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A Physical Theory Based on Barycenter Reference Frames I: Principles of Particle Flow Fields

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Abstract
In this paper, a new theory of particle flow fields is introduced. Instead of using the point mass model and the inertial frame of reference, this theory is based on the elastic particle (real particle) model and the barycenter frame of reference. This article applies vector analysis to derive a complete set of field equations in a space permeated with moving particles. It reveals a comparable connection between mass quantity and electric quantity within the barycenter reference framework, thereby merging the interactions of gravitation and electromagnetism. The article argues that quantum randomness originates from the uncertainty associated with time and space measurement in barycenter frames. However, this uncertainty can be eliminated by the principle of measurement, thus leading to deterministic conclusions. The proposed theory provides unique solutions and interpretations for various fundamental physics problems, such as the structure of objects, the existence of dark matter, the nature of light, and the phenomenon of black-body radiation. Notably, the presence of a cosmic electron fluid challenges our conventional understanding of the physical world and has significant implications for existing physical laws.

Keywords: Barycenter Frame of Reference, Particle Flow Fields, Elastic Particles, Quantum Uncertainty, Electron Fluid, Unified Field Theory

1. Introduction

To describe the motion of an object, an appropriate frame of reference must be chosen, and the use of different frames of reference often leads to different theoretical frameworks. Ptolemy's astronomy, for example, utilized the geocentric reference frame, whereas Copernicus's astronomy employed the heliocentric reference frame. Newtonian mechanics initially relied on an imaginary absolute frame of reference (absolute space), but later transitioned to the comprehensible inertial frame of reference. At the beginning of the 19th century, Einstein invented the spacetime frame of reference by changing the definition of simultaneity, which created the special theory of relativity and resulted in a paradigm shift from classical physics to modern physics. Because relativity theory intertwines time and space, its counter-intuitive ideas and conclusions are challenging for the general public to understand.

Newton believed that inertia is an intrinsic property of an object and is responsible for maintaining the object's movement in a straight line or at rest. In the context of an inertial frame of reference, an object that is not influenced by external forces will continue to move in accordance with its inertia [1]. However, in the presence of gravitational fields, there is no inertial system. To address this, Einstein introduced the concept of a curved space-time background through the equivalence principle. By applying the inertial principle, he formulated the general theory of relativity within this spacetime framework, also known as the local inertial frame [2]. Since there is no uniform linear motion in the gravitational field, there is no need to adhere to the inertial frame of reference. The laws of motion of objects in inertial systems have a simple form, but a complete theory of gravitation can only be established in non-inertial systems. In order to escape the limitations of inertial frames, the author proposes a novel theory based on the barycenter frame of reference [3-8]. This theory, which differs from classical and modern physics, is an axiomatic system that redefines five fundamental concepts of physics:

object, particle, motion, space and time. This paper develops the theory of flow fields using the barycenter frame of reference, elucidates the laws governing the motion of real-particle fluids, and provides original analyses and interpretations of several fundamental problems in physics.

Classical mechanics, electrodynamics, relativistic mechanics and quantum mechanics are four different theoretical frameworks in the history of physics. Starting from the first principle thinking, real-particle theory based on the barycenter reference frame introduces a new paradigm that integrates several theories into a unique discourse. In order to facilitate and improve the communication, the reader needs to be aware of some novel concepts as well as updated terminology to alleviate the conceptual conflicts caused by incommensurability [9].

2. Foundations of Flow Fields

2.1. Postulates

There are five postulates in the real particle theory. I. Object: the object is composed of finite discrete real particles with a nested structure. II. Real particle (r-particle): the real particle is an object that has the attributes of mass, volume, and elasticity. III. Real space (r-space): the real space is the dimension in which objects exist. Without space, there are no objects. The r-space is three-dimensional Euclidean and is permeated with moving r-particles. IV. Real time (r-time): the real time is the dimension in which objects move. Without time, there is no motion. The r-time is irreversible in one dimension. V. Motion: objects interact with each other and are in constant motion.

Modern physics considers the continuous field as the original form of matter and the discrete particles as the excited form of the field. According to classical fluid mechanics, discrete particle fluids can have their motion described by a continuous velocity field through the continuum hypothesis. Real particle theory holds that discrete particles are the original constituents of an object, and that the continuous field is a mathematical tool invented by humans to describe the discrete particle systems. The theory of particle flow fields transforms discrete particle distribution into continuous potential field by integral transformation, thus realizing the unity of field theory based on a unified form of matter.

The particles in Newtonian mechanics are point masses. A point mass has only mass, no spatial extension, and is a simplified model of actual objects. Objects have not only mass but also spatial structure. The real particles that make up an object are hierarchically nested, correlated, and in constant motion. The subversive aspect of real particle theory is the replacement of the point-mass model with the real object model. With respect to the center of mass (barycenter) of an object, the motion of the object consists of three modes: translational, rotational, and vibrational. The translation mode is the displacement of the object's barycenter, the rotation mode is the fixed-point rotation of the object about its barycenter, and the vibration mode is the radial oscillation of particles within the object relative to the barycenter. Each motion mode has three degrees of freedom, and an object has a total of nine degrees of freedom. The translation mode of the object's barycenter (the point mass) is called the orbital motion. A steady orbital motion can be further decomposed into three states: circulational, pulsational, and nutational. The circulation state is the revolution of the point-mass along a planar circle, the pulsation state is the radial oscillation with respect to the center of the circle, and the nutation state is the normal wobbling with respect to the plane of the circle. This paper proves that the theory of particle flow fields determines the interaction of particles. The theory of particle dynamics will demonstrate that the orbital motion of the particle is governed by the forces of flow fields [10].

2.2. Concepts

2.2.1. Measurable Space

According to postulates III and V, the real space is filled with moving particles (objects) and there is no absolutely empty space. As shown in Figure 1a, the real space can be divided into a measurable space and an unmeasurable space. Send a signal from the observation site O at a speed of c, and after a time interval t_m, the signal reaches a spherical surface S_m with a radius of $R_m = c \cdot t_m$. The space inside S_m ($r_0 \leq R_m$) is called the measurable space, and the space outside S_m ($r_0 > R_m$) is called the unmeasurable space.

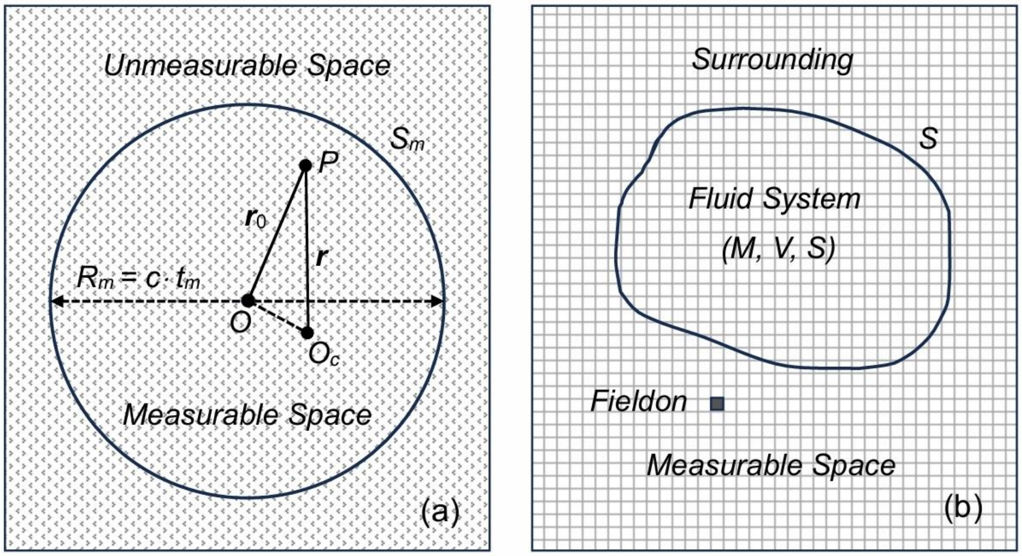

Figure 1: (a) Measurable Space and Unmeasurable Space. (b) System and Surrounding, Space Cells and Fieldsons

The observation site O is a reference point for determining the structure of space and time. The simultaneity of measurable space is stipulated by the following protocol. Send a signal of $t_0 = 0$ from site O, and set the time to $t = r_0 / c$ at the distance of r_0 ($r_0 \leq R_m$). In practice, synchronous signals are transmitted using electromagnetic waves at a rate of $c = 2.99792458 \times 10^8$ m/s.

Measurable space is a time-synchronized, observer-centered, three-dimensional spherical real space. The aim of defining the measurable space is to confine the spatial extent of quantitative investigation and introduce the barycenter frame of reference along with the notion of actual quantity. The flow field theory using the barycenter frame of reference is characterized by its finiteness and quantization.

2.2.2. Fluid Systems

A fluid system is defined as a subset of the measurable space. As shown in Figure 1b, let S be an arbitrary closed surface within the measurable space. All particles contained in S are called the fluid system, and the space outside S but inside S_m is called the fluid surroundings. The system and its surroundings can transfer momentum and energy across the interface.

Let the mass of fluid particles be M_i and the total number of particles be N, then the fluid has the total mass $M = \sum_{i=1}^{N} M_i$. The fluid system can be regarded as an object with mass, volume and deformation properties, and its spatial state can be described by the position, profile and posture [5].

The position state of an object is characterized by the position vector of the barycenter. Considering the object as a point mass system, the position vector of a particle in the Cartesian coordinate system is $\boldsymbol{r}_i = (x_i, y_i, z_i)$, and the position vector of the object's barycenter, $\boldsymbol{r}_c = (x_c, y_c, z_c)$, can be expressed as follows

$$x_c = \frac{1}{M}\sum_{i=1}^{N} M_i x_i, \quad y_c = \frac{1}{M}\sum_{i=1}^{N} M_i y_i, \quad z_c = \frac{1}{M}\sum_{i=1}^{N} M_i z_i. \tag{1}$$

The profile and posture of the object are determined by the inertia matrix [1]

$$I = \begin{pmatrix} I_{11} & -I_{12} & -I_{13} \\ -I_{21} & I_{22} & -I_{23} \\ -I_{31} & -I_{32} & I_{33} \end{pmatrix} \tag{2}$$

The elements of the inertia matrix are calculated as follows

$$I_{11} = \sum_{i=1}^{N} M_i\left(y_i^2 + z_i^2\right), \quad I_{22} = \sum_{i=1}^{N} M_i\left(x_i^2 + z_i^2\right), \quad I_{33} = \sum_{i=1}^{N} M_i\left(x_i^2 + y_i^2\right),$$

$$I_{12} = I_{21} = \sum_{i=1}^{N} M_i x_i y_i, \quad I_{13} = I_{31} = \sum_{i=1}^{N} M_i x_i z_i, \quad I_{23} = I_{32} = \sum_{i=1}^{N} M_i y_i z_i .$$

The inertia matrix is a third-order real symmetric matrix. According to the linear algebra theory, the inertia matrix has three positive eigenvalues $\{I_1, I_2, I_3\}$ and three orthogonal eigenvectors $\{\boldsymbol{e}_1, \boldsymbol{e}_2, \boldsymbol{e}_3\}$ [11]. The eigenvalues are the principal inertias, which is used to characterize the profile. The eigenvectors represent the inertial principal axes, which is used to characterize the posture. The three motion modes of the object (translation, vibration and rotation) correspond to the temporal changes in position, profile and posture, respectively.

Considering a fluid system as an object is a holistic view. In order to describe the motion of the particles inside the fluid and to include the interactions with the surroundings, a field-theoretic view must be adopted. In this paper, a theory of particle flow fields is developed based on the barycenter frame in the measurable space.

2.2.3. Reference Frames

An observer frame of reference is a framework that considers the point O as the observation site. In this frame, the time is indicated as t, and the location of the point P is specified by a position vector $\boldsymbol{r}_0 = \overrightarrow{OP}$. Meanwhile, the system also defines a center of mass O_c. A barycenter frame of reference is a framework that considers the point O_c as the observation site. In this frame, the time is also represented as t, and the location of the point P is specified by a position vector $\boldsymbol{r} = \overrightarrow{O_c P}$. Due to the non-uniform mass distribution, the barycenter does not coincide with the observation site, as illustrated in Figure 1a.

A Cartesian coordinate system can be established in the barycenter frame of reference. The inertia matrix of the measurable space has three orthogonal eigenvectors, which are served as Cartesian coordinate axes. The barycenter frame of reference is associated with the observer frame of reference, which is confined to the measurable space, and thus they are both bounded frames of reference. Traditional reference frames (both global and local) are unbounded reference frames. The introduction of a bounded frame of reference facilitates the quantization of the flow field and makes it easier to find out the laws of fluid motion.

2.2.4. Quantization

Due to the constant motion of the fluid, there is an uncertainty in the position of the barycenter O_c. If O_c is shifted by $\delta r_0 = r_s$ during the time interval $\delta t = t_s$, then the length of the position vector $\boldsymbol{r}$ seen by the observer has the uncertainty r_s. With t_s as the unit of time and r_s as the unit of spatial length, the time and position vectors in the barycenter frame of reference can be expressed as

$$t = \tilde{t} \cdot t_s, \quad \boldsymbol{r} = \tilde{\boldsymbol{r}} \cdot r_s . \tag{3}$$

We refer to t as a real time and $\boldsymbol{r}$ as a real position vector. The $\tilde{t}$ and $\tilde{\boldsymbol{r}}$ are the numerical values that correspond to the real time and the real position vector.

Since t_s and r_s are indeterminate, they are inseparable units of time and space. By postulate IV, we specify the direction of flow in real time as

$$t = \tilde{t} \cdot t_s, \quad \tilde{t} = 0,1,2,\cdots k, k+1,\cdots \tag{4}$$

That is, the numerical values take the sequence of natural numbers to reflect the irreversibility of real time.

The position vector of the barycenter frame can be expressed in Cartesian components as

$$\boldsymbol{r} = \tilde{\boldsymbol{r}} \cdot r_s = (\tilde{x}, \tilde{y}, \tilde{z}) \cdot r_s; \quad \{\tilde{x}, \tilde{y}, \tilde{z}\} = 0, \pm 1, \pm 2, \cdots \tag{5}$$

Here $\tilde{\boldsymbol{r}} = (\tilde{x}, \tilde{y}, \tilde{z})$ is referred to as the digit of the position vector, and the digital component $\{\tilde{x}, \tilde{y}, \tilde{z}\}$ must be integers. Above, we used the uncertainty in the position of the barycenter to realize the quantization of time and space in the barycenter frame of reference.

2.2.5. Fieldons

As shown in Figure 1b, the eigenvectors and length unit of a measurable space define a spatial array, the volume unit of the array $V_s = (r_s)^3$ is called a space cell, and the collection of particles within the space cell is called a fieldson, a neologism used to denote the elements of the flow fields. Real-space postulate III requires that the space cells are non-empty, *i.e.*, a fieldon must contain particles and has mass. A fluid system of volume $V = \tilde{V} \cdot V_s$ contains $\tilde{V}$ fieldons.

At the moment $\tilde{t} = k$, if a fieldon is located at $\boldsymbol{r}_\alpha(k)$ and has the mass $M_\alpha(k)$, then the velocity of the fieldon is defined as

$$\boldsymbol{v}_\alpha(k) = \frac{\boldsymbol{r}_\alpha(k+1) - \boldsymbol{r}_\alpha(k)}{t_s} = \tilde{\boldsymbol{v}}_\alpha(k) \cdot v_s \quad \left(\alpha = 1,2,\cdots,\tilde{V}\right) \tag{6}$$

$$\tilde{\boldsymbol{v}}_\alpha(k) = \boldsymbol{r}_\alpha(k+1) - \boldsymbol{r}_\alpha(k), \quad v_s = \frac{r_s}{t_s}.$$

Summing over all fieldons yields the total mass and momentum of the fluid system

$$M(k) = \sum_{\alpha=1}^{\tilde{V}} M_\alpha(k), \quad \boldsymbol{p}(k) = \sum_{\alpha=1}^{\tilde{V}} M_\alpha(k)\boldsymbol{v}_\alpha(k). \tag{7}$$

2.3. Principles

2.3.1. Actual Quantities

The units of time and space in the barycenter frame are variable. By extension, the units of physical quantities in the barycenter frame are all variables. The physical quantity $\boldsymbol{q}$ expressed in variable unit is called an actual quantity, which is defined as [3].

$$\boldsymbol{q} = \tilde{\boldsymbol{q}} \cdot q_s \quad (0 < \{\, |\boldsymbol{q}|, q_s \,\} < \infty). \tag{8}$$

where $\tilde{\boldsymbol{q}}$ is called the digit factor, labeled with the symbol "~"; q_s is called the scale factor, labeled with the subscript "s". A digit is the numerical value of a physical quantity, and a scale is the identity and metric of a physical quantity. Digits are scalars or vectors, and scales can only be scalars. Equation (8) also specifies the finiteness of physical quantities. Scale is an inseparable part of the physical quantity, the digits have only relative significance, no absolute significance.

2.3.2. Measurement Principle

For real quantities $\{x,y,z\}$, if there exists a physical relation $z = f(x, y)$ defined in the form of power and product, then the following condition must hold [8].

$$z = f(x,y) = \tilde{z} \cdot z_s \quad \Leftrightarrow \quad \tilde{z} = f(\tilde{x},\tilde{y}) \wedge z_s = f_s. \tag{9}$$

In the above formula, $\tilde{z} = f(\tilde{x},\tilde{y})$ is called the relation invariance, and $z_s = f_s$ is called the scale covariance. Relation invariance requires that digital relations remain consistent with the defining equation of the function, and scale covariance requires that scales vary according to the functional relationship.

Classical physics uses units to represent physical quantities, known as the unit system; real particle theory uses scales to represent physical quantities, known as the scale system. The difference between the two is that the units cannot change continuously, whereas the scales can change continuously. The scale covariance has been called the principle of measurement relativity and the principle of objectivity, both of which are based on the idea that units of measurement can vary continuously within physical constraints [12-14]. In this paper, we refer to relation invariance and scale covariance collectively as the measurement principle. The measurement principle is the central idea and mathematical foundation of real particle theory.

2.3.3. Scale Systems

The use of variable scales as physical units can be understood as a way to study low-dimensional physics in a high-dimensional mathematical space. In a real particle system, if there are P well-defined physical quantities, then the dimension of its mathematical parameter space is $2P$. Constrained by physical relations, the number of independent scales (scale bases) is only three, and all other scales (derived scales) can be derived from the scale bases. The scale system, or unit system, is an important symbol that distinguishes modern physics from classical physics.

Classical mechanics uses the unit system, the basic units (SI system) are: mass M_u = kg (kilogram), length r_u = m (meter), time t_u = s(second). The derived units include: velocity $v_u = r_u / t_u$ = m · s $^{-1}$, momentum $p_u = M_u v_u$ = kg · m · s $^{-1}$, angular momentum $h_u = p_u r_u$ = kg · m^2· s $^{-1}$, energy $E_u = M_u v_u^2$ = kg · m^2 · s $^{-2}$, etc. There are seven basic units of the SI system, all of which have strictly defined standards and cannot be varied continuously.

Quantum mechanics in fact uses a scale system with the following scale bases: velocity $v_s = c$ = 299792458 m/s (constant of light speed), angular momentum $h_s = h = 6.6260693 \times 10^{-34}$ J · s (Planck's constant), and frequency $v_s = \nu$. The derived scales include: time $t_s = 1 / \nu$, space $r_s = c / \nu = \lambda$, momentum $p_s = h_s / r_s = h / \lambda$, mass $M_s = h_s / (r_s v_s) = h / (\lambda c)$, energy $E_s = M_s v_s^2 = h\nu$, etc. The derived scales are all variables because the frequency scale in the scale bases is a variable. Since c is a constant, the scales of space and time have a constraint $c = r_s / t_s = \lambda\nu$. Since h is a constant, the constraint $h = r_s p_s = E_s t_s$ represents, in fact, the Heisenberg's uncertainty.

Relativistic mechanics also embodies the idea of a scale system, with the scale bases of mass M_s, time t_s, and velocity $v_s = c$. Only c is a constant scale in the theory of relativity, the rest scales are variables. Relativity assumes that the speed of light is a constant, and essentially takes c as the velocity scale. $r_s = ct_s$ indicates that a decrease in the unit of time must be accompanied by a decrease in the unit of space length. $E_s = M_s c^2$ indicates that an increase in the unit of mass must be accompanied by an increase in the unit of energy. The mass-energy relation in relativity is a scale relation, rather than the conversion between mass and energy.

2.3.4. Calculation Rules

The measurement principle determines the rules of arithmetic for actual quantities.

I. Addition and Subtraction

$$z = x \pm y = (\tilde{x} \pm \tilde{y}) \cdot x_s; \quad \tilde{z} = \tilde{x} \pm \tilde{y}, \qquad z_s = x_s = y_s.$$

II. Multiplication

$$z = xy = (\tilde{x}\tilde{y}) \cdot (x_s y_s); \quad \tilde{z} = \tilde{x}\tilde{y}, \quad z_s = x_s y_s\ .$$

III. Division

$$z = \frac{y}{x} = \left(\frac{\tilde{y}}{\tilde{x}}\right) \cdot \left(\frac{y_s}{x_s}\right); \quad \tilde{z} = \frac{\tilde{y}}{\tilde{x}}, \quad z_s = \frac{y_s}{x_s}.$$

IV. Actual Differential

$$z = z(x) = \tilde{z} \cdot z_s, \ \ dx = x_s;$$

$$dz = z(x + x_s) - z(x) = d\tilde{z} \cdot z_s;$$

$$d\tilde{z} = \tilde{z}(x + x_s) - \tilde{z}(x).$$

V. Actual Derivative

$$\frac{dz}{dx} = \frac{z(x + x_s) - z(x)}{x_s}, \quad \left(\frac{dz}{dx}\right)_d = d\tilde{z}, \quad \left(\frac{dz}{dx}\right)_s = \frac{z_s}{x_s}.$$

VI. Actual Integral

$$x_i = x_0 + (i-1)x_s, \quad dx = x_s;$$

$$Z = \int_{x_0}^{x_n} z(x)dx = x_s \sum_{i=1}^{n} z(x_i) = (x_s z_s) \sum_{i=1}^{n} \tilde{z}(x_i)\,;$$

$$Z_s = x_s z_s; \quad \tilde{Z} = \sum_{i=1}^{n} \tilde{z}(x_i)$$

VII. Digital Functions

$$e^{x} = e^{\tilde{x}\cdot x_s} = e^{\tilde{x}}, \quad x_s = 1.$$

$$\ln x = \ln(\tilde{x}\cdot x_s) = \ln\tilde{x}, \quad x_s = 1.$$

$$\sin x = \sin(x_s\cdot \tilde{x}) = \sin\tilde{x}, \quad x_s = 1.$$

3. Equations of Flow Fields

3.1. Density Field

If the mass of the fieldon at $\boldsymbol{r}_\alpha(t)$ is $M_\alpha(t)$ and the momentum is $\boldsymbol{p}_\alpha(t)$, then the mass density $\rho_\alpha(t)$ and momentum density $\boldsymbol{j}_\alpha(t)$ of the fieldon are

$$\rho_\alpha(t) := \frac{M_\alpha(t)}{V_s} = \tilde{\rho}_\alpha(t)\cdot\rho_s; \quad \tilde{\rho}_\alpha(t) = \widetilde{M}_\alpha(t), \;\; \rho_s = \frac{M_s}{V_s}. \tag{10a}$$

$$\boldsymbol{j}_\alpha(t) := \frac{\boldsymbol{p}_\alpha(t)}{V_s} = \tilde{\boldsymbol{j}}_\alpha(t)\cdot j_s; \quad \tilde{\boldsymbol{j}}_\alpha(t) = \tilde{\boldsymbol{p}}_\alpha(t), \;\; j_s = \frac{p_s}{V_s}. \tag{10b}$$

If V_s is large enough and each space cell contains enough particles, the density tends to be continuous, namely

$$\rho_\alpha(t) \to \rho(\boldsymbol{r},t) = \tilde{\rho}(\boldsymbol{r},t)\cdot\rho_s, \;\; \boldsymbol{j}_\alpha(t) \to \boldsymbol{j}(\boldsymbol{r},t) = \tilde{\boldsymbol{j}}(\boldsymbol{r},t)\cdot j_s. \tag{11}$$

At this point, the velocity of the flow field can be expressed in terms of the densities of mass and momentum as

$$\boldsymbol{v}(\boldsymbol{r},t) = \boldsymbol{j}(\boldsymbol{r},t)/\rho(\boldsymbol{r},t). \tag{12}$$

The existence of density fields $\{\rho, \boldsymbol{j}\}$ is a necessary and sufficient condition for constructing a complete theory of the real-particle fields.

3.2. Continuity Theorem

If there is a system quantity $\boldsymbol{Z}(t)$ and its density field is $z(r, t)$, then the time derivative of $\boldsymbol{Z}(t)$ is [6].

$$\frac{d\boldsymbol{Z}}{dt} = \frac{d}{dt}\left[\int_V \boldsymbol{z}(\boldsymbol{r}',t)dV'\right] := \int_V \frac{D\boldsymbol{z}}{Dt}dV' = \dot{\boldsymbol{Z}}(\delta\boldsymbol{z}) + \dot{\boldsymbol{Z}}(\delta V). \tag{13}$$

We call $D\boldsymbol{z}/Dt$ the motion derivative of the density field. $\dot{\boldsymbol{Z}}(\delta\boldsymbol{z})$ is the change rate of $\boldsymbol{Z}(t)$ caused by changing the density without changing the volume, while $\dot{\boldsymbol{Z}}(\delta V)$ is the change rate of $\boldsymbol{Z}(t)$ caused by changing the volume without changing the density.

$$\dot{\boldsymbol{Z}}(\delta\boldsymbol{z}) := \int_V \frac{\partial\boldsymbol{z}}{\partial t}dV' = \frac{1}{t_s}\int_V[\boldsymbol{z}(\boldsymbol{r}',t+t_s) - \boldsymbol{z}(\boldsymbol{r}',t)]dV', \tag{14a}$$

$$\dot{\boldsymbol{Z}}(\delta V) := \frac{1}{t_s}\int_{\delta V}\boldsymbol{z}(\boldsymbol{r}',t)dV'. \tag{14b}$$

The volume elements on the system boundary can be expressed by the area element as $dV' = (\boldsymbol{v}t_s)\cdot d\boldsymbol{S}'$, so $\dot{\boldsymbol{Z}}(\delta V)$ can be calculated by the area element

$$\dot{\boldsymbol{Z}}(\delta V) = \frac{1}{t_s}\int_{\delta V}\boldsymbol{z}(\boldsymbol{r}',t)dV' = \frac{1}{t_s}\oint_S \boldsymbol{z}(\boldsymbol{v}t_s)\cdot d\boldsymbol{S}' = \oint_S(\boldsymbol{z}\boldsymbol{v})\cdot d\boldsymbol{S}' = \int_V \nabla\cdot(\boldsymbol{z}\boldsymbol{v})dV' \tag{15}$$

where $\boldsymbol{zv}$ is of dyadic form. In the last step of the above formula, Gauss theorem of vector integral is applied to change the area integral back to the volume integral. Substituting Eq.(14a) and (15) into Eq. (13) yields

$$\int_V \frac{D\boldsymbol{z}}{Dt} dV' = \int_V \left[\frac{\partial \boldsymbol{z}}{\partial t} + \nabla \cdot (\boldsymbol{z}\boldsymbol{v})\right] dV' . \tag{16}$$

Since the volume V and the surface S of the system are arbitrary, the motion derivative can be finally expressed as

$$\frac{D\boldsymbol{z}}{Dt} = \frac{\partial \boldsymbol{z}}{\partial t} + \nabla \cdot (\boldsymbol{z}\boldsymbol{v}) . \tag{17}$$

The expression for the motion derivative is known as the continuity theorem. The motion derivative in fluid dynamics is also known as the material derivative [1].

If $D\boldsymbol{z} / Dt = 0$, then $d\boldsymbol{Z} / dt = 0$, and thus $\boldsymbol{Z}$ is a conserved quantity of the system. A real particle field allows the volume and shape of the system to change, but the total mass M of the system to be conserved, so the motion derivative of the mass density ρ equals zero.

$$\frac{D\rho}{Dt} = \frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \boldsymbol{v}) = \frac{\partial \rho}{\partial t} + \nabla \cdot \boldsymbol{j} = 0 . \tag{18}$$

3.3. Convolution Field

The convolution of density field in system space is called convolution field, which includes a mass convolution Φ and a momentum convolution $\boldsymbol{A}$.

$$\Phi(\boldsymbol{r},t) := \frac{-1}{\phi}\left[\rho(\boldsymbol{r},t) \circledast \left(\frac{1}{|\boldsymbol{r}|}\right)\right] = \frac{-1}{4\pi\phi_s}\int_V \frac{\rho(\boldsymbol{r}',t)}{r} dV' ; \quad \Phi_s = c^2, \quad \phi_s = \frac{M_s}{c^2 r_s}. \tag{19a}$$

$$\boldsymbol{A}(\boldsymbol{r},t) := \alpha\left[\boldsymbol{j}(\boldsymbol{r},t) \circledast \left(\frac{1}{|\boldsymbol{r}|}\right)\right] = \frac{\alpha_s}{4\pi}\int_V \frac{\boldsymbol{j}(\boldsymbol{r}',t)}{r} dV' ; \quad A_s = c, \quad \alpha_s = \frac{r_s}{M_s}. \tag{19b}$$

$$\phi = 4\pi\phi_s, \quad \alpha = \alpha_s/(4\pi), \qquad \alpha\phi = \alpha_s\phi_s = c^{-2}. \tag{19c}$$

where $r = |\boldsymbol{r} - \boldsymbol{r}'|$ and $\circledast$ is the convolution symbol. The ϕ and α are coefficients of the mass convolution and the momentum convolution, respectively. The digits of the convolution coefficients are constants, and the formula (19c) is the coefficient constraint relation. The convolution operation has two effects: first, it correlates the fieldons and introduces interactions; second, it converts the density field into smooth functions that guarantees the existence of derivatives of all orders. The convolution field is also known as the potential field, where Φ is a scalar potential and $\boldsymbol{A}$ is a vector potential. The scalar and vector potentials have opposite signs, indicating the opposite interactions of attraction and repulsion.

3.4. Action Field

The first-order spatial derivatives of convolutions are called the action field. The action field includes a gradient $\boldsymbol{G}$, a curl $\boldsymbol{C}$, and a divergence D.

$$\boldsymbol{G}(\boldsymbol{r},t) := -\nabla\Phi = \frac{-1}{\phi}\int_V \frac{\rho(\boldsymbol{r}',t)\boldsymbol{r}}{r^3} dV', \quad G_s = \frac{c}{t_s}. \tag{20a}$$

$$\boldsymbol{C}(\boldsymbol{r},t) := \nabla \times \boldsymbol{A} = \alpha\int_V \frac{\boldsymbol{j}(\boldsymbol{r}',t) \times \boldsymbol{r}}{r^3} dV', \quad C_s = \frac{1}{t_s}. \tag{20b}$$

$$D(\boldsymbol{r},t) := \nabla \cdot \boldsymbol{A} = \frac{1}{c^2}\frac{\partial \Phi}{\partial t} + D_0(t), \qquad D_s = \frac{1}{t_s}. \tag{20c}$$

$$D_0(t) = -\alpha\oint_S \frac{\boldsymbol{j}(\boldsymbol{r}',t) \cdot d\boldsymbol{S}'}{r} . \tag{20d}$$

The action field is deduced as follows:

Formula (20a)
$$\nabla\Phi = \frac{-1}{\phi}\int_V \rho(\boldsymbol{r}',t)\cdot\nabla\left(\frac{1}{r}\right)dV' = \frac{1}{\phi}\int_V \frac{\rho(\boldsymbol{r}',t)\boldsymbol{r}}{r^3}dV'.$$

Formula (20b)
$$\nabla\times\boldsymbol{A} = \alpha\int_V \nabla\times\left[\frac{\boldsymbol{j}(\boldsymbol{r}',t)}{r}\right]dV' = \alpha\int_V \nabla\left(\frac{1}{r}\right)\times\boldsymbol{j}\,dV'$$
$$= \alpha\int_V \frac{\boldsymbol{j}\times\boldsymbol{r}}{r^3}dV'.$$

Formula (20c)
$$\nabla\cdot\boldsymbol{A} = \alpha\int_V \boldsymbol{j}(\boldsymbol{r}',t)\cdot\nabla\left(\frac{1}{r}\right)dV' = -\alpha\int_V \boldsymbol{j}(\boldsymbol{r}',t)\cdot\nabla'\left(\frac{1}{r}\right)dV'$$
$$= -\alpha\int_V\left[\nabla'\cdot\left(\frac{\boldsymbol{j}}{r}\right) - \frac{\nabla'\cdot\boldsymbol{j}}{r}\right]dV' = -\alpha\oint_S \frac{\boldsymbol{j}\cdot d\boldsymbol{S}'}{r} - \alpha\int_V \frac{1}{r}\frac{\partial\rho}{\partial t}dV'$$
$$= D_0(t) - \alpha\frac{\partial}{\partial t}\left(\int_V \frac{\rho}{r}dV'\right) = D_0(t) + \frac{1}{c^2}\frac{\partial\Phi}{\partial t}\ .$$

The significance of the action field can be identified from the scale: the gradient represents acceleration, while the divergence and curl indicate vibrational and rotational frequencies, respectively. Both gradient and curl are inversely proportional to the square of the distance, and divergence is proportional to the change rate of the mass potential. The gradient formula is in the same form as Newton's law of gravitation and Coulomb's law of electrostatics, the curl formula is in the same form as the Biot-Savart's law for static magnetic fields, and the divergence formula is similar in form to the Lorenz gauge of electromagnetic fields. The D_0 in the divergence formula is the boundary integration constant, which is a constraint on the exchange of energy between the system and the surroundings.

3.5. Energy Field

Each action has its own energy field. Energy field includes a gradient energy E_G, a curl energy E_C, and a divergence energy E_D.

$$E_G = \frac{\phi_s}{2}(\boldsymbol{G}\cdot\boldsymbol{G}),\quad E_C = \frac{1}{2\alpha_s}(\boldsymbol{C}\cdot\boldsymbol{C}),\quad E_D = \frac{1}{2\alpha_s}D^2;\quad E_s = \rho_s c^2. \tag{21}$$

The scale of energy field is an energy density, so the energy field represent the energy of the fieldon. $\{E_G, E_C, E_D\}$ represent the energies of translation, rotation, and vibration, respectively.

3.6. Force Field

The coupling of the density field with the action field results in the force field. The force field includes a gradient force $\boldsymbol{f}_G$, a curl force $\boldsymbol{f}_C$, and a divergence force $\boldsymbol{f}_D$.

$$\boldsymbol{f}_G = \rho\boldsymbol{G} = -\rho\nabla\Phi\,, \tag{22a}$$

$$\boldsymbol{f}_C = \boldsymbol{j}\times\boldsymbol{C} = \rho\boldsymbol{v}\times\boldsymbol{C}\,, \tag{22b}$$

$$\boldsymbol{f}_D = \boldsymbol{j}D = \rho D\boldsymbol{v}\,. \tag{22c}$$

The scale of force field is $f_s = \rho_s v_s/t_s$, which represents the force on the fieldon. The $\boldsymbol{f}_G$ is of the same form as the gravitational force, $\boldsymbol{f}_C$ is of the same form as the Lorentz force, and $\boldsymbol{f}_D$ represents a force of elastic vibration [10].

3.7. Convolution Equations

There are six formulas for the second-order spatial derivatives of the convolution, which constitute the equations of convolution field.

$$\nabla\cdot\boldsymbol{G} = -\nabla^2\Phi = -\rho/\varphi_s\,, \tag{23a}$$

$$\nabla\times\boldsymbol{G} = -\nabla\times\nabla\Phi \equiv 0\,, \tag{23b}$$

$$\nabla\cdot\boldsymbol{C} = \nabla\cdot(\nabla\times\boldsymbol{A}) \equiv 0\,, \tag{23c}$$

$$\nabla^2 \boldsymbol{A} = -\alpha_s \boldsymbol{j}\,, \tag{23d}$$

$$\nabla D = \nabla(\nabla \cdot \boldsymbol{A}) = -\frac{1}{c^2}\frac{\partial \boldsymbol{G}}{\partial t}\,, \tag{23e}$$

$$\nabla \times \boldsymbol{C} = \nabla \times (\nabla \times \boldsymbol{A}) = \alpha_s \boldsymbol{j} - \frac{1}{c^2}\frac{\partial \boldsymbol{G}}{\partial t}. \tag{23f}$$

Equations (23b) and (23c) are mathematical identities, and the other equations are deduced as follows:
Equation (23a)

$$\nabla^2 \Phi = \frac{-1}{4\pi\phi_s}\int_V \rho(\boldsymbol{r}', t)\nabla^2\left(\frac{1}{r}\right)dV' = \frac{1}{\phi_s}\int_V \rho(\boldsymbol{r}', t)\delta(r - r')dV' = \frac{\rho}{\phi_s}.$$

Equation (23d)

$$\nabla^2 \boldsymbol{A} = \frac{\alpha_s}{4\pi}\int_V \boldsymbol{j}(\boldsymbol{r}', t)\nabla^2\left(\frac{1}{r}\right)dV'$$
$$= -\alpha_s \int_V \boldsymbol{j}(\boldsymbol{r}', t)\delta(r - r')dV' = -\alpha_s \boldsymbol{j}.$$

Equation (23e)

$$\nabla D = \nabla(\nabla \cdot \boldsymbol{A}) = \nabla\left[\frac{1}{c^2}\frac{\partial \Phi}{\partial t} + D_0(t)\right]$$
$$= \frac{1}{c^2}\nabla\left(\frac{\partial \Phi}{\partial t}\right) = -\frac{1}{c^2}\frac{\partial \boldsymbol{G}}{\partial t}.$$

Equation (23f)

$$\nabla \times \boldsymbol{C} = \nabla \times (\nabla \times \boldsymbol{A}) \equiv \nabla(\nabla \cdot \boldsymbol{A}) - \nabla^2 \boldsymbol{A}$$
$$= \nabla D + \alpha_s \boldsymbol{j} = -\frac{1}{c^2}\frac{\partial \boldsymbol{G}}{\partial t} + \alpha_s \boldsymbol{j}.$$

Convolution equations and electromagnetic field equations are alike in their forms. Eq. (23a) is similar to the Gauss theorem of electrostatics, and Eq. (23c) is similar to the Gauss theorem for magnetostatics. Eq. (23d) is comparable to Ampere law, Eq. (23e) is comparable to displacement current, and Eq. (23f) is comparable to Maxwell-Ampere law.

3.8. Action Equations

There are three formulas for the second-order spatial derivative of the action, which constitute the equations of action field.

$$\nabla^2 \boldsymbol{G} = -\nabla\rho/\phi_s \tag{24a}$$

$$\nabla^2 \boldsymbol{C} = -\alpha_s \nabla \times \boldsymbol{j} \tag{24b}$$

$$\nabla^2 D = \alpha_s \frac{\partial \rho}{\partial t} \tag{24c}$$

The action equations are deduced as follows:
Equation (24a)

$$\nabla^2 \boldsymbol{G} \equiv \nabla(\nabla \cdot \boldsymbol{G}) = -\nabla(\rho/\phi_s) = -\nabla\rho/\phi_s\,.$$

Equation (24b)

$$\nabla^2 \boldsymbol{C} \equiv \nabla(\nabla \cdot \boldsymbol{C}) - \nabla \times (\nabla \times \boldsymbol{C}) \equiv -\nabla \times (\nabla \times \boldsymbol{C}) = -\nabla \times (\nabla D + \alpha_s \boldsymbol{j})$$
$$= -\alpha_s \nabla \times \boldsymbol{j}\,.$$

Equation (24c)

$$\nabla^2 D \equiv \nabla \cdot (\nabla D) = -\frac{1}{c^2}\nabla \cdot \left(\frac{\partial \boldsymbol{G}}{\partial t}\right)$$
$$= -\frac{1}{c^2}\frac{\partial}{\partial t}(\nabla \cdot \boldsymbol{G}) = \alpha_s \frac{\partial \rho}{\partial t}.$$

The action equations are Poisson equations. It can be seen that the gradient of the mass density is the sink of the gradient field, the curl of momentum density is the sink of curl field, and the change rate of mass density is the source of divergence field. As long as the density $\{\rho, \boldsymbol{j}\}$ exist, there are certainly solutions to the field equations.

3.9. Motion Equation

The motion force on a fieldon is defined as the motion derivatives of the momentum density, *i.e.*

$$\boldsymbol{f} \coloneqq \frac{D\boldsymbol{j}}{Dt} = \frac{\partial \boldsymbol{j}}{\partial t} + \nabla \cdot (\boldsymbol{j}\boldsymbol{v}), \qquad f_s = \frac{j_s}{t_s} = \frac{\rho_s r_s}{t_s^2}. \tag{25}$$

The motion force can be calculated by using the formula of dyadic divergence

$$\boldsymbol{f} = \frac{\partial \boldsymbol{j}}{\partial t} + \nabla \cdot (\boldsymbol{j}\boldsymbol{v}) = \left(\frac{\partial \rho}{\partial t}\boldsymbol{v} + \rho\frac{\partial \boldsymbol{v}}{\partial t}\right) + (\nabla \cdot \boldsymbol{j})\boldsymbol{v} + (\boldsymbol{j} \cdot \nabla)\boldsymbol{v}$$
$$= \rho\frac{\partial \boldsymbol{v}}{\partial t} + (\boldsymbol{j} \cdot \nabla)\boldsymbol{v} = \rho\left[\frac{\partial \boldsymbol{v}}{\partial t} + (\boldsymbol{v} \cdot \nabla)\boldsymbol{v}\right].$$

The above results can be written in the form of Newton's second law

$$\boldsymbol{f} = \rho\boldsymbol{a}, \;\; \boldsymbol{a} = \frac{\partial \boldsymbol{v}}{\partial t} + (\boldsymbol{v} \cdot \nabla)\boldsymbol{v}\,; \quad a_s = \frac{f_s}{\rho_s} = \frac{r_s}{t_s^2}\,. \tag{26}$$

Above equation is known as the fluid dynamics theorem. In fluid dynamics, $\partial \boldsymbol{v}/\partial t$ is called the local derivative and $(\boldsymbol{v} \cdot \nabla)\boldsymbol{v}$ is called the convective derivative. The convection derivative contains the compressible effect of the fluid.

The force field results in the acceleration of the fieldons. According to $\boldsymbol{f} = \boldsymbol{f}_G + \boldsymbol{f}_C + \boldsymbol{f}_D$, we obtain the equation of fluid dynamics

$$\frac{\partial \boldsymbol{v}}{\partial t} + (\boldsymbol{v} \cdot \nabla)\boldsymbol{v} = \boldsymbol{G} + \boldsymbol{v} \times \boldsymbol{C} + D\boldsymbol{v}\,. \tag{27}$$

The above formula is a partial differential equation for the velocity of fieldons. According to the continuity theorem, $\boldsymbol{f} = 0$ is the condition for the conservation of momentum of the fieldsons.

4. Properties of Flow Fields

4.1. Unified Field

The theory of particle flow field assumes the existence of mass and momentum densities of particles in space, from which a complete set of field formulas and equations are derived. The density field is the original field, and the fields of velocity, convolution, action, energy, and force are all derived fields.

The fluid dynamics equation (27) covers the Navier-Stokes equation and Newton's laws of motion. It is the velocity equation with respect to the fieldon and can also be viewed as the equation of motion for a single real particle, which degenerates into Newton's laws of motion for particles under the zero-volume approximation.

The convolution equations (23) encompass Maxwell's equations for the electromagnetic field. When we view the gravitational and electrostatic forces as gradient forces, we can equate charge with mass, electric field with gradient, magnetic induction with curl, and electromagnetic field with divergence. Due to the coverage of attraction and repulsion in the convolution field, weak and strong forces can be attributed to the combined effects of gradient forces, curl forces, and divergence forces.

The action equations (24) can be compared to Einstein's gravitational field equation. In contrast to relativity, real particle theory restores the independence of time and space. However, the action field ($\boldsymbol{G}$,$\boldsymbol{C}$,D) is the counterpart of the metric field ($g_{\mu\nu}$) and the change rate of the density field is the counterpart of the energy-momentum tensor ($T_{\mu\nu}$). In addition, the particle flow field, which realizes the quantization of space and time in the barycenter frame, can be classified as a non-probabilistic quantum field. It can be said that the particle flow field theory is a unified theory of fields.

4.2. Gradient Field

The scale of the gradient is $G_s = a_s = v_s / t_s$, so the gradient represents the translational acceleration of the fieldon. The gradient is essentially a gravitation field and $g = 1/\phi$ is the gravitational constant. The digit of the mass convolution coefficient is 4π, and the digit of the momentum convolution coefficient is $(4\pi)^{-1}$. According to the convolution equation (23a), the mass density is the source of mass convolution; according to the action equation (24a), the mass density is the sink of the gradient field. The identity (23b) shows that the gradient is a curl-free field.

Real electrons possess both mass and volume, yet they do not possess any charges. Conversely, classical electrons possess mass and carry charges, but lack volume. By considering the electrostatic field as a gradient field and eliminating the negative charges, a comparable connection between the electric quantity and the mass quantity can be established. Assume the presence of a uniform sphere composed of classical electrons, which possesses a mass quantity M and an electric quantity Q. When an electron is located outside the sphere, it experiences both a gravitational force, denoted F_M, and an electrostatic force, denoted F_Q

$$F_M = -\frac{gM_eM}{r^2}, \quad F_Q = -\frac{Q_eQ}{\epsilon r^2}. \tag{28}$$

Here, $g = 6.6742867 \times 10^{-11}\ \mathrm{N \cdot m^2 \cdot kg^{-2}}$ is the gravitation constant. $\epsilon = 4\pi\epsilon_s$, and $\epsilon_s = 8.8541877\times10^{-12}\ \mathrm{C^2 \cdot N^{-1}) \cdot m^{-2}}$ is the vacuum dielectric constant. The ratio of the dielectric constant to the mass convolution coefficient is $\theta = \epsilon/\phi = \epsilon g = 7.4261454 \times 10^{-21}\ \mathrm{C^2 \cdot kg^{-2}}$. Given the established values for the electronic mass $M_e = 9.1093821\times10^{-31}$ kg, and the electronic charge $Q_e = 1.6021765 \times10^{-19}$ C, the electronic mass-to-charge ratio can be calculated as $\sigma = M_e / Q_e = 5.6856296\times10^{-12}\ \mathrm{kg \cdot C^{-1}}$. In the scenario where the electrostatic force is equal to the gravitational force, there exists a proportional relationship between the mass quantity and the electric quantity

$$Q = (\epsilon g\sigma)M = (\theta\sigma)M. \tag{29}$$

where $(\theta\sigma)=4.2222312\times10^{-32}\ \mathrm{C \cdot kg^{-1}}$. In addition, it is deduced that the electric potential is related to the mass convolution by $\Phi_e = \sigma\Phi$, and the electric field is related to the gradient by $\boldsymbol{E}_e = \sigma\boldsymbol{G}$. A fieldon experiences a gradient force $\boldsymbol{f}_G = \rho\boldsymbol{G}$, and the corresponding electrostatic force is $\boldsymbol{f}_e = (\theta\sigma^2)\,\boldsymbol{f}_G$.

4.3. Curl Field

The scale of curl is $C_s = v_s = 1/t_s$, which is related to the rotation frequency of fieldon [10]. The equivalence between charge and mass implies that the current density and the momentum density are related by $\boldsymbol{j}_e = (\theta\sigma)\,\boldsymbol{j}$. Similarly, the relation between magnetic potential and momentum convolution can be expressed as $\boldsymbol{A}_e = \sigma\boldsymbol{A}$, and the relation between magnetic induction intensity and curl is given by $\boldsymbol{B}_e = \sigma\boldsymbol{C}$. A fieldon experiences a curl force $\boldsymbol{f}_C = \boldsymbol{j} \times \boldsymbol{C}$, and the corresponding Lorentz force is $\boldsymbol{f}_m = (\theta\sigma^2)\,\boldsymbol{f}_C$. Based on Equation (23d), the momentum density acts as a sink for the momentum convolution. Similarly, Equation (24b) suggests that the curl of the momentum density acts as a sink for the curl field. The identity equation (23c) demonstrates that the curl field is devoid of any divergence.

4.4. Divergence Field

The scale of divergence is $D_s = v_s = 1/t_s$, which represents the orbital vibration frequency of the fieldon [10]. The divergence force on a fieldon is $\boldsymbol{f}_D = \rho D\boldsymbol{v}$, and the equivalent electric divergence force is $\boldsymbol{f}_d = (\theta\sigma^2)\,\boldsymbol{f}_D$. According to the action equation (24c), the divergence is caused by the change rate of mass density.

The scale bases suitable for the divergence field are: frequency $D_s = \nu$, velocity $v_s = c$ (signal speed), and angular momentum $h_s = h$ (Planck's constant). The derived scales include: time $t_s = 1/\nu$, space $r_s = c/\nu = \lambda$, momentum $p_s = h_s/r_s = h/\lambda$, mass $M_s = h_s/(r_s v_s) = h/(\lambda c)$, and energy $E_s = M_s c^2 = h\nu$.

An argument for the waves is specified as $\eta = \boldsymbol{\kappa} \cdot \boldsymbol{r} - \omega t$, where $\omega = 2\pi\nu$, $\boldsymbol{\kappa} = \nabla\eta$, and $\kappa = |\boldsymbol{\kappa}| = 2\pi/\lambda$. It can be demonstrated that for any positive functions $W(\eta)$ and $W_0(t)$, the convolution $\{\Phi', \boldsymbol{A}'\}$ satisfies the divergence equation

$$\Phi'(\eta, t) = -W(\eta) - W_0(t), \qquad \boldsymbol{A}'(\eta) = \frac{\boldsymbol{\kappa}}{\omega}\, W(\eta). \tag{30}$$

By performing the divergence calculation separately using equation (20c), we yield

$$D = \nabla \cdot \boldsymbol{A}'(\eta) = \left(\frac{\boldsymbol{\kappa}}{\omega}\right) \cdot \left(\frac{dW}{d\eta}\nabla\eta\right) = \frac{\kappa^2}{\omega}\frac{dW}{d\eta}, \tag{31a}$$

$$D = \frac{1}{c^2}\frac{\partial \Phi'}{\partial t} + D_0(t) = \frac{1}{c^2}\left(\omega\frac{dW}{d\eta} - \frac{dW_0}{dt}\right) + D_0(t). \tag{31b}$$

The equations above are equal if the following conditions are met

$$c = \frac{\omega}{\kappa} = \lambda\nu, \qquad D_0(t) = \frac{1}{c^2}\frac{dW_0}{dt}. \tag{32}$$

The presence of the divergence indicates the presence of a traveling wave. The speed of this wave, denoted by c, corresponds to the speed of signal for time synchronization. Therefore, divergent waves serve as the carrier of synchronous signals, with the reciprocal frequency serving as the time scale and the corresponding wavelength serving as the space scale. D_0 represents the divergence flowing from the boundary. In the case where $D_0 = 0$, the radiation energy is conserved and the system experiences no dissipation.

4.5. Object Structure

Postulates I and II define a nested structure of objects: Objects comprise real particles, and real particles are also objects. They have common attributes (mass, volume and shape), but they belong to different structural levels. The hierarchical nested structure of the object can be expressed by a family of particle sets [5,7].

Topson ⊇ Midson ⊇ Bason ⊇ Hidson

Topson, midson, bason and hidson are used to name the particles at the top level, middle level, basic level and hidden level, respectively. An upper-level particle includes lower-level particles, while the lower-level particles are a subset of the upper-level particle. In the context of flow field theory, the fluid system is a topson, the fieldsons are midsons, the fluid particles are basons, and the hidsons are the lower-level particles that constitute the basons. If the particle parameters are denoted by {*number, mass, volume*}, then the topson parameters are $\{1, M, V\}$, and the midson parameters are $\{\tilde{V}, M_\alpha, V_s\}$. The bason parameters are $\{N, M_i, -\}$ without specifying its volume. The elasticity of a bason is determined by the motion of hidsons; however, the parameters of the hidson are not involved in the calculation.

So far, the only real particles that cannot be decomposed by modern technology are electrons and protons. The real electron e and the real proton p are called primitive particles. The set of primitive particles is $A = \{e,p\}$, and its power set is $P(A) = \{\emptyset,\{e\},\{p\},\{e,p\}\}$. The $\emptyset$ represents the interparticle gap, $\{e\}$ the set of electrons, $\{p\}$ the set of protons, and $\{e,p\}$ the set of neutrons. Logically, it can be deduced that various objects are composed of subsets of $P(A)$, and the actual space, including what is called a vacuum, is permeated by an electron fluid $\{\emptyset,\{e\}\}$. The speed of light in a flow field depends on the distribution of the density and temperature of the electrons, and the speed of sound depends on the distribution of the density and temperature of the protons.

4.6. Dark Matter

According to the current theory of cosmology, galaxies are believed to be surrounded by a substance called dark matter, and the entire universe is filled with a form of energy known as dark energy. In the theory of flow field, the term "dark matte" refers to interstellar electron fluid, while the term "dark energy" refers to the energy associated with their motion. Although the nature of this widespread electron fluid is unknown to humans, it constitutes the majority of the mass in the vast universe and exerts a hidden influence on the motion of observable celestial bodies and on the evolution of the cosmos.

We can estimate the density of dark matter. Sunlight that radiates to the Earth is a wave that passes through the electron fluid. Because the fluid background heavily influences the travel of the electron beam, the solar spectrum contains ultraviolet light and is cut off at X-rays. The boundary between ultraviolet rays and X-rays occurs at a wavelength of $\lambda_c = 0.01\mu\text{m}$. The volume of fieldons corresponding to this wavelength is $\lambda_c^3 = 10^{-24}$ m^3. Since a fieldon must contain more than one electron, the low bound on the number density is $n_c = \lambda_c^{-3} = 2 \times 10^{24}$ m^{-3}, and the lower bound on the mass density is $\rho_c = n_c M_e = 1.82 \times 10^{-6}$ kg · m^{-3}. The ρ_c is much smaller than the mass density of air at standard atmospheric pressure (~1.2 kg·m^{-3}). As a result, it is challenging for humans to perceive the existence of the electron fluid.

Let us estimate the mass of dark matter in the solar system. By considering the orbit of Neptune as the outer boundary, the radius of the solar system is denoted as $R_0 = 4.4984 \times 10^9$ km. Within this range, the mass of the electron fluid can be calculated as $M_D = (4/3)\pi R_0^3 \rho_c = 6.94 \times 10^{32}$ kg. Comparatively, the mass of the Sun plus the eight major planets is $M_S = 1.9912 \times 10^{30}$ kg. Consequently, dark matter in the solar system constitutes at least 99.7% of the total mass. Planetary motion has little impact on the barycenter of the solar system after taking into account the mass of dark matter.

The electron fluid does not resist shear stress and thus does not impede the motion of objects. The compression modulus of electronic fluid can be estimated using the fluid wave formula. The formula used to determine the wave speed, known as the Newton-Laplace formula, is given by $c = \sqrt{K/\rho}$. In this equation, ρ is the density of the fluid and K is the compression modulus [15,16]. As a result, the compression modulus of the electron fluid is not less than $K_c = \rho_c c^2$=163 GPa. This value is about two orders of magnitude larger than the compression modulus of water, which is approximately 2.18 GPa.

4.7. Photon Properties

Lights are waves that travel in the electron fluid, and the electron fluid is the medium to transmit light. Although the mass density of the electron fluid is extremely small, people can perceive its existence through light waves. Photons are fieldons of the electron fluid, with mass, volume and elasticity. Photons are spatially localized and the displacement of their center of mass is less than the wavelength. Photons are related to each other through waves at the speed of light and there is no super distance action. In the process of transmitting light waves, photons are stimulated to vibrate and emit wavelets. The wavelets emitted by photons are spherical waves, which is the physical basis of diffraction optics.

The volume of a photon is $V_s = \lambda^3 = (c/v)^3$, containing the number of electrons $N_c = n_c V_s$, the mass $M_c = \rho_c V_s$, and the energy $E_s = hv$. The photon energy per unit volume is

$$Y_s = \frac{E_s}{V_s} = \frac{hv^4}{c^3}. \tag{33}$$

The Y_s is the elastic modulus of the photon and is proportional to the fourth power of the frequency. As a medium for transmitting light waves, the rigidity of the photon rapidly increases with the decrease of wavelength. Taking blue and red lights as examples, Table 1 lists the physical parameters of two photons with wavelengths λ_B = 450nm and λ_R=650nm.

Photon	Blue (450nm)	Red (650nm)
Electron number	1.82250×10^5	5.49250×10^5
Mass (kg)	1.65848×10^{-25}	4.99818×10^{-25}
Energy (J)	4.41432×10^{-19}	3.05607×10^{-19}
Elastic modulus (Pa)	4.84425	1.11282

Table 1: Performances of Typical Blue and Red Photons

It follows that low-frequency photons are large and soft, and high-frequency photons are smaller and harder. The properties of the electron fluid are very similar to those of the gravitation aether or luminiferous aether: enormous density, but little mass; incompressible, but no resistance; ubiquitous, but hard to detect.

4.8. Black-Body Radiation

The energy levels of a photon are

$$E_n = nE_s = nhv, \quad n = 1,2,3,\cdots \tag{34}$$

where $n = 1$ is the ground state of the photon. A system with a volume V has the photonic number $\tilde{V} = V/\lambda^3 = V(v/c)^3$, thus the energy density of photons in the ground state can be expressed as

$$U_1 = \frac{E_1\tilde{V}}{V} = \frac{hv^4}{c_3} = Y_s. \tag{35}$$

Therefore, the elastic modulus of photons is equivalent to the energy density of photons in their ground state. The function that describes the distribution of frequencies for U_1 is given by

$$\rho(\nu) = \frac{dU_1}{d\nu} = \frac{4h\nu^3}{c^3}. \tag{36}$$

The temperature of a thermal equilibrium system can be expressed as $T = (\beta k_B)^{-1}$, where k_B is the Boltzmann constant. The Boltzmann distribution states that the likelihood that a photon is at the level E_n is proportional to $P_n(\beta,\nu) \propto e^{-\beta En}$). Therefore, the overall probability, which encompasses all energy levels, is given by

$$P(\beta,\nu) = a\sum_{n=1}^{\infty} e^{-\beta E_n} = a\sum_{n=1}^{\infty} e^{-n\beta h\nu} = \frac{a}{e^{\beta h\nu} - 1}. \tag{37}$$

Here, a represents a coefficient used for normalization. At this juncture, the spectral density that covers all energy levels is

$$\rho(\beta,\nu) = P(\beta,\nu)\cdot\rho(\nu) = \frac{4ah}{c^3}\frac{\nu^3 d\nu}{e^{\beta h\nu} - 1}. \tag{38}$$

The above equation is known as the Planck radiation law. The coefficient $a = 2\pi$ is determined by comparing it with the standard formula of the black-body radiation.

The findings of cosmological observation provide evidence that the Cosmic Microwave Background (CMB) is consistent with black-body radiation at a temperature of $T_0 = 2.72548$ K [17]. Interpreting the CMB as the thermal equilibrium radiation of the electron fluid suggests that the density of the electron fluid is evenly distributed throughout the universe and that there is no overall motion. The uniform density of the electron fluid is the underlying cause for the constant speed of light in the interstellar space.

4.9. Quantum Nature

In the flow field theory, a fieldon serves as the physical manifestation of quantum, and is the counterpart of fluid micelle in hydrodynamics. The fieldon contains many fluid particles and is not the smallest particle unit. In the electron fluid, for example, photons serve as fieldons, with a single photon of visible light containing approximately 10^5 electrons. In the statistical theory of real-particles, the quantum is represented by a cluster. A cluster is an object comprising a few number of particles. The translation mode of clusters displays particle-like behavior, the vibration mode exhibits wave-like behavior, and the rotation mode forms the basis for quantum spin.

The scales of space and time are uncertain in the barycenter frame of reference. This fact suggests that quantum unpredictability is not confined to the microscopic realm. Therefore, it is necessary to reconsider the interpretation of quantum mechanics.

Consider a cluster consisting of two stars with masses M_1 and M_2 ($M_1 > M_2$), identified as O_1 and O_2, respectively. Both stars revolve around their shared center of mass O_c with the same period (τ). In the barycenter frame of reference, the two stars have well-defined elliptical orbits expressed by polar coordinates (r, θ) as [18,19].

$$r_i(\theta) = a_i - d_i\cdot\cos(\theta + i\pi),\ \ (i = 1,2). \tag{39}$$

Where $\theta = \omega t$ is the polar angle and $\omega = 2\pi/\tau$ is the angular frequency. The symbol a_i represents both the semi-major axis and the rotation radius, while the symbol d_i represents both the semi-focal length and the vibration amplitude. Taking O_1 as a reference point, the ellipse equation can be expressed as

$$r(t) = a - d\cdot\cos(\omega t),\ \ (r = r_1 + r_2,\ \ a = a_1 + a_2,\ \ d = d_1 + d_2). \tag{40}$$

The presence of other celestial bodies may distort the orbital shape and cause oscillations at higher frequencies. By defining a vibration factor m, we can describe the modified orbit as

$$r(t) = a - d\cdot\cos(m\omega t),\quad (m = \pm1, \pm2, \pm3, \cdots). \tag{41}$$

In this case, $m\omega$ denotes the angular frequency of vibration. The vibration factor must be integers to satisfy the periodicity condition $r(\theta + 2\pi m) = r(\theta)$. The modified orbital equation includes the elliptical orbit for $m = \pm 1$, but exclude the circular orbit for $m = 0$. The elliptical orbit is named the ground state, whereas modified orbits with $m > 1$ are named excited states. Within a single period, the time uncertainty is $t_s = \tau$, and the space uncertainty is $r_s = d$. The modified orbit equation can be reduced to a scale-free form

$$\tilde{r} + \cos(m\tilde{\omega}\tilde{t}) = \tilde{a}, \quad (\tilde{a} = 2,3,4,\cdots; \ m = \pm 1, \pm 2, \pm 3, \cdots). \tag{42}$$

It is clear that the rotation and vibration of the orbit are both quantized.

If it is not possible to determine the position of the barycenter, then the orbital parameters cannot be determined either. In this case, we shift our focus from determining the orbit to making probabilistic descriptions of various orbits. For this purpose, we give the rotation energy L and the vibration energy H of the binary star cluster as following

$$L = L_1 + L_2 = \frac{1}{2}\mu(\omega a)^2 = \frac{p^2}{2\mu}, \quad p = \mu\omega a; \tag{43a}$$

$$H = H_1 + H_2 = \frac{1}{2}\mu(m\omega d)^2 = \frac{1}{2}sd^2, \quad s = \mu(m\omega)^2. \tag{43b}$$

In the above equations, $\mu = (M_1 M_2)/(M_1 + M_2)$ is the reduced mass of the cluster, p represents the rotation momentum, and s represents the stiffness of the cluster. In this case, the cluster has a potential energy $U = H - L$, and the vibration energy $H = L + U$ is a quantity equivalent to the Hamiltonian.

To establish the relationship between the orbital parameters $\{a,d,m,\omega\}$ and the motion states $\{p,H\}$, we map the left end of the orbital equation (42) to a complex plane and express it through a complex function ψ.

$$\psi(\tilde{r},\tilde{t}) = A_{\tilde{p}}(\tilde{r})e^{2\pi j(\tilde{p}\tilde{r} - \tilde{H}\tilde{t})}, \quad \psi(r,t) = A_p(r)e^{2\pi j(pr - Ht)}. \tag{44}$$

The ψ is called the orbital state function. The mapping relation from Eq. (42) to Eq. (44) is

$$f: \{\tilde{r} \to \tilde{r}, \ \tilde{t} \to \tilde{t}, \ (\tilde{\omega}\tilde{a}) \to \tilde{p}, \ (m\tilde{\omega}) \to \tilde{H}, \ \tilde{a} \to A_{\tilde{p}}\}. \tag{45}$$

The quantum mechanics textbook explains that the orbital state function obeys the Schroedinger equation given by

$$j\hbar_s \frac{\partial \psi}{\partial t} = -\frac{\hbar_s^2}{2\mu}\nabla^2\psi + U(r)\psi, \ \ \hbar_s = \frac{h_s}{2\pi}. \tag{46}$$

The h_s corresponds to the scale of the angular momentum of the system. Taking the potential function $U(r) = -gM_1 M_2 / r$, the eigen equation of the cluster is

$$-\frac{\hbar_s^2}{2\mu}\nabla^2\psi - \frac{e_0^2}{r}\psi = H\psi, \quad e_0^2 = gM_1M_2. \tag{47}$$

The energy eigenvalues for planar orbits are given by [20].

$$H_{nm} = \frac{\mu e_0^4}{2\hbar_s^2(n + |m| + 1/2)^2}, \quad (n = 0,1,2,\cdots; \ m = 0, \pm 1, \pm 2, \cdots). \tag{48}$$

In this formula, m denotes the magnetic quantum number, and n denotes the radial quantum number. By comparison, we find that the magnetic quantum number is associated with the vibration factor, whereas the radial quantum number is associated with the rotation radius $\tilde{a}$. This result confirms that the quantum state function is a stochastic description of the deterministic orbits.

5. Conclusions

The real-particle theory is founded on a set of axioms, and the particle flow field theory, centered on barycenter reference frame, introduces a fresh paradigm. The particles in the new paradigm are elastic objects, and the uncertainty linked to the barycenter of these flexible entities leads to quantum randomness. However, this randomness can be eliminated by the measurement principle, showing that the laws of physics are deterministic and universal.

The high similarity between electromagnetic field equations and convolution equations shows that electromagnetic phenomena originate from the particle density field, and electromagnetic field is essentially the particle action field. The effect of the action field on the fieldon is expressed by the force field (gradient force, curl force, and divergence force), which should include four fundamental interactions (gravitational, electromagnetic force, strong force, and weak force). It is undoubtedly a important and urgent task to establish a dynamics theory by applying the principle of particle flow fields

The flow field theory implies that the universe contains an electron fluid that serves as the medium for the transmission of gravitation and light waves. Photons, which serve as elements of flow fields, have a finite mass, a definite volume, and a specific shape. The thermal radiation of this electron fluid is responsible for the Cosmic Microwave Background (CMB). The uniform density of the cosmic electron fluid, indicated by the black-body nature of the CMB, explains the constant speed of light. The electron fluid has huge density and compressive modulus, enabling it to transmit gravitation. In contrast, its mass density and shear modulus are extremely small, making it challenging to detect. However, the existence of the electron fluid can be truly felt through light waves and by its influence on the motion of celestial bodies. The existence of Cosmic Electron Fluid changes the form of existing physical laws and will overturn people's traditional knowledge of the physical world.

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