Tetrahedron model for physics

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Abstract: We discuss how three-dimensional space with one-dimensional time is formed based on the "observation" system implemented in a regular tetrahedron. Then physics laws such as Maxwell equations and the equation of motion are studied using this model. The difference between classical physics and quantum physics is also discussed.

Keywords: three-dimensional space, observation, tetrahedron, hierarchy of matter, classical and quantum physics

1. Observation and dimension

Formation of space-time

In the following, a system is described in which four-dimensional space-time (three-dimensional space with one-dimensional time) is formed by a series of "observations".

Let A be an object which is the unique presence in the entire world. Then an observer B appears and observes A, which is denoted by "B→A". Here B is not in the world. Next the second observer C appears who observes that situation and relates A with B. If they are unified with their difference (as an object and an observer) kept, it is called "equalization". On the contrary, if the difference is lost, it is called "neutralization". By this observation, B is involved in the world and the edge (line-segment) AB is formed, which has two dimensions.

Then the third observer, D, observes that situation. If A, B and C are unified with their difference kept, it is called "equalization". On the contrary, if the difference is lost, it is called "neutralization". By this observation, C is involved in the world and the triangle ABC is formed, which has three dimensions. A, B, C and D can be implemented in the four vertices of a regular tetrahedron. Our three-dimensional space corresponds to the "neutralized" ABC. If ABC and its observer D are again "neutralized" by the higher-level observer E, they form four-dimensional space-time.

Condensation

When the next observer E observes both ABC and D, the triangle ABC (three dimensions) is reduced to a single point F (one dimension) by the neutralization of them, called "condensation". As a result, the case of F, D and E returns to the case of A, B and C. By repeating this process, the hierarchy of matter and universe is formed. One example is a hydrogen atom. Three quarks, correspond to the triangle ABC, are reduced to a proton F by the observer E, then a hydrogen atom is formed, which consists of the proton and an electron D.

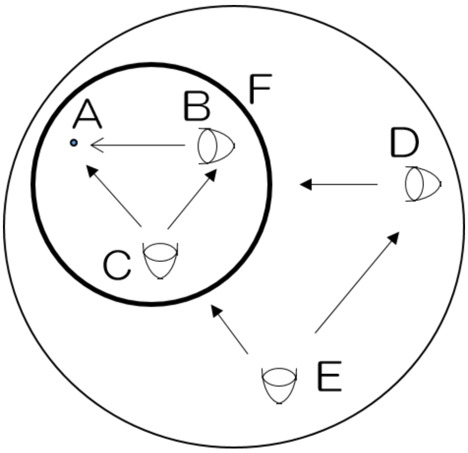


Figure 1: The system of "successive observations" described in the text. A figure of an eye indicates an observer and an arrow indicates an observation.

2. Tetrahedron model for physics

A regular tetrahedron, which has four vertices, six edges and four triangular faces, has two special orthogonal projections. One centered on an edge and the other centered on a vertex. We call the former "2x2" and the latter "3+1".

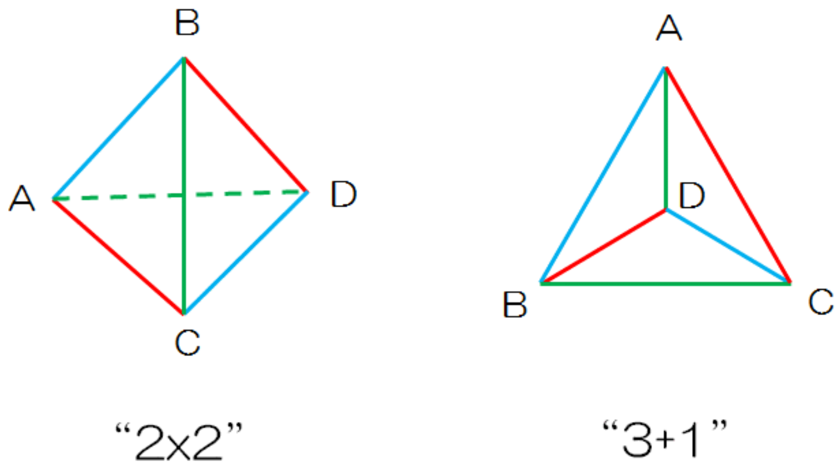


Figure2: Two types of orthogonal projection of a regular tetrahedron, "2x2" and "3+1".

With the "2x2" projection, a tetrahedron ABCD is considered to be composed of two opposite edges such as AB and CD, called "dual", lying on two skew lines. With "3+1", four vertices of a tetrahedron are separated into three vertices or equivalently a triangular face, ABC for example, and one vertex D. Six edges are grouped into two sets of three edges, that is, AB, BC, CA and AD, BD, CD. "3+1" patterns can be found in the structure of matter as well as physics laws, for example, hydrogen atom as stated above.

Maxwell equations and "2x2"

$$\boldsymbol{\nabla} \cdot \boldsymbol{E} = \frac{\rho}{\varepsilon_0} \cdots (1)$$

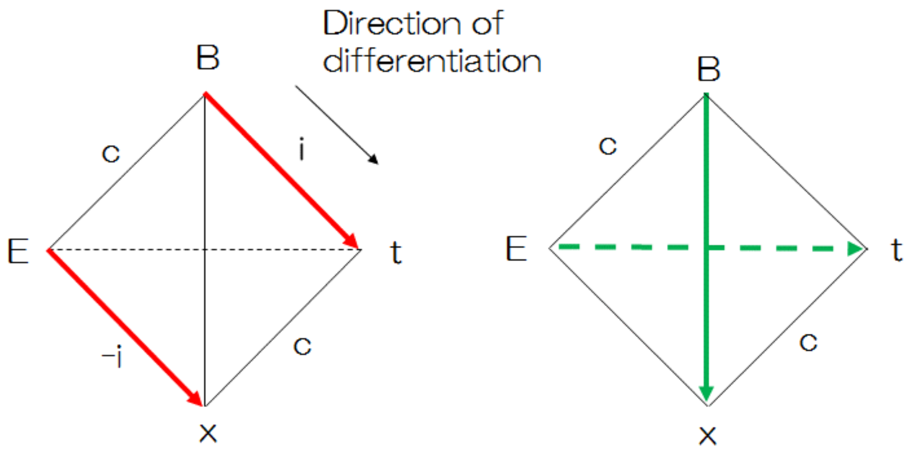
$$\boldsymbol{\nabla} \cdot \boldsymbol{B} = 0 \cdots (2)$$

$$\boldsymbol{\nabla} \times \boldsymbol{E} = -\frac{\partial \boldsymbol{B}}{\partial t} \cdots (3)$$

$$\boldsymbol{\nabla} \times \boldsymbol{B} = \mu_0 \boldsymbol{j} + \frac{1}{c^2}\frac{\partial \boldsymbol{E}}{\partial t} \cdots (4)$$

The first two equations, (1) and (2), the Gauss's law for an electric and a magnetic field, are related to "3+1". Divergence changes a vector (three dimensions) to a scalar (one dimension). These two equations show asymmetry in an electric and a magnetic field.

The last two equations, (3) and (4), the Faraday's law and the Ampere's law, are regarded as the equalization of two dual edges. An electric field $\boldsymbol{E}$ is assigned to A, a magnetic field $\boldsymbol{B}$ to B, a displacement (position) vector $\boldsymbol{x}$ to C, and time t to D, where A, B, C and D are four vertices of a tetrahedron. The observation AB→CD can be decomposed into two observations, either A→C with B→D, or A→D with B→C. The first decomposition corresponds to the Faraday's law and the second one to the Ampere's law respectively. Differentiation with respect to $\boldsymbol{x}$ (rotation) or $\boldsymbol{t}$ indicates observation. The negative sign (-1 or i^2) in the Faraday's law originates in the distortion of AC and BD in the depth direction for the viewer of the "2x2" projection of the tetrahedron. In the same way, the coefficient c^2 in the Ampere's law, where c is the light speed, originates in the distortion of AD and BC in the width direction, that is, the crossing of AD and BC. The term "$\mu_0 \boldsymbol{j}$" in the Ampere's law shows asymmetry in AD and BC, two diagonal edges of the tetrahedron. When the edge BC is visible to the viewer of "2x2", AD is invisible.



$$\boldsymbol{\nabla} \times \boldsymbol{E} = -\frac{\partial \boldsymbol{B}}{\partial t} \qquad \boldsymbol{\nabla} \times \boldsymbol{B} = \mu_0 \boldsymbol{j} + \frac{1}{c^2}\frac{\partial \boldsymbol{E}}{\partial t}$$

Figure3: The "2x2" models for the Faraday's law and the Ampere's law

SU(2) and "2x2"

The special unitary group of degree 2, denoted SU(2), is the group of 2x2 unitary matrices with determinant 1. It gives a mathematical foundation of the electroweak interaction. It transforms a spinor $\Psi = (\phi_1, \phi_2)$ where ϕ_1 and ϕ_2 are complex numbers. An element of SU(2), $U_1(\theta) = \exp(\frac{1}{2} i\theta\sigma_1)$ where σ_1 is one of the Pauli matrices, gives rotations in the Im ϕ_1-Re ϕ_2 and Re ϕ_1-Im ϕ_2 planes. In the same way, $U_2(\theta) = \exp(\frac{1}{2} i\theta\sigma_2)$ gives rotations in the Im ϕ_1-Im ϕ_2 and Re ϕ_1-Re ϕ_2 planes, and $U_3(\theta) = \exp(\frac{1}{2} i\theta\sigma_3)$ in the Im ϕ_1-Re ϕ_1 and Im ϕ_2-Re ϕ_2 planes. A rotation is considered to be equalization (or neutralization) of two dimensions, resulting in an edge of a tetrahedron.

These three sets of rotations are fit to the three sets of dual edges of the "2x2" projection, where Im ϕ_1, Re ϕ_1, Im ϕ_2 and Re ϕ_2 are assigned to the four vertices.

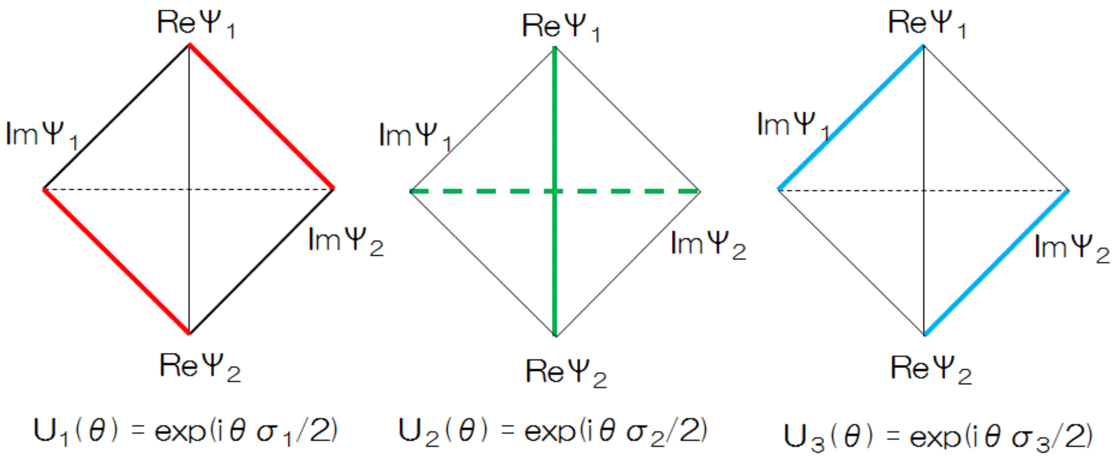


Figure 4: Three sets of rotations of SU(2) and "2x2"

Tree-level scattering processes of elementary particles and "2x2"

Initial and final states of two elementary particles in a tree-level (leading-order) scattering process are assigned to the four vertices of a tetrahedron. Each set of dual edges of the "2x2" projection corresponds to t-channel, u-channel or s-channel process respectively.

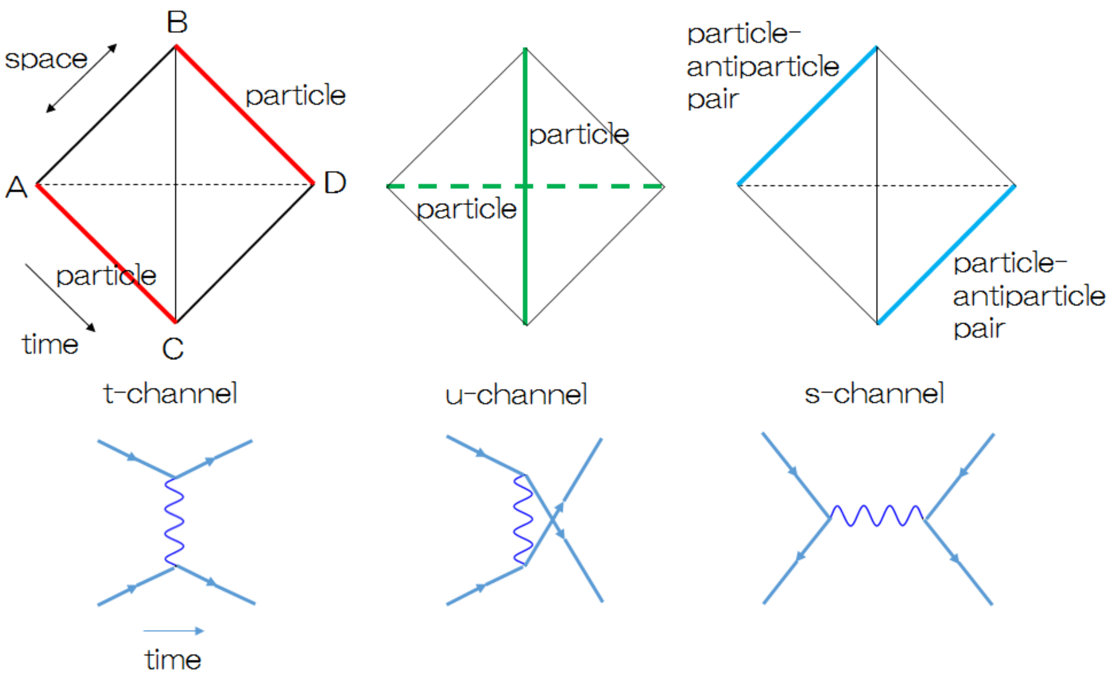
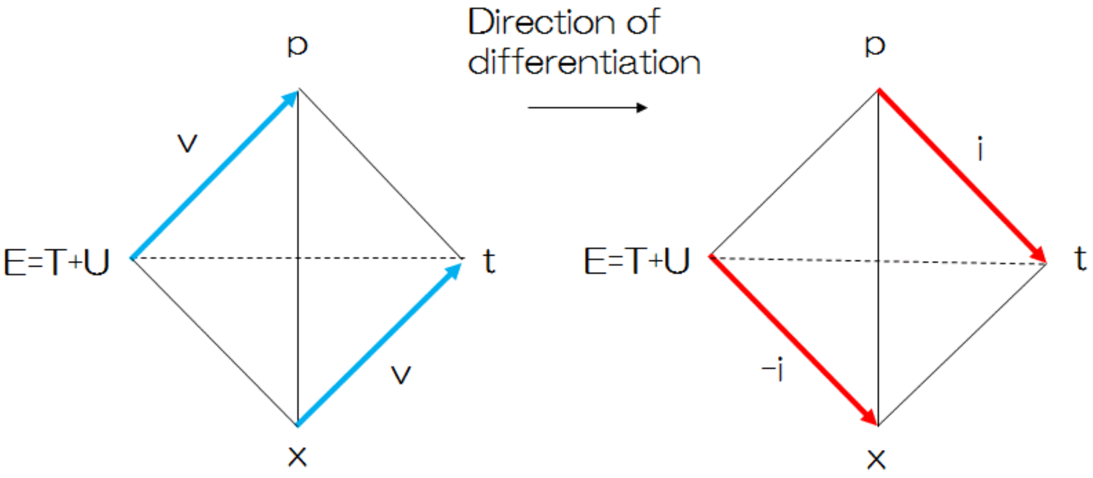


Figure 5: Tree-level scattering processes of elementary particles and "2x2"

Classical mechanics (the equation of motion) and "2x2"

Let's take up the motion of a body in one dimension. Energy E is assigned to the vertex A, momentum p to B, displacement (position) x to C, and time t to D of a tetrahedron ABCD. Energy E is the sum of kinetic energy T and potential energy U ($E=T+U$). Two diagonal edges, AD and BC, are latent in the classical mechanics, that is, A and D (B and C) are independent. Observations A→B and C→D correspond to "the velocity of a body", while A→C and B→D correspond to the equation of motion, $\frac{dp}{dt} = -\frac{dU}{dx}(= F)$.



$$v = \frac{dT}{dp} = \frac{dx}{dt} \qquad -\frac{dU}{dx} = \frac{dp}{dt}$$

Figure 6: Classical mechanics and "2x2"

Difference between classical and quantum mechanics

In classical mechanics, momentum p and position x are independent in general, in other words, p and x do commute. In quantum mechanics, they do not commute with each other, which is shown by the commutation relation $[x, p] = i\hbar$, where $\hbar$ is the reduced Planck's constant. The difference is thought to originate in the difference between "equalization" (p is an observer and x is an object) and "neutralization".

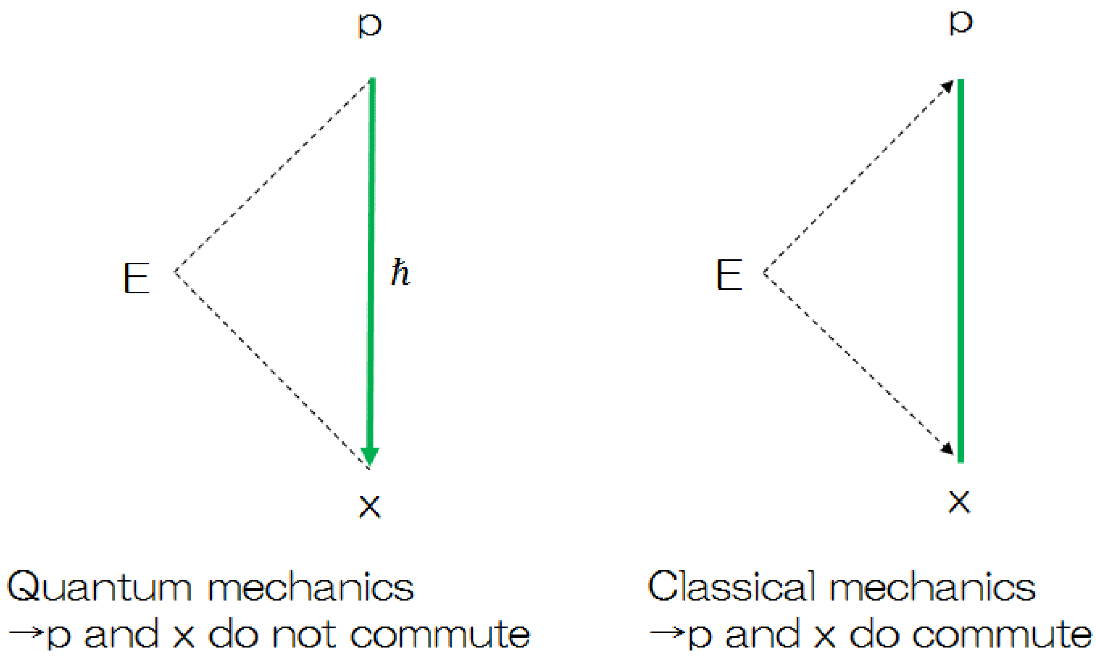


Fig7: Difference between quantum and classical mechanics

3. Summary

We have discussed how three-dimensional space with one-dimensional time is formed based on the "successive observation" system implemented in a regular tetrahedron. Repeating this process with "condensation" brings forth the hierarchy of matter and universe. Physics equations such as Maxwell equations and the equation of motion are fit to the "2x2" projection of a tetrahedron. Two distinct results of an observation of two dimensions may explain the discrepancy between quantum and classical physics.