Article

Organizer Operator as a Space Generator

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Abstract: The validity of our universe as a three-dimensional space ($3+1$ in relativity) is considered a fundamental fact in physics. In this study, we show that our observed world is thus the output of a prior fundamental operator referred to as an organizer. The organizer is an expansion of projecting operators. It is been shown that identical weighted projecting operators, which are associated with identical particles, generate subspaces of entangled states, whereas groups of unequal weighted coefficients are responsible for finite-size subspaces that are associated with unidentical particles. Considering $3D$-subspaces as evidence of the coefficients' arrangement in our universe, we implement our formalism to describe the implacable vectors, location, momentum, and force within each $3D$ subspace. By implementing the Heisenberg relation, we drive both the classical and quantum expressions for the laws of motion.

Keywords: interpretation; state construction; entropy reduction; observer

The novel theories of the 20th century introduced the brilliant concept of the correspondence principle. Underneath lies the assumption of a fundamental theory that, by converging one of its parameters into an extreme value, a somewhat limited theory (mostly an old theory) can be restored. This has been well implemented in relativity theories. For example, in the special theory converging the speed of light to infinity, the theory is reduced to non-relativistic mechanics. In the early days of quantum mechanics, attempts were made to implement the correspondence principle to derive classical mechanics from the principles of quantum mechanics. For example, it was suggested that classical mechanics becomes valid in the limit when $\hbar \to 0$ or when some quantum numbers such as the principle numbers in the hydrogen atom reach high values [1]. Over the years, the coherence concept has been recognized as a crucial component in quantum mechanics. In 1970, the concept of de-coherence was introduced [2,3] with the purpose of solving the collapse problem but also as a solution to the question of ''whether and how the 'classical world' may emerge from quantum mechanics" [4]. Quantum coherence yields the concept of entanglement [5–7]. Initially, it seemed as if entanglement was a unique feature of quantum mechanics. However, lately, a classical analogy of entanglement of type II was suggested using classical light beams [8–10]. Still, no analogy for the entanglement of many particles was found. In the end, we are left with three quantum phenomena that seem to have no analogies in classical mechanics: collapse in quantum measurements, entanglement of many particles, and quantum jumps. The last issue was examined in detail in ref. [12], where the quantum-classical mechanics theorem was suggested as an alternative for dealing with quantum mechanics in molecular and chemical physics. Regarding the quantum collapse, we published two studies [13,14] suggesting that by labeling classical particles, a classical observer collapses the entangled state of particles. Accordingly, the collapse phenomenon belongs to both quantum and classical theories.

This study suggests that both quantum and classical phenomena originate from a common feature, described mathematically by what we refer to as the organizer. We show that for identical particles (as in quantum mechanics), the organizer allows entangled states of many particles, whereas for unidentical particles, mass terms enforce particles to stay in a three-dimensional space. We implement our formalism to derive both classical and quantum dynamics.

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I. First Type: Equal Weighted Organizer Operator as a Space Spanner

Herein, we define a fundamental operator, namely, the organizer, which translates any fundamental state into what we refer to as ''degrees of freedom." We begin with an N degrees of freedom space spanned by a complete orthogonal basis of states $|i\rangle$, where i is the degree of freedom index. We allow $N \to \infty$.
The ''organizer" is defined by

$$\mathbb{O}_{\mu} = \sum_{i=1}^{N} \mu_i |i\rangle\langle i|$$

where μ_i describes the impact factor for each degree of freedom. In this section, we consider the equal weighted coefficients

$$\mathbb{O} = \sum_{i=1}^{N} |i\rangle\langle i| \tag{1}$$

Operating $\mathbb{O}$ in the state $|d\rangle = \prod_{i=1}^{d} |i\rangle$ with $d \leq N$, we obtain

$$\mathbb{O}|d\rangle = d|d\rangle, \tag{2}$$

Consequently, although $\mathbb{O}$ is predefined for a product of N states, it also detects the dimension of a lower product of states. In addition, because all projecting operators are equally weighted, we can define entangled states, thereby enabling us to define subspaces . For example, consider a $4D$-dimensional subspace spanned by the single-item states $|i\rangle, i = 1,2,3,4$ and consider an arbitrary superposition $|\psi\rangle = A|1\rangle|2\rangle + B|3\rangle|4\rangle$. Operating $\mathbb{O}$ on $|\psi\rangle$, we obtain

$$\mathbb{O}|\psi\rangle = 4|\psi\rangle. \tag{3}$$

In other words, $\mathbb{O}$ detects the space dimension for all representations, thereby defining a $4D$ subspace. In general, if we have entangled states composed of a state's product of length d, we can implement $\mathbb{O}$ to define an embedded subspace in the N space. For that scenario, we define a state in an d-dimensional subspace as

$$|\Psi_d\rangle = \sum_{i=1}^{d/2} A_i \prod_{j=d(i-1)+1}^{di} |x_j\rangle, \tag{4}$$

with the result

$$\mathbb{O} = |\Psi_d\rangle = d|\Psi_d\rangle. \tag{5}$$

I.1. Example: Identical Particle Space

The organizer is well implemented in quantum mechanics, where the concept of identical particles is valid. Identical particles define equal weighted coefficients, allowing states of different particles to be in a superposition to formulate the entanglement phenomenon. A simple example is the two identical particles of spin $1/2$. It can be seen that for all possible superpositions ,

$$|\psi\rangle = A|\uparrow\rangle_1|\uparrow\rangle_2 + B|\downarrow\rangle_1|\uparrow\rangle_2 + C|\uparrow\rangle_1|\downarrow\rangle_2 + D|\downarrow\rangle_1|\downarrow\rangle_2$$

when subject to the operation of $\mathbb{O}$ will provide the same result as in Eq. 5. To conclude this part, not only can single state products unite the separated subspaces into a united single space (as in quantum mechanics), subspaces can be integrated to form a united space as well.
In the following, we show that it is the weight coefficient in the projection operator series of Eq. 1 that determines the level of superposition in a subspace.

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II. Second Type : Organizer with Different Weights–Birth of the 3D Space

In the previous part, we defined an organizer as a series of projecting operators with equal weights. We now consider an organizer with different weights. We show that, whereas a product of distinguishable states remains an eigenstate of the organizer, superposition between different states is allowed only for projecting operators with equal weights. In our three-dimensional world, we realize that only triples of degrees of freedom can share the same weight.
The unequal weighted organizer is

$$\mathbb{O}_\mu = \sum_{i=1}^{N} \mu_i |i\rangle\langle i| \tag{6}$$

where μ_i (described later) is a mass term representing the relative impact of each degree of freedom.
The superposition of states is invalid unless some partial coefficients are equal. These define a subspace that is later associated with a 3D particle. It is realized that regardless of the relative relations between coefficients, the state's product $|\psi\rangle = \prod_{i=m}^{n} |i\rangle$ always serves as an eigenstate of the organizer, that is,

$$\mathbb{O}_\mu |\psi\rangle = \sum_{i=m}^{n} \mu_i |\psi\rangle \tag{7}$$

A vector is defined by the superposition of its unit vectors. Thus, if we follow classical mechanics that include the $3D$ component of a vector in the total count of the number of degrees of freedom, we conclude that the organizer must be divided into triple equal weighted groups:

$$\mathbb{O}_\mu = \sum_{i=1}^{N_p} \mu_i \quad \not\succ_i^{(3)} \tag{8}$$

where N_p describes the number of tripled groups referred to as the number of particles, and $\not\succ_i^{(3)}$ is a projecting operator given as

$$\begin{aligned} \not\succ_i^{(3)} &= \sum_{R=1}^{3} |R_{i,j}\rangle\langle R_{i,j}| \\ R_{i,j} &= R + 3i - 3 \end{aligned} \tag{9}$$

where the superscript (3) denotes the $3D$ dimension of the subspace. The symbol R in the index $R_{i,j}$ is chosen as a reminder that R may serve as the coordinate index (e.g ., $(R = x, y, z)$). In addition, $R_{i,j}$ is defined such that it is a part of a continuous index . For example, for a particle labeled as $i = 1$, the subspace ''coordinates" are counted as $R_{1,j} = 1, 2, 3$ for the next particle $i = 2$. The counting continues with $R_{2,j} = 4, 5, 6$, and so on.

III. Vectors in 3D Space

Thus far, we have shown that in a system with N degrees of freedom, $3D$ subspaces exist that are referred to as the spaces of particles. In this section, we show how physical concepts such as location or momentum are defined within the $3D$ subspace. Accordingly, we associate each physical quantity with a projecting operator that projects all states into the $3D$ corresponding vector. Our derivation here can be applied to all vectors in the $3D$ subspace in which we focus on the fundamental vectors, location, momentum, and force.
Suppose that we have a vector $\vec{A}$. Presenting the vector in an operator form, we assume

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that it belongs to a space with defined norm $\left|\vec{A}\right|$ (such as in a Hilbert space) to define the operator

$$\mathbb{A}_i = |A_i| \ \nsucc_i^{(\nVdash)} \tag{10}$$

where $\nsucc_i$ is defined in Eq. 9. To obtain the vector components, we define the normalized state (‘’unit vector” in the terminology of classical mechanics) as

$$|A_i\rangle = \frac{1}{|A_i|} \sum_{R_{i,j}=1}^{3} A_{R_{i,j}} \ |R_{i,j}\rangle \tag{11}$$

where $A_{R_{i,j}}$ are the three components of the A vector. Implementing $\mathbb{A}_i$ on $|A_i\rangle$, we obtain

$$\mathbb{A}_i \ |A_i\rangle = |A_i| \ |A_i\rangle = \sum_{R_{i,j}=1}^{3} A_{R_{i,j}} \ |R_{i,j}\rangle \tag{12}$$

Observe that two steps define the process of vector generation. First, a concept is introduced by the norm $\left|\vec{A}\right|$, which defines both the essence of the measured quantity and the units of measurement. By implementing $\nsucc^{(3)}$ on the defined state, the quantity is distributed among the three components. Note that as a density matrix, $\nsucc^{(3)}$ satisfies the relation $(\nsucc)^2 = \nsucc^{(3)}$. Thus, ordinary operations such as multiplication are maintained, as seen by the relation $\left(|A_i| \ \nsucc^{(3)}\right)^2 = |A_i|^2 \ \nsucc^{(3)}$.

IV. Location concept

Location refers to a point in space described by coordinates with length dimensions. Following the literature, we refer this space to the term *real space*.
To define the location vector, we define the location operator $\vec{\mathbb{R}}_i$ as

$$\vec{\mathbb{R}}_i = |r_i| \ \nsucc_i^{(3)} \tag{13}$$

where $|r_i|$ is a positive variable with length dimension that is later associated with the norm of the location vector. Because both $\vec{\mathbb{R}}_i$ and $\mathbb{O}_\mu$ are diagonal under the $|i\rangle$ basis, they commute. A normalized location vector for an i particle is

$$|r_i\rangle = \frac{1}{|r_i|} \sum_{R_{i,j}=1}^{3} x_{R_{i,j}} \ |R_{i,j}\rangle \tag{14}$$

In classical terminology, the state $|R_{i,j}\rangle$ refers to the unit vectors denoted by Cartesian geometry as $\hat{x}$, $\hat{y}$ and $\hat{z}$. In quantum terminology, $\frac{x_{R_{i,j}}}{|r_i|}$ are referred to as the expansion coefficients of the state in an i-3D subspace. In that sense, the coordinates x are parameters rather than operators.
Implementing $\vec{\mathbb{R}}_i$ on $|r_i\rangle$, we obtain

$$\vec{\mathbb{R}}_i \ |r_i\rangle = |r_i||r_i\rangle \tag{15}$$

Following Eq. 8, we can define the location organizer operator as

$$\mathbb{O}_r = \sum_{i=1}^{N_p} |r_i| \ \nsucc^{(3)}. \tag{16}$$

The center of the mass coordinate is defined by the product

$$\mathbb{O}_{cm} = \mathbb{O}_r \mathbb{O}_\mu \tag{17}$$

to provide the known expression for the center of mass coordinate

$$\mathbb{O}_{cm}\prod_i |r_i\rangle = \sum_i \mu_i r_i \prod_i |r_i\rangle \tag{18}$$

V. Functions

In the literature, a function (denoted by ψ) is as an expression, rule, or law that defines a relationship between at least two variables [15]. Let us add the following preliminary remark. In the same manner that location serves as a concept, so does the function. A function defines a relationship between concepts. More specifically, the concept of ψ and, for example, that of location can be associated with the states $|\psi\rangle$ and $|r\rangle$, respectively. The overlap term $\psi(r) = \langle r\,|\psi\rangle$ describes the function generated by these concepts. Consider a concept ψ defined equally for all spaces, which is represented in terms of location, that is,

$$\psi_i = \langle r_i\,|\psi\rangle \tag{19}$$

This function definition allows us to consider operators such as derivatives operators in the proceeding.

V.1. Classical Versus Quantum Dynamics

Now that a particle is identified with a $3D$ subspace generated by the organizer and its location is defined within this subspace, we introduce the concept of motion. For this, we implement conventional physical tools (i.e., the Hamiltonian) to generate time evolution for conventional operator expressions. We implement the Heisenberg relation for inexplicably time dependent operators:

$$\frac{d\mathbb{A}}{dt} = \frac{i}{\hbar}[\mathbb{H}, \mathbb{A}] \tag{20}$$

where $\mathbb{A}$ is within the Heisenberg picture and $\mathbb{H}$ is the system Hamiltonian.
To reconstruct the equations of motion, we reformulate the momentum vector and operator. Following our formulation that each observable in the $3D$ subspace must be multiplied by the projecting operator $\nsucc^{(3)}$ $\left(\nsucc^{(3)} = \sum_{j=1}^{3} |R_{i,j}\rangle\langle R_{i,j}|\right)$, we define the operator as

$$\vec{\mathbb{O}}_{\mu_i r_i} = \mu_i |r_i| \;\; \nsucc^{(3)} \tag{21}$$

We implement the conventional form of the Hamiltonian in the coordinate representation. In our formalism, this becomes $\mathbb{H} \to \mathbb{H}_i = \left(-\frac{\hbar^2}{2\mu_i}\nabla_i^2 + V(\vec{r}_i)\right)\nsucc^{(3)}$. Implementing the relation $\left(\nsucc^{(3)}\right)^2 = \nsucc^{(3)}$ and substituting in Eq. 20, we obtain the momentum operator

$$\vec{\mathbb{P}}_i = -i\hbar\;\vec{\nabla} \tag{22}$$

using the ‘’classical operator”

$$\vec{\mathbb{P}}_i = |p|_i \;\nsucc^{(3)}, \quad |p|_i = \mu_i \frac{d|r|_i}{dt} \tag{23}$$

and the ‘’quantum operator”

$$-i\hbar\;\vec{\nabla}_i = -i\hbar\frac{\partial}{\partial r_i} \quad \nsucc^{(3)} \tag{24}$$

Clearly, this relation between classical and quantum mechanics is only valid for a diagonal representation of the operator $-i\hbar\vec{\nabla}_i$ $\left(\text{that is a wave function of the form } e^{i\vec{k}\cdot\vec{r}}\right)$. Note that the classical operator obeys the rule as defined in Eq. 13.
Eq. 23 represents the classical relation $\dot{\vec{r}}_i = \partial_{p_i}\mathbb{H}$. To obtain the second Hamiltonian equation

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$\dot{\vec{p}}_i = -\partial_{x_i}\mathbb{H}$, we find the operator's form of force. Implementing a Heisenberg relation on the momentum operator

$$\frac{d\vec{\mathbb{P}}_i}{dt} = \frac{i}{\hbar}\left[\left(-\frac{\hbar^2}{2\mu_i}\nabla_i^2 + V(\vec{r}_i)\right)\ngtr^{(3)}, \left(-i\hbar\vec{\nabla}_i\right)\ngtr^{(3)}\right] \tag{25}$$

yields

$$\frac{d\vec{\mathbb{P}}_i}{dt} = -\gvertneqq \mathbb{V}_i \tag{26}$$

with the operator

$$\gvertneqq \mathbb{V} = |\nabla V_i|\ngtr^{(3)}. \tag{27}$$

When the classical Hamiltonian $\mathbb{H} = \sum_i \left(\frac{p_i^2}{2m} + V(\vec{r}_i)\right)$ is considered, Eq. 26 becomes equivalent to the Hamiltonian equation of motion $\dot{\vec{p}}_i = -\partial_{x_i}\mathbb{H}$.

VI. summary

In this study, we showed that all spaces in the universe are originated from a fundamental organizer operator. We revealed that for identical particles, that is, when all coefficients in the organizer are identical, entangled states are allowed, whereas organizers with different coefficients are divided into groups of partially identical coefficients to establish subspaces, which are referred to as particles. We also showed that straightforward evidence indicating that unidentical particles are arranged in groups of three degrees of freedom teaches us about the nature of our universe. A result of our study is to consider possibilities of other universes with different organizers such that an unidentical particle will exist, for example, in a $5D$ space.

Consider the scenario of an earlier symmetric organizer that defines a global state without the definitions of particles. In the next step in our universe evolution, this symmetry breaks to define the lower symmetry of 3D identical particles. Proceeding with this symmetry breaking, we obtain the unidentical particles scenario. Locating quantum and classical mechanics in the same timeline of the universe evolution may provide a new path for understanding the relationship between quantum and classical mechanics.

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Additional Information

The author declares no competing interests, financial or non-financial. He is the only author of this study.