only the extracted classical information is *observed* [10]. The unextracted information is not represented by objective reality. The word *mind* may be the term for that information
2. The extracted from living organism information is not sufficient to describe the state of living organism. Living organism cannot be reconstructed from extracted information
3. The extraction of maximum information from living organism is incompatible with the state of *living* [1]:

   I have tried to express this situation by saying that every experimental arrangement suitable for following the behavior of the atoms constituting an organism in as exhaustive a way as implied by the possibilities of physical observation and definition would be incompatible with the maintaining of the life of the organism. – N. Bohr

   The extraction of $\log_2 M\ bits$ from $\boldsymbol{X}_M$ device turns device completely into classical object, as no more information can be extracted

Information extracted from output of $\boldsymbol{X}_M$ device is encoded in values of commuting observables. Output of $\boldsymbol{X}_3$ device in Stern-Gerlach experiment is encoded by operators $t \cdot \boldsymbol{T}$ and $r \cdot \boldsymbol{R}$, in position of clock hands, as observable t, and in position of the spot where atomic beam hit detector, as observable r. Separately, the encoded outputs of $t \cdot \boldsymbol{T}$ and $r \cdot \boldsymbol{R}$ operators bear no relation to each other. Knowing only the position of the spot where atomic beam hit detector, one cannot deduce the time when it happened. One would not even know if it happened at all, as the fact of measurement is encoded by the other operator, $t \cdot \boldsymbol{T}$. The spot at the detector screen does not signify the measurement event, as one cannot ascertain, without additional information, that the spot was not there all along. Conversely, knowing only the time of measurement event, one cannot deduce the position r of the spot where atomic beam hit detector. There must be an additional information establishing correlation between outputs of $t \cdot \boldsymbol{T}$ and $r \cdot \boldsymbol{R}$ operators. If there is no encompassing measurement, this additional information remains unextracted from $\boldsymbol{X}_3$ device, in the amount of $\log_2(M-1) = 1\ bits/event$, a Boolean value indicating if outputs of $t \cdot \boldsymbol{T}$ and $r \cdot \boldsymbol{R}$ operators are correlated. This unextracted information is contained inside the mind of a living organism represented by $\boldsymbol{X}_3$ device.

If there is an encompassing measurement by $\boldsymbol{X}_4$ device, the facts of measurement by $t \cdot \boldsymbol{T}$ operator materialize as current in detector circuit, encoded by $\gamma \cdot \boldsymbol{\Upsilon}$ operator of encompassing $\boldsymbol{X}_4$ device as observable γ. The facts of measurement by $\gamma \cdot \boldsymbol{\Upsilon}$ operator would materialize as *current of currents*, to be encoded by encompassing $\boldsymbol{X}_5$ device as observable λ. Yet, there is no known materialization of information representing *current of currents*. Perhaps, there is a limit lower than $\log_2(M)\ bits/event$ on amount of information which can be extracted from output of $\boldsymbol{X}_{M>4}$ device. The limit could be from lack of capability to measure current of currents, or it could be of $3D$ observation space only able to accommodate classical information extracted by 3 orthogonal measurement operators in (9): $r \cdot \boldsymbol{R}$, $t \cdot \boldsymbol{T}$, $\gamma \cdot \boldsymbol{\Upsilon}$ [10], constituting traceless, i.e., encoding, part of

$\boldsymbol{X}_4$ device, with $2\, bits/event$ limit on extraction of information[22]. The limit of $3D$ observation space may account for unavailability of a [classical] device able to measure current of currents. In any case, if we accept the premise that $\boldsymbol{X}_{M>2}$ device represents living organism, the inability to extract $\log_2 M\, bits$ is a life-saver for the organism, as extraction of $\log_2 M\ bits$ would signify complete transformation of living organism into non-live classical object. This conclusion helps answer question, if it's possible to create living organism from non-live matter. Creating living organism, represented by $\boldsymbol{X}_M$ device, requires $\log_2(M^2 - M)\ bits$ of information to set its input state. This information would have to be extracted somewhere, presumably, from output of $\boldsymbol{X}_{M'=M^2-M}$ device. Setting input state of living organism of minimum cardinality $M = 3$ requires $\log_2(M^2 - M) = \log_2 6\, bits$, while, as suggested above, max $2\ bits/event$ of classical information can be extracted from output of any device. The input state of $\boldsymbol{X}_M$ device can only be set by feeding output of $\boldsymbol{X}_{M'=M^2-M}$ device directly into $\boldsymbol{X}_M$ input interface[23], without intermediate extraction of information from $\boldsymbol{X}_{M'}$ device output.

[22] It may as well explain why all theories built on $SU(M > 4)$ symmetry groups, such as Georgi–Glashow model [18], are at odds with objective reality [10]

[23] *then the LORD God formed the man of dust from the ground and breathed into his nostrils the breath of life, and the man became a living creature*, - Genesis 2:7

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