Unified Theory of Particles

－ Symmetry of Spinor and Source of Mass －

SEIKO KONO

河野　誠公　著

Introduction

Assume quark and lepton as matter elementary particle, among three interaction with them and various (gauge) boson, describe electromagnetic and weak interaction in electro-weak (EW) gauge theory integrally and compile a theory to describe strong interaction in QCD gauge theory, and which is called a standard theory (model). In this theory, the mass that an elementary particle has been thought to hold it essentially is explained for quantity provided secondarily by spontaneous symmetry breaking. (Higgs mechanism) However, only by this Higgs mechanism, not only the mixing phenomenon of quark three generations and neutrino vibration cannot be explained, but also the regularity of each mass of quark, lepton three generations cannot be found at all. Furthermore, because the Einstein gravity field that is another interaction field has difficulty in quantization, it cannot be incorporated in a framework of standard theory as gauge theory. On the other hand, energy scale ~10^{15} GeV of the grand unified theory (GUT) to try unification of three interaction except the gravitational interaction, and the Planck scale ~10^{19} GeV that the unification of the gravitational interaction is expected, it is thought that there is the hierarchy problem that how can maintain naturally in the big hierarchy characteristics with those scales and energy scale ~10^{2} GeV of the electro-weak theory. [1), 2), 11)]

In this book, discuss the process to form each field that each matter elementary particle and boson leave the thermal equilibrium state that is a vacuum and is released in the 4D (4-dimensions) outer space according to the space expansion in the space formative period, and develop "the unified theory of particles" to describe all known elementary particles and four interaction integrally. By this unified theory, show that it gives one solution or interpretation for most of unsolved problems that the standard theory has.

This book is constructed in 2 parts. In Part I , review process that the standard theory had been built and reconfirm each unsolved problem to have. At first in Chapter 1 and 2, review about Lorentz transformation led by the principle of relativity which is essential in describing the particle equation of motion, the equation of motion in free field led by global symmetry of space-time and local symmetry appearing in each interaction. In Chapter 3, look back toward the electro-weak (EW) theory being the nucleus of the standard model. In Chapter 4 and 5, review process to lead to a quark model and constitution of the hadrons, and confirm problem of the quark confinement and problem of the origin of hadrons mass. In Chapter 6, look back on the derivation of the Einstein gravity field and confirm ground that the quantization is difficult. In Chapter 7 of the last of part I , summarize to refer to documents (1),(2),(11), etc. unsolved problems that the standard theory has.

In Part II , develop “unified theory of particles” based on “new particle theory beyond standard model”[15),16)], “new cosmic formation” [12)], “new quantum gravity theory and mass charge”[21)] and etc.[17),19)] which I already published. At first, in Chapter 8, suppose a vacuum which causes whole space and has structure of D=2(n+1) dimensions spin space expressed by combinations of n+1 unit helicity. Describe the formative period of space where 4D space-time which has three helicity to a component in n+1 unit ones expands and all known elementary particles are produced as some vacuum energy released in the outer space. In Chapter 9, scalar field, vector field and metric tensor field are created in n = 0, 2, 4, and quark and lepton of the 1st, 2nd, 3rd generations are created in n = 1, 3, 5(4) under the frame of 4D Lorentz group concretely. In Chapter 10, each boson and matter field separates and leaves the vacuum in the thermal equilibrium state according to the space expansion and the change of each energy density. And discuss a process forming those each field. In Chapter 11, give new interpretation for the color enclosure with the gluon field composed of

9-4 section. In Chapter 12, take up a problem in the origin of nucleon spin and show that this problem is solved by the hierarchy structure of quark three generations composed of 9-3 section. In Chapter 13, perform the quantization by the operational calculus for metric tensor field to be comprised of two connections, spin and affine connections composed of 9-5 section. Because the Lagrangian density of this quantum metric tensor field is given with the sum of Lagrangian density of two connection gauge fields, it is not necessary to treat differential term of the metric tensor in the Feynman diagram directly, and can treat it like the effective field theory that is renormalizable. In Chapter 14, perform the BRS conversion that is quantization by the path integral calculus for this metric tensor field. Then the relation of gauge phase of two connection gauge fields is led. A new charge "mass unit-charge" which gives the hierarchy structure of the mass of three generations matter particles can be constructed by composition with the phase difference of two connections and the helicity which matter doublet exchanges in the interaction. In Chapter 15, lead mass expression of quark and lepton doublet of three generations using this "mass unit-charge" and identify each mass. In Chapter 16, apply to quark three generations mixing and neutrino vibration phenomena. Each generation mixing is available to explain integrally as a phenomenon to exchange a "mass unit-charge" which each quark or neutrino of three generations holds, and show that each mixing angle is identified by the exchange probability amplitude defined using a mass unit-charge. In Chapter 17, apply it to the mass of hadrons which are the composite particles of quarks. Using "the mass charge" that a quark (u, d, s) constituting π, K meson and nucleon, Λ particle holds, lead each mass expression and show that the mass of each hadron can be identified with high precision.

Finally, in Chapter 18 and 19, summarize "unified theory of particles" developed with part II and unsolved problems of standard theory resolved by this unified theory. In Chapter 18, summarize unified expression of three generations matter particle and boson field using the spinor expression at first, and summarize unified expression of four interaction expressed by Yukawa coupling of the direction restoring supersymmetry. In 18-4 section, each quantum number to characterize each elementary particle and each interaction is expressed using spinor symmetry (symmetry of helicity). In Chapter 19, summarize solutions or interpretation provided by this unified theory for unsolved problems summarized in Chapter 7 which the standard theory has. In 19-2 section, show problems to still remain as non-solution and problems to produce by this unified theory newly. I hope that it is helpful for the growth of the future theory of elementary particles and cosmology.

January, 2020 (in Japanese)
December, 2020 (translated into English)

Seiko Kono
(河野　誠公)

Contents

Part I Standard Theory (Model) and Unsolved Problems

Part I Standard Theory (Model) and Unsolved Problems

Chapter 1 Symmetry of 4D Space-Time and Lorentz Group

1－1． Principle of Relativity and Lorentz Transformation [3), 4), 21)]

All natural rules are the same in every inertial frame of reference when they obey the theory of relativity that is a law learned by experience. In other words, the equation representing the natural rule is invariant in coordinate transforming from one inertial frame of reference to other inertial ones.

The interaction between the material particles was expressed as a function of the coordinate of the particle which interacted. It was implied that the interaction carried out instantaneously. However, we know empirically that there is no interaction which carries out instantaneously and a certain limited time is necessary. It is called propagation velocity of interaction that a distance between two interacting particles is divided by its finite time. This propagation velocity must be called the maximal velocity of the interaction and be the same in all inertial frames of reference, according to the theory of relativity. This propagation velocity is a universal constant and is regarded as the speed that light is transmitted through the vacuum namely light velocity. [3)]

In the Galileo's principle of relativity which follows the principle of relativity, the interaction occurred instantaneously. In the Einstein's principle of relativity to distinguish from it, finiteness of the light velocity which is propagation speed of the interaction is combined with the principle of relativity.

In the classical mechanics, space is relative, however, time is absolute. However, when obey to the composition law of the velocity vector, the velocity of the compositing motion becomes the vector sum of each velocity of the motion to constitute it. As this law should be applied to propagation velocity of the interaction, the propagation velocity will be different in the different inertial frame of reference. This completely contradicts the Einstein's principle of relativity. By the measurement of the light velocity by Michelson (1881), it was confirmed that the light velocity did not depend on its spread direction, and the Einstein's principle of relativity was confirmed.[3)] It was concluded that time is not absolute and there is inherent time in an inertial frame of reference.

(Inherent Time and Lorentz Transformation)[3)]

In inertial frame of reference, consider to observe a clock moving any activity for static frame. The 'moving clock' advances only to distance $\sqrt{dx^2+dy^2+dz^2}$ during minute time interval dt measured by a clock in the static frame. As this clock is static state in the coordinate (x', y', z', t') of 'moving clock', it is dx' = dy' = dz' = 0. By invariance of element ds of the length,

$$ds^2 = c^2\,dt^2 - dx^2 - dy^2 - dz^2 = c^2\,dt'^2 \qquad (1\text{-}1)$$

$$\therefore\ dt' = ds / c = 1/c\ \sqrt{c^2\,dt^2 - dx^2 - dy^2 - dz^2}$$

Here, assume velocity of 'moving clock' υ ,

$$\upsilon^2 = (dx^2 + dy^2 + dz^2) / dt^2 \qquad (1\text{-}2)$$

When substitute it for eq.(1-1),

$$dt' = ds / c = dt\sqrt{1-\upsilon^2/c^2} = dt\sqrt{1-\beta^2},\quad \beta \equiv \upsilon / c \qquad (1\text{-}3)$$

Thus, the length at the time that 'moving clock' ticks away is as follows, while 'clock in static state' ticks only $t_2 - t_1$.

$$t'_2 - t'_1 = \int_{t_1}^{t_2} dt\ \sqrt{1-\beta^2} \qquad (1\text{-}4)$$

This interval $t'_2 - t'_1$ which 'moving clock' ticks is the inherent time of this frame.

Then, suppose a coordinate transformation between two frames to move at uniform velocity each other. Transform from frame K(x, y, z, t) to frame K' (x', y', z', t'). The K' frame moves in constant velocity υ in forward direction of x-axis on the basis of K. This problem is easily solved in the classical mechanics using the Galilei transformation;

$$x' = x + \upsilon t, \quad y' = y, \quad z' = z, \quad t' = t \tag{1-5}$$

However, the relativistic transformation formula is expressed as a rotation of the 4D-coordinate frame (x, y, z, t). Suppose the rotation of τ −x plane using a parameter $\tau = i\,ct$. The y- and z-axis do not change by this rotation. When take θ as rotation-angle, the relations between old and new coordinates are expressed as follows;

$$x = x' \cos\theta - \tau' \sin\theta, \quad \tau = x' \sin\theta + \tau' \cos\theta \tag{1-6}$$

The coordinate transformation results in a problem to seek this rotation angle θ . θ depends only on relative velocity υ between frames K and K'. Suppose movement of the origin of K' in K frame. As it becomes x' = 0, eq.(1-6) is

$$\begin{cases} x = -\tau' \sin\theta \\ \tau = \tau' \cos\theta \end{cases} \qquad \therefore \frac{x}{\tau} = -\tan\theta \tag{1-7}$$

As $x/\tau \sim x/t$ is velocity υ of K' for K frame clearly,

$$\tan\theta = -\frac{x}{\tau} = \frac{i\,x}{ct} = \frac{i\,\upsilon}{c} = i\beta \tag{1-8}$$

$$\therefore \quad \sin\theta = \frac{i\beta}{\sqrt{1-\beta^2}}, \quad \cos\theta = \frac{1}{\sqrt{1-\beta^2}} \tag{1-9}$$

When replace it with $\tau = i\,ct$, $\tau' = i\,ct'$ and substitute eq.(1-9) for eq.(1-6),

$$x = \frac{x' + \upsilon t'}{\sqrt{1-\beta^2}}, \; y = y', \; z = z', \quad t = \frac{t' + \beta x'/c}{\sqrt{1-\beta^2}} \tag{1-10}$$

This eq.(1-10) is the formula of Lorentz-transformation.

The inherent length is obtained by eq.(1-10), in the same way the inherent time is given by eq.(1-4). A length of stick in static state is expressed in $\ell_0 = \triangle x = x_2 - x_1$, and a length of stick of a frame K' is expressed in $\ell = \triangle x' = x'_2 - x'_1$.

$$\ell_0 = \triangle x = x_2 - x_1 = \frac{x'_2 + \upsilon t'}{\sqrt{1-\beta^2}} - \frac{x'_1 + \upsilon t'}{\sqrt{1-\beta^2}}$$

$$= \frac{x'_2 - x'_1}{\sqrt{1-\beta^2}} = \ell / \sqrt{1-\beta^2}$$

$$\therefore \quad \ell = \ell_0 \sqrt{1-\beta^2} \qquad (1\text{-}11)$$

A length of stick becomes maximum in a static frame, and it shrinks $\sqrt{1-\beta^2}$ times in a frame moving in velocity υ. (Lorentz-contraction)

Then, time and space are expressed to emphasize 4-dimensions (4D) space-time as follows;

$$x^0 = ct, \quad x^1 = x, \quad x^2 = y, \quad x^3 = z \qquad (1\text{-}12)$$

Element of the length ds that is invariant is expressed below for Lorentz transformation when express the minute displacement of each coordinate direction in dx^μ.

$$ds^2 = \eta_{\mu\nu} dx^\mu dx^\nu \qquad (1\text{-}13)$$

here, $\eta_{00} = +1$, $\eta_{ii} = -1$, $\eta_{\mu\nu} = 0 \quad (\mu \neq \nu)$

When the same subscript appears up and down, add it from 0 to 3.

The Lorentz-transformation of eq.(1-10) is expressed by using a matrix as follows;

$$\begin{pmatrix} ct' \\ x' \\ y' \\ z' \end{pmatrix} = \begin{pmatrix} k & -k\beta & 0 & 0 \\ -k\beta & k & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} ct \\ x \\ y \\ z \end{pmatrix} \qquad (1\text{-}14)$$

here, $k = 1 / \sqrt{1-\beta^2}$, $\beta = \upsilon / c$

When $\Lambda^{\mu}{}_{\nu}$ represents component (μ , ν) of matrix, eq.(1-14) becomes

$$x'^{\mu} = \Lambda^{\mu}{}_{\nu} x^{\nu} \tag{1-15}$$

Here, give below a 4D velocity vector;

$$u^{\mu} \equiv c \frac{dx^{\mu}}{ds} \tag{1-16}$$

When a particle is in static state, it is dx = dy = dz = 0. Using eq.(1-13),

$$\begin{cases} u^0 = c \dfrac{dx^0}{ds} = c \sqrt{dx^0 dx^0 / ds^2} = c \sqrt{1/\eta_{00}} = c \\ u^i = c \dfrac{dx^i}{ds} = 0 \qquad \text{at} \quad i = 1, 2, 3 \end{cases} \tag{1-17}$$

When a particle moves in velocity υ to x-direction, use the Lorentz transformation eq.(1-14) in which the coordinate moves in velocity $-\upsilon$,

$$\begin{cases} u^0 = c \dfrac{dx^0}{ds} = c \cdot k = c / \sqrt{1-\beta^2} \;, u^2 = u^3 = 0 \\ u^1 = c \dfrac{dx^1}{ds} = c(-k \cdot (-\upsilon / c)) = k \cdot \upsilon = \upsilon / \sqrt{1-\beta^2} \end{cases} \tag{1-18}$$

4D-momentum p^{μ} is obtained when multiply mass m by 4D-velocity vector. This particle energy E is equal to 0-component p^0 times c.

$$E = c\, p^0 = mc\, u^0 = mc^2 / \sqrt{1-\beta^2} \tag{1-19}$$

When particle velocity υ is small enough for light velocity c ($\upsilon \ll c$),

$$E \approx mc^2 \left(1 + \frac{1}{2} \beta^2\right) = mc^2 + \frac{1}{2} m \upsilon^2 \tag{1-20}$$

Kinetic energy of the Newton dynamics is provided in the 2nd term.