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Outline of Real Physics

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— God does not play dice. God made dice, and man plays dice.

I. General Introduction

Real physics is a new theoretical system [1-9] different from classical physics and modern physics. The meaning of real physics includes actual physics, realistic physics, and real number physics. This paper briefly reviews the core concepts, basic principles, main contents, and major achievements of real physics.

a) Core concepts

Matter, particle, space, time, and interaction are the core concepts of physics. The difference in core concepts is the basis for the classification of different theoretical systems. Table 1 summarizes the core concepts of the three physics systems, of which the conceptions of real physics are put forward as physical axioms.

Table 1: The core concepts of three physics systems

Core concept	Classical physics	Modern physics	Real physics
Matter	Discrete particle	Continuous field	Discrete particle
Particle	Point-like geometry, mass conservation, zero volume	Wave-like exciting field, mass non-conservation, infinite volume	Body-like elastic object, mass conservation, finite volume
Space	Uniform, empty, 3-dimensional space	Non-uniform, energy suffused, 4-dimensional spacetime	Uniform, particle filled, 3-dimensional space
Time	Uniform, unidirectional	Non-uniform, non-unidirectional	Uniform, unidirectional
Interaction	Gravitational force, electromagnetic force	Gravitational force, electromagnetic force, weak force, strong force	Mass attraction, motion repulsion

b) Physical axioms

(1) Matter. Discrete particle is the only form of matter. Real physics proves that the field is composed of elastic particles, thus denying the modern idea that matter is a continuous field.

(2) Particle. The cornerstone of real physics is the model of elastic particles. Elastic particles are objects with both mass and volume, which can spin and deform. The mass of elastic particles is conserved, but the volume and shape are variable. Elastic particles have three independent motion modes of translation, rotation, and vibration. The particle model of classical physics is a point-like geometry (point-mass and point-charge), the particle model of modern physics is a wave-like field (wave-particle duality), and the particle model of real physics is a body-like (three-dimensional) elastic object. The elastic particle model has made fundamental amendments to classical physics and modern physics.

(3) Space. Real-space is three-dimensional, uniform, and full of particles. The three-dimensionality gives up the assumption of four-dimensional spacetime in modern physics and indicates that space is independent of time.

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The uniformity shows that the real-space is isotropic and translation invariant. The real-space axiom holds that the physical space is full of particles, and the vacuum of classical physics does not exist.

(4) Time. Real-time is uniform and unidirectional. Uniformity indicates that time is incompressible, and unidirectionality means that time is irreversible. The four-dimensional spacetime of relativity theory permits the compression of time. The mathematical spacetime of quantum theory allows the reversal of time. The principle of real physics requires that the physical process is irreversible, and the causality is unbreakable.

(5) Interaction. The interaction of elastic particles includes mass attraction and motion repulsion, which can unify the four fundamental interactions of gravitational force, electromagnetic force, weak force, and strong force.

c) Main contents

The contents of real physics include the particle field theory, the motion state theory, and the thermodynamics theory. Real physics essentially is a statistical theory of elastic particles. The basis of the particle field theory is the statistics of mass and momentum, the basis of the motion state theory is the statistics of motion energy, and the basis of the thermodynamics is the statistics of particle number. Table 2 lists the statistical methods and the main mathematical tools used in the three theories.

Table 2: Main contents, statistical methods, mathematical tools, and references

Content	Statistical method	Mathematical tool	Reference
Particle field theory	Mass and momentum statistics	Statistics, vector calculus, differential equations	1, 2, 6, 9
Motion state theory	Motion energy statistics	Statistics, algebra, analytic geometry	3, 5-9
Thermodynamic theory	Particle number (ensemble) statistics	Statistics, calculus, differential equations	4, 6-9

d) Theoretical features

Real physics inherits the tradition of simplicity and intuition of classical physics and integrates the principles of the relativity and quantum theories of modern physics. The theoretical hardcore is the elastic particle model, and the initial method is the particle statistics. Real physics is presented in the form of an axiomatic system with mathematical rigor and logical consistency. The simplicity of principles and the universality of conclusions are the remarkable characteristics of real physics.

e) Major achievements

(1) On the basis of the physical axioms, real physics strictly deduces the classical laws of motion, gravitation, electromagnetism, and thermodynamics. It modified the laws of physics, rebuilt the foundation of physics, and unified the theories of physics.

(2) It solved many fundamental problems in physics. For example, the essence of quantum, the nature of dark matter, and the unity of interactions.

(3) It solves many physical application problems. Such as the equation of motion, the equation of state, the phase transition, and the radiation mechanism.

f) Important conclusions

(1) There are only two types of primary particles in nature: protons and electrons. They are elastic particles. Other elementary particles in modern physics are the composite particles of protons and electrons.

(2) There are two kinds of interactions between elastic particles: mass attraction and motion repulsion. They can unify the four fundamental interactions in modern physics. The charge is a defective concept and is no longer necessary in real physics.

(3) Mass and energy are two different physical quantities. Mass is the intrinsic attribute of an object, and energy is the motion attribute of the object. The mass of an elastic particle is conserved, and the mass and energy are not interchangeable.

(4) The vacuum does not exist, but "dark matter" does exist. Dark matter is the ubiquitous electrons. Gaseous electrons are the background of the cosmos, and gathered protons are isolated islands in the universe.

(5) Gravitational waves and electromagnetic waves are the same things in nature. They are the vibration of the electron gas. They have the same propagation speed.

(6) Elastic particles transfer interactions. Electron gas is the medium that transmits gravitational and electromagnetic forces. The speed of action is finite, and there is no spooky action at a distance.

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(7) The physical space is isotropic and flat. The anisotropic curved space of general relativity is an unreal mathematical imagination. The isotropic space does not need the metric of tensor form.
(8) The essence of quantum is the scale of a physical quantity. The scale is the metric and identifier of the physical quantity. Physical space is isotropic, and the metric of the physical quantity must be a scalar.
(9) There is no black hole in the cosmos. The black hole is a false thing produced by the theory of curved space. The interaction of motion repulsion excludes the possibility of star collapse. The motion of galaxies does not need the gravitational support of black holes.
(10) The motion laws of matter are the statistical conclusions of the random motion of elastic particles. The statistical nature of motion laws explains the irreversibility of natural processes.
(11) The motion laws of matter are unified. No matter classical or quantum world, low-speed or high-speed movement, low-energy or high-energy particles, all follow the same mathematical formulation.

g) On relativity theory

Einstein's motivation in establishing the relativity theory was to solve the problem of relative motion. Classical mechanics uses trajectory to describe the movement (position, velocity, acceleration) of particles. The calculation of trajectory needs the help of the coordinate frame. Describing relative motion leads to the concepts of inertial, non-inertial, and absolute reference frames. Real physics abandons the trajectory method due to the complexity of the motion of elastic particles. Real physics adopts the center-of-mass reference frame of elastic particles. In the center-of-mass frame, elastic particles have three independent motion modes of translation, rotation, and vibration. Also, real physics uses the quantities of spacing and displacement to exclude the influence of the fixed reference frame.

To extend the classical laws of physics (laws of motion, electromagnetism, and gravitation) to any reference frame (inertial frame and non-inertial frame), Einstein established his special relativity and general relativity. Relativity principle requires that the motion equations are invariant under the coordinate transformation (or covariant under the metric transformation), namely, the physical laws are independent of the reference frames. Therefore, the soul of relativity is the unity of physics. Although the relativity theory broke the confinement of the reference frame, the price was to enter a complicated four-dimensional mathematical spacetime. Real physics uses the center-of-mass reference frame in three-dimensional space to eliminate the influence of relative motion. Furthermore, it introduces a new mathematical dimension (scale dimension) to establish the unity principle of real physics (objectivity principle).

h) On quantum theory

The essence of quantum involves the digitization of physical quantity. Physical quantity must be digitized (quantized) to calculate and measure. Classical physics uses coordinates to digitized the particle motion, and quantum theory uses the energy quantum $(h\nu)$ to digitized the continuous field. Elastic particles are discrete. Based on the number of particles (N), the statistical average of physical quantity provides an objective standard for measurement. This standard is called scale. The scale is the metric and identifier of a physical quantity, and its essence is quantum. For example, the energy scales of the three motion modes are translation quantum $(K_s = K/N = kT)$, rotation quantum $(L_s = L/N = lz)$, and vibration quantum $(H_s = H/N = h\nu)$.

The basic principle to unify the quantum field is the invariance of the Lagrangian gauge transformation. Up to now, the unified field theory, including gravitational and electromagnetic interactions, has not been successful. The main reason is that the particle model and the charge concept are incorrect. The unity principle of real physics is the principle of objectivity. The objectivity principle requires the invariance of scale transformation of the mathematical formulas; that is, the physical equations apply to any scale range of the physical quantity.

i) Objectivity principle

The objectivity principle that combines the basic ideas of relativity and quantum theories is the fundamental principle of real physics. The thought of the objectivity principle is that the law of motion of matter is objective and does not depend on the observer's subjectivity. The physical equations must exclude all human subjective factors.

The physical process is objective, but a physical observation (measurement) is subjective. Physical observation involves the establishment of measuring standards and the selection of reference frames, both of which are subjective factors. The principle of objectivity requires that the physical equations are scale irrelevant and origin irrelevant.

Real physics realizes the objectivity principle by expressing the physical quantitiy in the form of real-quantity. The real-quantity $(\boldsymbol{x})$ is the product of the scale factor (x_s) and the digit factor $(\tilde{\boldsymbol{x}})$; that is, $\boldsymbol{x} = x_s \cdot \tilde{\boldsymbol{x}}$. The scale irrelevance means that the physical quantities and equations are scale transformation invariant. Real physics demonstrates that the form of real-quantity is the most convenient scheme of digitization (quantization), and the objectivity principle is the most practical principle of unification.

II. Models of Theory

The first task of real physics is to establish the theoretical models for physical axioms and basic principles [1-6,9]. To transform the physical thought into a mathematical form is the necessary step to the success of a new theory.

a) Space

The real-space is uniform, three-dimensional, and full of particles. In real-space, the physical quantities are defined in the domain of the real number, the imaginary number and infinity (∞) have no physical meaning. The uniformity of real-space includes the isotropy and translational invariance. The isotropy of real-space requires that the metric (measurement unit) of physical quantity must be a scalar, namely, the physical quantity $\boldsymbol{x}$ can be expressed in the form of real-quantity as follows

$$\boldsymbol{x} = x_s \cdot \tilde{\boldsymbol{x}}; \quad 0 < x_s < \infty. \tag{1}$$

The factor x_s is a scalar and is called scale. The scale is the metric and identifier of a physical quantity and essentially is the quantum. The factor $\tilde{\boldsymbol{x}}$ is the amount of the physical quantity and is called a digit. The digit $\tilde{\boldsymbol{x}}$ is a vector or a scalar, depending on the physical quantity.

A position vector $(\boldsymbol{r})$ expresses the position of real-space

$$\boldsymbol{r} = r_s \cdot \tilde{\boldsymbol{r}} = \overrightarrow{OP} = (x, y, z). \tag{2}$$

Where the position scale r_s is also called space scale (space quantum). $\boldsymbol{r}$ and $\tilde{\boldsymbol{r}}$ are three-dimensional vectors, indicating that space is three-dimensional. The origin of the position vector (O), is a spatial reference point. The three-dimensionality of real-space also means that space is independent of time. Space and time are two different physical quantities.

The volume scale (volume quantum) of real-space is $V_s = r_s^3$. The volume quantum is a cube of side length r_s, which is also called space cell. The real-space filled with particles means that every space cells contain particles. Therefore, the particle density in real-space is not zero, $n(\boldsymbol{r}) \neq 0$. Real physics holds that there is only proton and electron in nature. Apart from protons, the particles that fill the cosmos can only be electrons. The ubiquitous electrons are so-called dark matter.

b) Time

Real physics defines the real-time as

$$t = t_s \cdot \tilde{t}\,; \quad \tilde{t} = 0,1,2,\cdots,k,k+1,\cdots \tag{3}$$

The time scale t_s is called time quantum. The digit of time, $\tilde{t}$, is a sequence of natural numbers, indicating that time is uniform and unidirectional. The definition includes the incompressibility of time and the irreversibility of physical processes. It is a direct expression of causality.

In formula (3), $\tilde{t} = 0$ is starting time, $\tilde{t} = k$ is any time, and $\tilde{t} = k + 1$ is next time. The starting time is determined by a synchronizing protocol [1,2,6]. It stipulates to send a signal t_0 from the origin O with a communication speed c. The observer at spatial point $P(\boldsymbol{r})$ set the time to $t = t_0 + r/c$ when he receives the signal. After synchronization, we mark the spatial point by $P(\boldsymbol{r}, t)$, where $\boldsymbol{r}$ and t are mutually independent parameters. The signal speed c used for synchronization has special significance in real physics. Signal speed is a system constant, not a universal constant. Both light speed and sound speed can be employed as signal speed.

c) Particle

Real particles are three-dimensional (body-like) elastic objects. Elastic particles have both mass and volume and can spin and deform. Electrons, protons, and atoms are elastic particles. Electrons and protons are the only two primary particles. The mass density of an elastic particle is finite, as it has both mass and volume. The mass of an elastic particle is conserved, but its volume, density, and shape can be changed.

The spatial states of an elastic particle include position, profile, and posture. We describe the position by the position vector of the center of mass $\boldsymbol{r}_c = (x_c, y_c, z_c)$, the profile by the eigenvalues of the inertia matrix $\boldsymbol{I}_c = (I_1, I_2, I_3)$, and the posture by the directions of the eigenvector $\boldsymbol{\theta}_c = (\theta_1, \theta_2, \theta_3)$. The elastic particle has three independent motion modes of translation, rotation, and vibration, which correspond to the time variations of position, posture, and profile. Translation leads to temperature, rotation leads to magnetism, and vibration leads to radiation. The elastic vibration of particles is the cause of wave-particle duality. The motion of elastic particles covers the translation mode of point-like particles in classical physics and the vibration mode of wave-like particles in modern physics.

d) Matter

Matter in nature is made up of discrete elastic particles. Strict mathematical analysis shows that continuous field is not an independent form of matter, but a statistically related object composed of a large number of discrete particles [1,2,6,9].

Let the velocity scale be the speed of synchronizing signal ($u_s = c$), then the space quantum is $r_s = ct_s$. By calculating the mass and momentum in space cell ($V_s = r_s^3$), we can construct the mass potential (scalar potential) and momentum potential (vector potential) of the particle field. The mass and momentum potentials have definite physical meanings. They are the spatial correlation functions of mass density and momentum density. Starting from the mass and momentum potentials, we derived a set of differential equations by using vector calculus. The spatial first derivative of the potential field is the action field. The spatial second derivative of the potential field includes the gravitational potential equation, and the formulas similar to electromagnetic field equations. The scale transformation shows that both gravitational field and electromagnetic field originate from mass potential and momentum potential. Gravitational field, electromagnetic field, and fluid field are all unified in elastic particle field.

e) Interaction

The interaction between elastic particles includes mass attraction and motion repulsion. Mass attraction represents the aggregation tendency of particles, and motion repulsion indicates that there are gaps between particles. The mathematical condition of motion repulsion is that the spacing of different particles is larger than zero, namely, $r_{ij} = \sqrt{\boldsymbol{r}_{ij} \cdot \boldsymbol{r}_{ij}} > 0$. The direct inference of motion repulsion is that the mass density of any object is finite, namely, $\rho = M/V < \infty$.

In the theory of particle field, the mass potential represents mass attraction, and the momentum potential represents motion repulsion. The calculation shows that the forms of interaction include gradient force, curl force, and divergence force, which correspond to the translation force, rotation force, and vibration force, respectively. Gravitational and electrostatic forces belong to gradient force, magnetic force belongs to curl force, and alternating electromagnetic force belongs to divergence force. Weak force and strong force are the combined effects of gradient force, curl force, and divergence force.

f) Objectivity principle

The principle of objectivity states that the laws of motion are objective and do not depend on the subjective consciousness of the observer. The physical process is objective, but a physical observation (measurement) is subjective. The physical observation needs to choose the measurement unit and the reference system, both of which contain human factors. The principle of objectivity requires that physical formulas have scale irrelevance and origin irrelevance.

In the form of real-quantity (formula 1), the physical quantity is objective and absolute, the scale is a subjective factor and the digit is a relative factor. The mathematical expression of scale irrelevance is the equivalence between the physical relation and the digital relation, namely

$$z = R(x, y) = z_s \cdot \tilde{z}; \quad \tilde{z} = R(\tilde{x}, \tilde{y}). \tag{4}$$

Formula (4) determines the operation rules of physical quantity [1,2,6].

The origin irrelevance requires that the physical formulas have nothing to do with the selection of reference points of time and space. Therefore, we define the physical quantity at any time ($\tilde{t} = k$). The position vector of particles $\left(\boldsymbol{r}_i = \overrightarrow{OP_i}\right)$ can only appear in the form of spacing $\boldsymbol{r}_{ij} = \overrightarrow{OP_j} - \overrightarrow{OP_i} = \overrightarrow{P_iP_j}$ and displacement $\Delta\boldsymbol{r}_i(k) = \overrightarrow{OP_i(k+1)} - \overrightarrow{OP_i(k)} = \overrightarrow{P_i(k)P_i(k+1)}$ to eliminate the influence of spatial reference point.

The scale irrelevance indicates that the physical laws apply to any scale range of the physical quantity. No matter of the classical or quantum world, high-speed or low-speed motion, low-energy or high-energy particles, all follow the same and indistinguishable equations of motion (no approximation). The origin irrelevance indicates that the physical laws apply to any time and any place, independent of the choice of the reference frame. The objectivity principle is the universal and unifying principle of physics.

g) Operation rules

The scale irrelevance specifies the following operation rules of the physical quantity, in which the difference quotient does not involve taking the limit, thus eliminating the logic contradiction implied in the operation of the differential quotient. [1,6]

(1) Addition and subtraction.

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

(2) Multiplication.

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

(3) Division.

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

(4) Difference.

$$\Delta x_k = x_{k+1} - x_k = x_s \cdot (\tilde{x}_{k+1} - \tilde{x}_k) = x_s \cdot \Delta \tilde{x}_k; \quad \Delta \tilde{x}_k = \tilde{x}_{k+1} - \tilde{x}_k.$$

(5) Integral.

$$z(n) = \sum_{k=1}^{n} [y(x_k) \cdot \Delta x_k]_{\Delta x_k = x_s} = (y_s \cdot x_s) \cdot \sum_{k=1}^{n} \tilde{y}(x_k) = z_s \cdot \tilde{z};$$

$$z_s = y_s \cdot x_s, \qquad \tilde{z}(n) = \sum_{k=1}^{n} \tilde{y}(x_k).$$

(6) Difference quotient.

$$\frac{dy}{dx} = \left(\frac{\Delta y}{\Delta x}\right)_{\Delta \tilde{x}=1} = \frac{y_s}{x_s} \cdot \left(\frac{\Delta \tilde{y}}{\Delta \tilde{x}}\right)_{\Delta \tilde{x}=1} = \frac{y_s}{x_s} \cdot \Delta \tilde{y}.$$

(7) Differential quotient.

$$\frac{\tilde{d}y}{\tilde{d}x} = \left(\frac{\Delta y}{\Delta x}\right)_{\Delta \tilde{x}\to 0} = \frac{y_s}{x_s} \cdot \left(\frac{\Delta \tilde{y}}{\Delta \tilde{x}}\right)_{\Delta \tilde{x}\to 0} = \frac{y_s}{x_s} \cdot \frac{d\tilde{y}}{d\tilde{x}}.$$

(8) Others. The operations of exponent, logarithm, and trigonometric functions demand $x_s = 1$. In other words, these functions only operate on digits.

$$\mathrm{e}^x = \mathrm{e}^{x_s \cdot \tilde{x}} = (\mathrm{e}^{x_s})^{\tilde{x}} = \mathrm{e}^{\tilde{x}}.$$

$$\ln x = \ln(x_s \cdot \tilde{x}) = \ln x_s + \ln \tilde{x} = \ln \tilde{x}.$$

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

h) Quantum relations

The scale is the identifier and metric of physical quantities, and scale is the quantum. Scales are the identification for distinguishing physical quantities, and the same scale represents the same kind of physical quantities. Scales are the measurement standards, *i.e.*, metric or units. We emphasize that scale is the metric of the physical quantity, not the metric of space. The scale is a scalar because the real-space is flat and isotropic, not curved and anisotropic.

The real-space is three-dimensional, and there are only three independent scales in the physical system. The scale system of relativity theory consists of $E_s, t_s, u_s = c$ (E_s energy scale, t_s time scale, u_s velocity scale, c communicating speed), which includes the following scale relations

$$r_s = ct_s, \quad \omega_s = 1/t_s, \quad M_s = E_s/c^2,$$

$$I_s = E_s t_s^2, \quad p_s = E_s/c, \quad s_s = E_s t_s. \tag{5}$$

Among them, r_s is the space scale, ω_s the frequency scale, M_s the mass scale, I_s the rotary inertia scale, p_s the momentum scale, and s_s the angular momentum scale. In this scale system, the velocity scale (speed quamtum) is a constant, and the others are variables. $r_s \omega_s = c$ is the uncertainty relation between the space scale and the frequency scale. $E_s = M_s c^2$ is the famous Einstein energy.

The scale system of quantum theory consists of $u_s = c$, $s_s = h$, $\omega_s = \nu$ (h Planck constant), which includes the following relations

$$t_s = 1/\nu, \quad r_s = c/\nu, \quad E_s = h\nu,$$

$$M_s = h\nu/c^2, \quad I_s = h/\nu, \quad p_s = h\nu/c. \tag{6}$$

The scale system of quantum theory has two constants (c, h), and the only variable scale is frequency (ν). The quantum uncertainty relations include $r_s p_s = E_s t_s = h$. The space scale $r_s = c/\nu$ is the wavelength, and $r_s = h/(M_s c)$ is the Compton wavelength. $E_s = h\nu$ is the famous Planck energy.

Elastic particles have three independent motion modes. The scales of translation, rotation, and vibration energies $\{K, L, H\}$ are respectively

$$K_s = K/N = kT,\ L_s = L/N = lz,\ H_s = H/N = hv. \tag{7}$$

Where N is the number of particles. T is the thermodynamic temperature, z is the magnetic induction strength, v is the vibration frequency. k, l, h are Boltzmann constant, Bohr magneton constant, and Planck constant, respectively. In fact, Einstein energy is the translation quantum, which is suitable for the translation of high-speed particles. Planck energy is the vibration quantum, which is suitable for the vibration of microscopic particles.

III. Theory of Particle Field

The premise of particle field theory is the axiom of real-space. The real-space assumes that space is full of particles, and the cosmos is full of electrons. The ubiquitous electrons are so-called dark matter. Statistics on the mass and momentum of particles constitute the mass potential and momentum potential. The potentials contain all the interactions of particles. The classical laws of motion, gravitation, and electromagnetism are all inferences of the particle field theory [1,2,6,9].

a) *Essence of field*

Modern physics believes that the field is the basic form of matter. The field is the energy dispersed in continuous space, and particles are the excited states of field. Strict mathematical analysis shows that the field is not the basic form of matter, but the statistical effect of a large number of discrete particles. The field of real physics describes the motion of elastic particles in a continuous form, called elastic particle field. Based on the statistics of particle mass and momentum, the particle field theory derives a complete set of field equations under the constraint of mass conservation, thus revealing the particle nature of the field and disclosing the motion laws of field.

b) *Space quantization*

Real-space is continuous. It is necessary to quantize (discretize) space with volume quantum to describe the field. The particle field theory uses the wave speed c as the velocity scale $(u_s = c)$. Therefore, the space quantum is $r_s = ct_s$, and the volume quantum is $V_s = r_s^3$. The volume quantum is also called space cells.

Consider any object that has a finite volume V, a free boundary S, and contains the number of particles N. The volume is divided by the V_s into $\tilde{V}$ cells. Thus $V = V_s \cdot \tilde{V}$. The space cells are marked by $\mathrm{C}(\boldsymbol{r}_q, \tilde{t})$, where $\boldsymbol{r}_q$ is the position vector of the q-cell. Figure 1 is a sketch map showing the space quantization, which is a two-dimensional field containing nine cells and 30 particles. Gaps are reserved between particles to reflect the repulsion of motion.

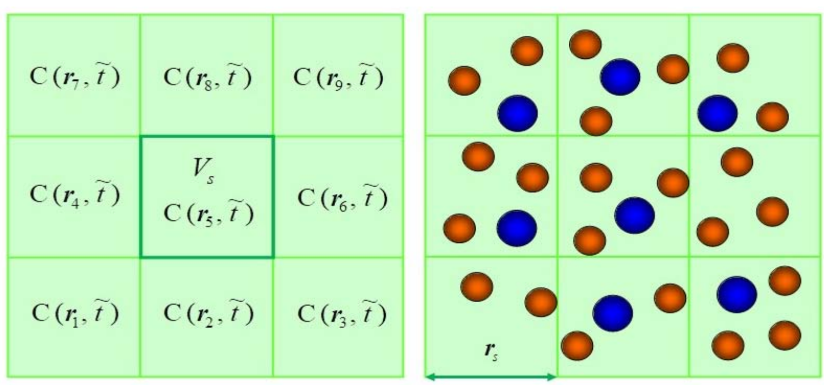

Figure 1: Sketch map showing the space quantization

c) *Equations of field*

(1) Density field. By calculating the mass and momentum of the particles in cells, we obtain the sum of particle mass, $M_q(\boldsymbol{r}_q, \tilde{t})$, and the sum of particle momentum, $\boldsymbol{p}_q(\boldsymbol{r}_q, \tilde{t})$. The mass density and momentum density are $\rho_q(\boldsymbol{r}_q, \tilde{t}) = M_q/V_s$ and $\boldsymbol{j}_q(\boldsymbol{r}_q, \tilde{t}) = \boldsymbol{p}_q/V_s$, respectively. $\rho_q(\boldsymbol{r}_q, \tilde{t})$ and $\boldsymbol{j}_q(\boldsymbol{r}_q, \tilde{t})$ are called density field.

(2) Potential field. We construct the mass potential Φ_q and momentum potential $\boldsymbol{A}_q$ by using the mass and momentum of the cells

$$\Phi_q(\boldsymbol{r}_q, \tilde{t}) = \frac{-1}{\varphi} \sum_{k=1,k\neq q}^{N_q=\tilde{V}} \frac{M'_k}{|\boldsymbol{r}_q - \boldsymbol{r}'_k|} = \frac{-1}{\varphi} \sum_{k=1,k\neq q}^{N_q=\tilde{V}} \frac{M'_k}{r_{kq}}, \tag{8a}$$

$$A_q(\mathbf{r}_q,\tilde{t}) = \alpha \sum_{k=1,k\neq q}^{N_q=\tilde{V}} \frac{\mathbf{p'}_k}{|\mathbf{r}_q - \mathbf{r'}_k|} = \alpha \sum_{k=1,k\neq q}^{N_q=\tilde{V}} \frac{\mathbf{p'}_k}{r_{kq}}. \tag{8b}$$

φ and α are respectively called medium constant and dynamic constant. When $\tilde{V} \ll N$, the summation is converted into integral form. The continuous density field and potential field are

$$\rho = \rho(\mathbf{r},t), \qquad \mathbf{j} = \mathbf{j}(\mathbf{r},t). \tag{9}$$

$$\Phi(\mathbf{r},t) = \frac{-1}{\varphi} \iiint_V \frac{\rho(\mathbf{r}',t)}{|\mathbf{r}-\mathbf{r}'|} d\mathbf{r}' = \frac{-1}{4\pi\varphi_s} \iiint_V \frac{\rho(\mathbf{r}',t)}{r} d\mathbf{r}'; \ \Phi_s = c^2. \tag{10a}$$

$$\mathbf{A}(\mathbf{r},t) = \alpha \iiint_V \frac{\mathbf{j}(\mathbf{r}',t)}{|\mathbf{r}-\mathbf{r}'|} d\mathbf{r}' = \frac{\alpha_s}{4\pi} \iiint_V \frac{\mathbf{j}(\mathbf{r}',t)}{r} d\mathbf{r}'; \ A_s = c. \tag{10b}$$

Where the mass potential Φ is a scalar potential, and the momentum potential $\mathbf{A}$ is a vector potential. They are the spatial correlation functions of the mass density ρ and momentum density $\mathbf{j}$, respectively. These correlations include all the connections between the cells and are inversely proportional to the distance between the cells. By using vector calculus, we can derive the laws of interaction from the potential field.

Mathematically, the opposite signs of the mass potential and momentum potential are specified to indicate the opposite effects of attraction and repulsion. But that's not exactly the case, because the mass potential and momentum potential are not independent. They are related to each other through the medium constant φ and the dynamic constant α. The relationship between φ and α is

$$\alpha\varphi = \alpha_s\varphi_s = c^{-2}. \tag{11}$$

(3) Mass conservation. Conservation of mass is the demand for physical axiom. Its mathematical form in particle field theory is [1]

$$\frac{D\rho}{Dt} \equiv \frac{\partial\rho}{\partial t} + \nabla\cdot(\rho\mathbf{u}) = \frac{\partial\rho}{\partial t} + \nabla\cdot\mathbf{j} = 0, \tag{12}$$

where $\mathbf{u} = \mathbf{j}/\rho$ is the velocity field, and $D\rho/Dt$ is called the motion derivative of the mass density. The influence of the boundary is the cause of the second term in the motion derivative.

(4) Boundary condition. The boundary condition of the particle field is

$$B(S) = \frac{\alpha_s}{4\pi} \oiint_S \frac{\mathbf{j}(\mathbf{x}',t)\cdot d\mathbf{S}'}{r} = 0. \tag{13}$$

The condition is valid at the place far from the boundary.

(5) Action field. The action field is the spatial first derivative of the potential field. The action field includes gradient field $\mathbf{G}$, curl field $\mathbf{C}$, and divergence field D.

$$\mathbf{G}(\mathbf{r},t) \equiv -\nabla\Phi = \frac{-1}{4\pi\varphi_s} \iiint_V \frac{\rho(\mathbf{r}',t)\,\mathbf{r}}{r^3} d\mathbf{r}'; \ G_s = \frac{\Phi_s}{r_s} = \frac{r_s}{t_s^2}. \tag{14}$$

$$\mathbf{C}(\mathbf{r},t) \equiv \nabla\times\mathbf{A} = \frac{\alpha_s}{4\pi} \iiint_V \frac{\mathbf{j}(\mathbf{r}',t)\times\mathbf{r}}{r^3} d\mathbf{r}'; \ C_s = \frac{A_s}{r_s} = \frac{1}{t_s}. \tag{15}$$

$$D(\mathbf{r},t) \equiv \nabla\cdot\mathbf{A} = \frac{1}{u_s^2}\frac{\partial\Phi}{\partial t}; \ D_s = \frac{A_s}{r_s} = \frac{1}{t_s}. \tag{16}$$

The curl and divergence fields are frequency fields, which respectively represent the rotation and vibration frequencies. The gradient field is an acceleration field. Negative acceleration represents attraction, and positive acceleration represents repulsion. Since the gradient of the mass potential can be positive or negative, the gradient force includes both attraction and repulsion.

(6) Field equations. The field equations contain the spatial second and third derivatives of the potential field. The eq.17 in Table 3 is the Poisson equation of mass potential, which is also the equation of Newtonian potential. The first four equations (eqs.17-20) are similar to Maxwell equations. There are two pairs of Poisson equations: the Poisson equation of potential field (eqs.17,22) and the Poisson equation of action field (eqs.23,24). Eq.23 shows that the gradient of mass density is the source of the gradient field. Eq.24 shows that the curl of momentum density is the source of the curl field. Eq.21 shows that the temporal variation of the gradient field results in the spatial variation of the divergence field. The particle field equations are derived from the density field, and the density field is no other than the solution of the field equations.

Table 3: The basic equations of the elastic particle field

Name	Field equation	Scale	
Divergence of gradient field	$\nabla\cdot\boldsymbol{G}=-\nabla^2\Phi=-\rho/\varphi_s$	$G_s r_s^{-1}=t_s^{-2}$	(17)
Curl of gradient field	$\nabla\times\boldsymbol{G}=-\nabla\times\nabla\Phi\equiv 0$	$G_s r_s^{-1}=t_s^{-2}$	(18)
Divergence of curl field	$\nabla\cdot\boldsymbol{C}=\nabla\cdot(\nabla\times\boldsymbol{A})\equiv 0$	$C_s r_s^{-1}=r_s^{-1}t_s^{-1}$	(19)
Curl of curl field	$\nabla\times\boldsymbol{C}=\alpha_s\,\boldsymbol{j}-\frac{1}{u_s^2}\frac{\partial\boldsymbol{G}}{\partial t}$	$C_s r_s^{-1}=r_s^{-1}t_s^{-1}$	(20)
Gradient of divergence field	$\nabla D=\nabla(\nabla\cdot\boldsymbol{A})=-\frac{1}{u_s^2}\frac{\partial\boldsymbol{G}}{\partial t}$	$D_s r_s^{-1}=r_s^{-1}t_s^{-1}$	(21)
Poisson equation of momentum potential	$\nabla^2\boldsymbol{A}=-\alpha_s\,\boldsymbol{j}$	$A_s r_s^{-2}=r_s^{-1}t_s^{-1}$	(22)
Poisson equation of gradient field	$\nabla^2\boldsymbol{G}=-\nabla\rho/\varphi_s$	$G_s r_s^{-2}=r_s^{-1}t_s^{-2}$	(23)
Poisson equation of curl field	$\nabla^2\boldsymbol{C}=-\alpha_s\,\nabla\times\boldsymbol{j}$	$C_s r_s^{-2}=r_s^{-2}t_s^{-1}$	(24)

(7) Elastic particle waves. The equation of the divergence field (eqs.16,21) is the wave equation with a general solution

$$\Phi(\xi)=-W(\xi),\ \boldsymbol{A}(\xi)=(\boldsymbol{\kappa}/\omega)W(\xi),\ \ \xi=\boldsymbol{\kappa}\cdot\boldsymbol{x}-\omega t. \tag{25}$$

$W(\xi)$ is an analytic function in the positive real domain.

d) Equation of motion

(1) Motion theorem. We define the force density as the motion derivative of the momentum density [1].

$$\boldsymbol{f}\equiv\frac{D\boldsymbol{j}}{Dt}=\frac{\partial\boldsymbol{j}}{\partial t}+\nabla\cdot(\boldsymbol{j}\boldsymbol{u})=\rho\left[\frac{\partial\boldsymbol{u}}{\partial t}+(\boldsymbol{u}\cdot\nabla)\boldsymbol{u}\right];\quad f_s=\frac{j_s}{t_s}=\frac{\rho_s r_s}{t_s^2}. \tag{26}$$

This equation is called the motion theorem. We can write it in the form of Newton's second law

$$\boldsymbol{f}=\rho\boldsymbol{a},\quad \boldsymbol{a}=\frac{\partial\boldsymbol{u}}{\partial t}+(\boldsymbol{u}\cdot\nabla)\boldsymbol{u};\quad a_s=\frac{f_s}{\rho_s}=\frac{r_s}{t_s^2}. \tag{27}$$

Where $\boldsymbol{a}$ is acceleration, $\partial\boldsymbol{u}/\partial t$ is linear acceleration, and $(\boldsymbol{u}\cdot\nabla)\boldsymbol{u}$ is curve acceleration.

(2) Force field. The coupling of the density field and action field produces the force field, which includes gradient force $\boldsymbol{f}_G$, curl force $\boldsymbol{f}_C$, and divergence force $\boldsymbol{f}_D$.

$$\boldsymbol{f}_G=\rho\boldsymbol{G}=-\rho\nabla\Phi;\qquad f_s=\rho_s G_s=\rho_s r_s/t_s^2. \tag{28a}$$

$$\boldsymbol{f}_C=\boldsymbol{j}\times\boldsymbol{C}=\rho\boldsymbol{u}\times\boldsymbol{C};\ \ f_s=\rho_s u_s C_s=\rho_s r_s/t_s^2. \tag{28b}$$

$$\boldsymbol{f}_D=D\boldsymbol{j}=\rho D\boldsymbol{u};\qquad f_s=\rho_s D_s u_s=\rho_s r_s/t_s^2. \tag{28c}$$

The gradient force appears as gravitational force and electrostatic force, the curl force appears as Coriolis force and Lorentz force, and the divergence force appears as motion resistance. The curl force is perpendicular to the curl field and the motion direction. The divergence force is proportional to the speed, and the resistance coefficient is ρD.

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(3) Motion equation. The condition of the force balance $\boldsymbol{f} = \boldsymbol{f}_G + \boldsymbol{f}_C + \boldsymbol{f}_D$ gives the motion equation of objects as follows

$$\boldsymbol{f} = \rho\left[\frac{\partial \boldsymbol{u}}{\partial t} + (\boldsymbol{u}\cdot\nabla)\boldsymbol{u}\right] = \rho(\boldsymbol{G} + \boldsymbol{u}\times\boldsymbol{C} + D\boldsymbol{u}). \quad (29)$$

The motion equation has the position of the Navier-Stokes equation in fluid dynamics. The force densities at the right side of the equation have definite sources and meanings. The solution of the equation must exist.

e) Unification of fields

(1) Particle field and fluid field. The particle field is a Euler description of fluid motion. The equations of the elastic particle field are unified fluid field equations. For general fluids, sound speed is used as the speed quantum when dealing with dynamics problems, and light speed is used as the speed quantum when dealing with optical phenomena.

(2) Particle field and gravitational field. The mass potential (eq.10a) of particle field is the same as Newton's gravitational potential. Taking gravitational constant as $\gamma = 6.6742867 \times 10^{-11}\mathrm{Nm^2kg^{-2}}$, and speed quantum as $c = 2.9979246 \times 10^{8}\mathrm{ms^{-1}}$, we can determine the medium constant φ and the dynamic constant α.

$$\varphi = \gamma^{-1} = 1.4982874 \times 10^{10}\ \mathrm{N^{-1}m^{-2}kg^{2}}, \quad (30a)$$

$$\alpha = \varphi^{-1}\mathrm{c}^{-2} = \gamma c^{-2} = 7.4261454 \times 10^{-28}\ \mathrm{Ns^2kg^{-2}}. \quad (30b)$$

(3) Particle field and electromagnetic field. The electromagnetic field is a pure electron field. As shown in Table 4, we obtain the relationship between the electromagnetic field and particle field by introducing the mass-to-charge ratio β and the scale conversion factor θ.

$$\beta = M_e/Q_e = -5.6856296 \times 10^{-12}\mathrm{kg\ C^{-1}}; \quad \beta_s = M_s/Q_s. \quad (31a)$$

$$\theta = \epsilon/\varphi = 4\pi\epsilon_s\gamma = 7.4261454 \times 10^{-21}\mathrm{C^2kg^{-2}}; \quad \theta_s = Q_s^2/M_s^2. \quad (31b)$$

Table 4: The transformation between the electromagnetic field and elastic particle field

Electromagnetic field	Transformation relation	Transformation coefficient
Vacuum permittivity	$\epsilon_s = \theta\varphi_s$	$\theta = 7.4261454 \times 10^{-21}\mathrm{C^2kg^{-2}}$
Vacuum permeability	$\mu_s = \theta^{-1}\alpha_s$	$\theta^{-1} = 1.3465936 \times 10^{20}\mathrm{C^{-2}kg^{2}}$
Charge density	$\rho_e = \beta\theta\rho$	$\beta\theta = -4.2222312 \times 10^{-32}\mathrm{Ckg^{-1}}$
Current density	$\boldsymbol{j}_e = \beta\theta\boldsymbol{j}$	$\beta\theta = -4.2222312 \times 10^{-32}\mathrm{Ckg^{-1}}$
Electric potential	$\Phi_e = \beta\Phi$	$\beta = -5.6856296 \times 10^{-12}\mathrm{kgC^{-1}}$
Magnetic potential	$\boldsymbol{A}_e = \beta\boldsymbol{A}$	$\beta = -5.6856296 \times 10^{-12}\mathrm{kgC^{-1}}$
Electric field	$\boldsymbol{E}_e = \beta\boldsymbol{G}$	$\beta = -5.6856296 \times 10^{-12}\mathrm{kgC^{-1}}$
Magnetic induction	$\boldsymbol{B}_e = \beta\boldsymbol{C}$	$\beta = -5.6856296 \times 10^{-12}\mathrm{kgC^{-1}}$

The main difference between the transformed particle field equations (17)-(20) and Maxwell's equations is that the curl of the electric field is not zero. Maxwell's equations are incomplete, as shown by the particle field equations (Table 3). In addition to Maxwell's equations, there is a separate wave equation (divergence field equation). The theory of the elastic particle field should replace the theory of electromagnetic field.

f) Important conclusions

(1) The cosmos is full of electrons. Electrons are so-called dark matter. The electronic background of the cosmos is the basis of the application of particle field theory to cosmology.

(2) The potential field contains all the interactions between particles in the field. The potential field is the spatial correlation functions of the mass density and momentum density. The correlation between each pair of space cells is directly proportional to the mass and momentum, and inversely proportional to their distance.

(3) Gravitational field, electromagnetic field, and fluid field are all unified in the elastic particle field. The particle field equations show that the source of the gradient field is the gradient of mass density, and the source of the curl field is the curl of momentum density. The temporal variation of the gradient field results in the spatial variation of the divergence field. The divergence field equation is the wave equation, which has a general solution in the real number domain.

(4) The electromagnetic field is a pure electron field (electron gas). Electron is the medium of transmitting waves and interactions. The propagation speed of the electromagnetic field is the wave speed in the electron gas, namely, the speed of light.

(5) Maxwell's equations are incomplete. They are only part of the particle field equations. Although Maxwell's equations are self-consistent, they only retain the property of waves and lose the interaction of particles.
(6) The concept of electric charge is defective. The charge model stipulates that protons carry positive charges, and electrons carry negative charges. The stipulation can explain the attraction of protons and electrons, but it excludes the motion repulsion between them.
(7) Newton's law of gravitation needs amendment. Both the gravitational field and electrostatic field belong to the gradient field. The gradient field is the spatial derivative of mass potential, which can be positive or negative. The gradient force may be either attraction or repulsion, namely, there is repulsive gravitation.
(8) Newton's second law needs supplement. Acceleration includes linear acceleration and curve acceleration. The curve acceleration causes the bending motion of the object.
(9) The equation of motion in the form of Newton's second law is similar to the Navier-Stokes equation. The force density at the right end of the equation has clear physical significance. The solution of the equation must exist.
(10) The basis of the particle field equations is the statistics of the mass and momentum of elastic particles. The classical laws of motion, gravitation, and electromagnetism are all inferences of particle field theory. The statistical nature of the field is the source of the irreversibility of natural processes.

IV. Theory of Motion State

The motion state theory comprehensively copes with the translation, rotation, and vibration of elastic particles. The motion energy of the particle system constitutes an energy space. The state variation in the energy space reflects the state variation of matter [3-9].

a) Object structure

An object is a system of elastic particles. The spatial structure of an object is the nesting of particles at different levels. For example, nuclei and electrons form atoms, atoms form molecules, and molecules form supra-molecule, and so on. We put forward a general model to describe the nested structure [3-8]

Top-particle ⊇ meso-particles ⊇ base-particles ⊇ sub-particles.

The top-particle is the object to be studied, while the base-particle is the elastic particle with a conservative number. The meso-particles may be inelastic with a non-conservative numbers. The elasticity of base-particles comes from the motion of sub-particles. For example, the atomic elasticity mainly comes from the electronic motion outside the nucleus. An upper-level particle comprises all particles in lower levels. The more particle levels of an object contain, the more complex the structure of the object.

b) Object state

(1) Space state. The space state of an object includes position, profile, and posture. We express the position by the position vector of the center-of-mass in a fixed coordinate frame, $\boldsymbol{r}_c = (x_c, y_c, z_c)$, the profile by the eigenvalues of the inertia matrix, $\boldsymbol{I}_c = (I_1, I_2, I_3)$, and the posture by the directions of the eigenvectors of the inertia matrix, $\boldsymbol{\theta}_c = (\theta_1, \theta_2, \theta_3)$.
(2) Motion state. The changes of position, posture, and profile are respectively called translation, rotation, and vibration. The translation is the shift of the center-of-mass in space, the rotation is the spin of the object around the center-of-mass, and the vibration is the extension and contraction of the object relative to the center-of-mass. Translation, rotation, and vibration are three independent modes of motion, each of which has three degrees of freedom. An elastic particle has 3×3=9 degrees of freedom, and an object composed of *N* base-particles has 9*N* degrees of freedom.
(3) Energy state. The motion energy of the particle system, $\{H, L, K\}$, represents the energy state of an object. If the vibration, rotation, and translation energies of the base-particle are $H_{i\alpha}, L_{i\alpha}, K_{i\alpha}$ $(\alpha = 1,2,3)$, then the total energies of vibration, rotation, and translation are respectively

$$H = \sum_{i=1}^{N} \sum_{\alpha=1}^{3} H_{i\alpha}\,;\;\; H_{i\alpha} = \frac{V_i \chi_{i\alpha}^2}{2Y_{i\alpha}}.$$

$$L = \sum_{i=1}^{N} \sum_{\alpha=1}^{3} L_{i\alpha}\,;\;\; L_{i\alpha} = \frac{s_{i\alpha}^2}{2I_{i\alpha}}. \qquad (32)$$

$$K = \sum_{i=1}^{N} \sum_{\alpha=1}^{3} K_{i\alpha}\,;\;\; K_{i\alpha} = \frac{p_{i\alpha}^2}{2M_i}.$$

Among them, $Y_{i\alpha}$ is the principal elastic modulus, $I_{i\alpha}$ is the principal rotary inertia, and M_i is the mass of the particle. $\chi_{i\alpha}$ is the principal stress component, $s_{i\alpha}$ is the angular momentum component, and $p_{i\alpha}$ is the translation momentum component. H, L, K are respectively the sum of 3*N* independent square terms, so $H > 0,\ L > 0,\ K > 0$, namely, the motion energy of the object is always positive.

c) *Energy space*

(1) Definition of energy space. The energy space of object is a set of ordered array $\{\mathbb{E}^h, \mathbb{E}^l, \mathbb{E}^k\}$ composed of $\{H, L, K\}$

$$\mathbb{E}^h = \langle H^h, L^h, K^h \rangle,\ \ \mathbb{E}^l = \langle L^l, K^l, H^l \rangle,\ \ \mathbb{E}^k = \langle K^k, H^k, L^k \rangle. \tag{33}$$

Where $x = h, l, k$ is the zone index. $\mathbb{E}^h, \mathbb{E}^l, \mathbb{E}^k$ are respectively called a gas zone, solid zone, and liquid zone.

We can express the energy space intuitively by a Cartesian coordinate space composed of (H, L, K). Due to the positivity of motion energy, we confine the energy space to the first octant $(+,+,+)$ of the Cartesian space. The energy vectors $(\boldsymbol{E}^x)$ of the three zones in the energy space are

$$\begin{aligned} \boldsymbol{E}^h &= (H^h, L^h, K^h) = H^h\,\mathbf{i} + L^h\,\mathbf{j} + K^h\,\mathbf{k} = E^h\,\mathbf{e}_0, \\ \boldsymbol{E}^l &= (H^l, L^l, K^l) = H^l\,\mathbf{i} + L^l\,\mathbf{j} + K^l\,\mathbf{k} = E^l\,\mathbf{e}_0, \\ \boldsymbol{E}^k &= (H^k, L^k, K^k) = H^k\,\mathbf{i} + L^k\,\mathbf{j} + K^k\,\mathbf{k} = E^k\,\mathbf{e}_0. \end{aligned} \tag{34}$$

Where $\mathbf{e}_0$ is the unit vector in the direction of the energy vector. The energy vector has the length

$$E^x = \sqrt{(H^x)^2 + (L^x)^2 + (K^x)^2}\,. \tag{35}$$

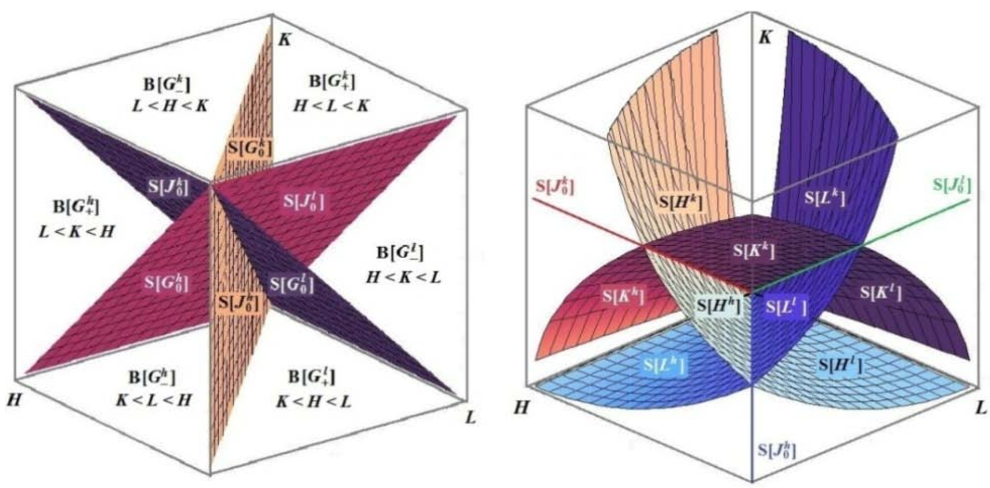

Figure 2: (a) Structure of energy space. (b) Equilibrium surfaces in energy space

(2) Structure of energy space. Three planes $\{H = K, K = L, L = H\}$ divide the energy space into six phases: $\{\mathrm{B}[G^h_\pm], \mathrm{B}[G^l_\pm], \mathrm{B}[G^k_\pm]\}$. $\mathrm{B}[H] = \mathrm{B}[G^h_+] + \mathrm{B}[G^h_-]$ is the gas zone, $\mathrm{B}[L] = \mathrm{B}[G^l_+] + \mathrm{B}[G^l_-]$ is the solid zone, and $\mathrm{B}[K] = \mathrm{B}[G^k_+] + \mathrm{B}[G^k_-]$ is the liquid zone. There are six interfaces between the six phases. Among them, the J-type interface $\{\mathrm{S}[J^h_0], \mathrm{S}[J^l_0], \mathrm{S}[J^k_0]\}$ is the interface of zero potential energy, the G-type interface $\{\mathrm{S}[G^h_0], \mathrm{S}[G^l_0], \mathrm{S}[G^k_0]\}$ is the interface of zero chemical energy. Figure 2(a) shows the structure of the energy space.

(3) Equations of equilibrium state. We define the entire energy equals the length of the energy vector, *i.e.*,

$$\begin{aligned} E^h &\equiv L^h + K^h = \sqrt{(H^h)^2 + (L^h)^2 + (K^h)^2}, \\ E^l &\equiv K^l + H^l = \sqrt{(H^l)^2 + (L^l)^2 + (K^l)^2}, \\ E^k &\equiv H^k + L^k = \sqrt{(H^k)^2 + (L^k)^2 + (K^k)^2}. \end{aligned} \tag{36}$$

These relations give the equations of equilibrium state as

$$(H^h)^2 = 2L^h K^h, \quad (L^l)^2 = 2K^l H^l, \quad (K^k)^2 = 2H^k L^l. \tag{37}$$

(4) Surfaces of equilibrium state. There are three parabolic surfaces in the energy space that represent the equilibrium state of the object. They are the vibration surface $\mathrm{S}[H]$, the rotation surface $\mathrm{S}[L]$, and the translation surface $\mathrm{S}[K]$. Their corresponding equilibrium equations are

$$H = \sqrt{2LK}, \quad L = \sqrt{2KH}, \quad K = \sqrt{2HL}. \tag{38}$$

$\mathrm{S}[H]$, $\mathrm{S}[L]$, and $\mathrm{S}[K]$ represent vibration (radiative) equilibrium, rotation (magnetic) equilibrium, and translation (thermal) equilibrium, respectively. Each surface extends to four phases and three zones, as shown in Figure 2(b).

Table 5 is a matrix describing the structure of the equilibrium surfaces. The diagonal elements $\{\mathrm{S}[H^h], \mathrm{S}[L^l], \mathrm{S}[K^k]\}$ are stable areas, and the rest are excited areas.

Table 5: Structure of equilibrium surface

	$\mathbf{B}[\boldsymbol{H}]$	$\mathbf{B}[\boldsymbol{L}]$	$\mathbf{B}[\boldsymbol{K}]$
$\mathrm{S}[H]$	$\mathrm{S}[H^h]$	$\mathrm{S}[H^l]$	$\mathrm{S}[H^k]$
$\mathrm{S}[L]$	$\mathrm{S}[L^h]$	$\mathrm{S}[L^l]$	$\mathrm{S}[L^k]$
$\mathrm{S}[K]$	$\mathrm{S}[K^h]$	$\mathrm{S}[K^l]$	$\mathrm{S}[K^k]$

(5) Definition of energy parameter. Table 6 lists the parameters on the equilibrium surfaces. Among them, $\{X, Y, Z\}$ is motion energy, and $\{E, Q, J, G\}$ is auxiliary energy. $\{a, b\}$ is called the order parameter, which satisfies the relation $ab = 1/2$.

Table 6: The definition of the parameters on the equilibrium surfaces

Equilibrium surface	Definition	$\mathbf{S}[\boldsymbol{H}]$	$\mathbf{S}[\boldsymbol{L}]$	$\mathbf{S}[\boldsymbol{K}]$
Equilibrium equation	$X = \sqrt{2YZ}$	$H = \sqrt{2LK}$	$L = \sqrt{2KH}$	$K = \sqrt{2HL}$
Major energy	X	H	L	K
Ahead energy	Y	L	K	H
Back energy	Z	K	H	L
Ahead parameter	$a = Y/X$	L/H	K/L	H/K
Back parameter	$b = Z/X$	K/H	H/L	L/K
Entire energy	$E = Y + Z$	$L + K$	$K + H$	$H + L$
Thermal energy	$Q = Z + X$	$K + H$	$H + L$	$L + K$
Potential energy	$J = Y - X$	$L - H$	$K - L$	$H - K$
Chemical energy	$G = Z - Y$	$K - L$	$H - K$	$L - H$
Energy quantum	X_s	$H_s = hv$	$L_s = lz$	$K_s = kT$

d) Quantum state

(1) Energy quantum. The energy quanta of the *N*-particle system are the average energies of three-modes of motion

$$H_s = H/N = hv, \; L_s = L/N = lz, \; K_s = K/N = kT. \tag{39}$$

In the SI system, v is the vibration intensity (frequency) with unit hertz (Hz), z is the rotation intensity (magnetic induction strength) with unit tesla (T), and T is the translation intensity (thermodynamic temperature) with unit kelvin (K). Taking the energy unit as joule (J), then, $h = 6.6260693 \times 10^{-34}\ \mathrm{J \cdot Hz^{-1}}$ is Planck constant, $l = 9.2740095 \times 10^{-24}\ \mathrm{J \cdot T^{-1}}$ is Bohr magneton constant, and $k = 1.3806506 \times 10^{-23}\ \mathrm{J \cdot K^{-1}}$ is Boltzmann constant.

(2) Quantum state theorem. A quantum state is a state in which the digits of energy on the equilibrium surface take integers $\{\tilde{X}, \tilde{Y}, \tilde{Z}\}$. The quantum state $\{\tilde{X}, \tilde{Y}, \tilde{Z}\}$ is a set of positive integer solutions of the algebraic equations $\{X^2 = 2YZ, Y^2 = 2ZX, \; Z^2 = 2XY\}$.

(3) Quantum state plot: With *Z* as abscissa and *Y* as ordinate, we can plot the quantum state of the curved surface $\mathrm{S}[X]$ with the *Y*-*Z* plane, as shown in Figure 3.

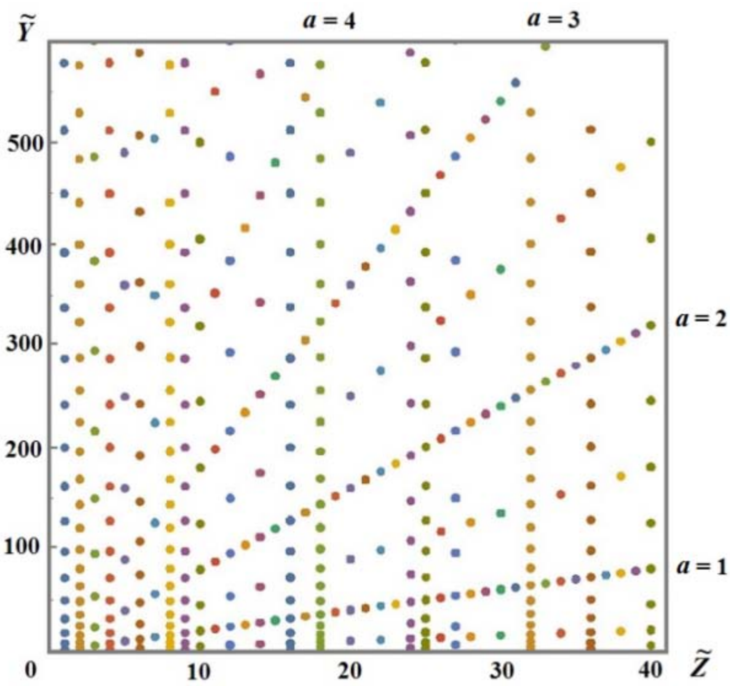

Figure 3: The plane plot of the quantum state of equilibrium surface $S[X]$

e) *Application examples*

(1) Equations of state. The entire energy of an object can be decomposed according to the motion mode, volume, and particle number, as shown in Table 7. The equations of state (including gas, solid, and liquid) are obtained by equating various decomposition formulas [3,4,6].

Table 7: The decompositions of entire energy and the equations of state

Zone (index x)	Gas (index h)	Solid (index l)	Liquid (index k)
Energy quantum	$H_s = hv$	$L_s = lz$	$K_s = kT$
Mode decomposition	$E^h = \mu_h^h H^h$	$E^l = \mu_l^l L^l$	$E^k = \mu_k^k K^k$
Volume decomposition	$E^h = q^h V^h$	$E^l = q^l V^l$	$E^k = q^k V^k$
Particle decomposition	$E^h = \mu_h^h N H_s$	$E^l = \mu_l^l N L_s$	$E^k = \mu_k^k N K_s$
Equation of state	$q^h V^h = \mu_h^h N H_s$	$q^l V^l = \mu_l^l N L_s$	$q^k V^k = \mu_k^k N K_s$

(2) Phase transition. Two types of phase interfaces correspond to two different types of phase transition: G-type interface corresponds to the continuous phase transition, J-type interface corresponds to the discontinuous phase transition. Table 8 shows the phase transition parameters in the J-type interface. The order parameter on the interface has 1/2 jump, and the leap of potential energy represents the latent energy of phase transition [4,6].

Table 8: The discontinuity at the zone interfaces (J-type phase transition)

Zone interface	Gas-Solid $\mathbf{S}[J_0^h]$	Solid-liquid $\mathbf{S}[J_0^l]$	Liquid-Gas $\mathbf{S}[J_0^k]$
Equilibrium condition	$H^h = L^h = 2K^h$	$L^l = K^l = 2H^l$	$K^k = H^k = 2L^k$
	$H^l = L^l = 2K^l$	$L^k = K^k = 2H^k$	$K^h = H^h = 2L^h$
Order parameter	$\Delta a^{hl} = -1/2$	$\Delta a^{lk} = -1/2$	$\Delta a^{kh} = -1/2$
	$\Delta b^{hl} = 1/2$	$\Delta b^{lk} = 1/2$	$\Delta b^{kh} = 1/2$
Entire energy	$\Delta E^{hl} = 3(K^l - K^h)$	$\Delta E^{lk} = 3(H^k - H^l)$	$\Delta E^{kh} = 3(L^h - L^k)$
Chemical energy	$\Delta G^{hl} = K^l + K^h$	$\Delta G^{lk} = H^k + H^l$	$\Delta G^{kh} = L^h + L^k$
Thermal energy	$\Delta Q^{hl} = 4K^l - 3K^h$	$\Delta Q^{lk} = 4H^k - 3H^l$	$\Delta Q^{kh} = 4L^h - 3L^k$
Potential energy	$\Delta J^{hl} = -K^l$	$\Delta J^{lk} = -H^k$	$\Delta J^{kh} = -L^h$

(3) Hydrogen spectrum [5]. Table 9 is the quantum state of $\tilde{L} = 1{\sim}10$ on the thermal equilibrium surface $\mathrm{S}[K]$. In the table, $\mathrm{S}[K^h]$ represents the excited state of vibration. $\mathrm{L}[J_0^k]$ is the intersection of $\mathrm{S}[K]$ and $\mathrm{S}[H]$, representing a stable state. The first column, $\tilde{L} = 1$, is the ground state.

Table 9: Quantum state of $\tilde{L} = 1{\sim}10$ with ground state $\tilde{L} = 1$ on the $\mathrm{S}[K]$ surface

State	$\mathbf{L}[J_0^k]$	$\mathbf{S}[K^h]$									
$\tilde{K}$	2	8	18	32	50	72	98	128	162	200	…
$\tilde{H}$	2	16	54	128	250	432	686	1024	1458	2000	…
$\tilde{L}$	1	2	3	4	5	6	7	8	9	10	…
a	1	2	3	4	5	6	7	8	9	10	…

According to the equilibrium state equation and the above table, we obtain the Balmer formula of the emission spectrum for the ground state $(\tilde{L} = 1)$.

$$\bar{v}_{a'a} = \frac{H(a)}{2h}\left(\frac{1}{a^2} - \frac{1}{a'^2}\right), \quad (a = 1,2,3,\cdots;\ a' = a+1, a+2, a+3, \cdots). \tag{40}$$

$\bar{v}_{a'1}, \bar{v}_{a'2}, \bar{v}_{a'3}$ are the spectral frequencies of the Lyman series, the Palmer series, and the Paschen series of hydrogen atoms, respectively. The ahead order parameter is the principal quantum number in Bohr's atomic theory.

f) Important conclusions

(1) Elastic particles have three independent motion modes of translation, rotation, and vibration. They are the origins of heat, magnetism, and radiation of objects, respectively. The wave-particle duality comes from the elastic vibration of the microscopic particles.

(2) The motion energies of the three modes $\{H, L, K\}$ express the state of an object. Energy space is a complete description of the motion state of particles inside an object. We can use it to explain the mechanism of state variation (such as the equations of state, phase transition, and light emission).

(3) There are three equilibrium surfaces in the energy space, which represent the thermal (translation) equilibrium, magnetic (rotation) equilibrium, and radiative (vibration) equilibrium.

(4) Energy quantum $\{H_s = hv,\ L_s = lz,\ K_s = kT\}$ is the statistical average of motion energy $\{H, L, K\}$. Quantum states are thermodynamic equilibrium states in which the digits of energy take integers $\{\tilde{H}, \tilde{L}, \tilde{K}\}$.

(5) The order parameter is the ratio of motion energy. The order parameter includes ahead parameter and back parameter. The ahead parameter (a) represents the ordered degree of the system, and the back parameter (b) represents the disordered degree of the system. It has $ab = 1/2$ for an equilibrium system.

(6) The essence of pressure is the density of motion energy. There are three modes of motion energy, and so, three modes of pressure. The pressure is a vector of energy space, not a vector of physical space.

(7) Mass and energy are two different physical quantities. Mass is the intrinsic quantity of an object, and energy is the motion quantity of the object. Without motion, there is no energy. Mass and energy are not interchangeable.

(8) Relativity theory applies to high-speed translating particles, and quantum theory applies to microscopic vibrating particles. Real physics comprehensively considers the translation, rotation, and vibration of elastic particles, and applies to any object.

V. Theory of Thermodynamics

The thermodynamics of real physics is a theory of the ensemble statistics based on the conservation of particle number. The basic goal is to derive thermodynamic relations and equations through the particle statistics and reveal the essence of classical thermodynamic laws [3,4,6,9].

a) Statistical principle

(1) Cluster ensemble. The object volume V is divided into $\tilde{V}$ cells by the volume quantum $V_s = r_s^3$. The set of particles in a space cell is called a cluster, and the cluster with *n* particles is called an *n*-cluster. Imagine to take the "snapshot" of the particle configuration by the time interval t_s. Within the finite time $t = t_s \cdot \tau;\ \tau = 1,2,\cdots,k,\cdots N_\tau$, the set of all snapshots is called a cluster ensemble. Figure 4 is a sketch map of a cluster ensemble with ten particles at $\tau = 1,2,3,4$.

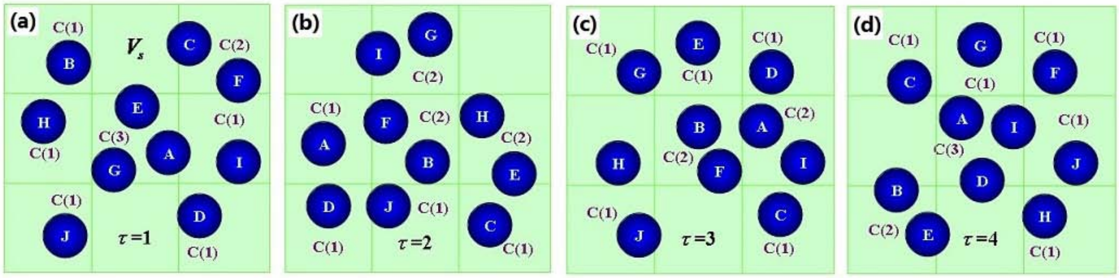

Figure 4: Sketch map for the statistical principle of cluster ensemble

(2) Cluster statistics. An $N \times N_\tau$ matrix describes the cluster of the ensemble, and the matrix element $C_{n\tau}$ represents the number of n-clusters in the τ-snapshot. The number of n-clusters (C_n) and the total number of clusters (C) are

$$C_n = \frac{1}{N_\tau} \sum_{\tau=1}^{N_\tau} C_{n\tau}, \tag{41}$$

$$C = \sum_{n=1}^{N} C_n = \frac{1}{N_\tau} \sum_{n=1}^{N} \sum_{\tau=1}^{N_\tau} C_{n\tau} = \tilde{V} \leq N. \tag{42}$$

The cluster ensemble satisfies the condition of the particle number conservation

$$\sum_{n=1}^{N} (n \cdot C_n) = N. \tag{43}$$

The occurrence probability of n-cluster satisfies the condition of normalization

$$\rho_n \equiv \frac{C_n}{C}, \quad \sum_{n=1}^{N} \rho_n \equiv \sum \rho_n = 1. \tag{44}$$

(3) Cluster energy. The energies of n-clusters, $\eta_n, \lambda_n, \kappa_n, \varepsilon_n, \theta_n, \varphi_n, \gamma_n$, are respectively the vibration energy, rotation energy, translation energy, entire energy, thermal energy, potential energy, and chemical energy. Thus, we can obtain the total energies through cluster statistics.

$$\begin{aligned}
H &= \sum C_n \eta_n = C \sum \rho_n \eta_n = C\eta, \quad \eta = \sum \rho_n \eta_n. \\
L &= \sum C_n \lambda_n = C \sum \rho_n \lambda_n = C\lambda, \quad \lambda = \sum \rho_n \lambda_n. \\
K &= \sum C_n \kappa_n = C \sum \rho_n \kappa_n = C\kappa, \quad \kappa = \sum \rho_n \kappa_n. \\
E &= \sum C_n \varepsilon_n = C \sum \rho_n \varepsilon_n = C\varepsilon, \quad \varepsilon = \sum \rho_n \varepsilon_n. \\
Q &= \sum C_n \theta_n = C \sum \rho_n \theta_n = C\theta, \quad \theta = \sum \rho_n \theta_n. \\
J &= \sum C_n \varphi_n = C \sum \rho_n \varphi_n = C\varphi, \quad \varphi = \sum \rho_n \varphi_n. \\
G &= \sum C_n \gamma_n = C \sum \rho_n \gamma_n = C\gamma, \quad \gamma = \sum \rho_n \gamma_n.
\end{aligned} \tag{45}$$

Where $\eta, \lambda, \kappa, \varepsilon, \theta, \varphi, \gamma$ are the average energies of the cluster.

(4) Partition function. The partition functions of gas, solid, and liquid are respectively

$$\begin{aligned}
Z_L^h &= \int_{\Gamma^h} \exp(-\tilde{L}^h)\, d\Gamma^h, \\
Z_K^l &= \int_{\Gamma^l} \exp(-\tilde{K}^l)\, d\Gamma^l, \\
Z_H^k &= \int_{\Gamma^k} \exp(-\tilde{H}^k)\, d\Gamma^k.
\end{aligned} \tag{46}$$

Where $\Gamma^x (x = h, l, k)$ is the space of statistical zone. $\exp(-\tilde{L}^h)$, $\exp(-\tilde{K}^l)$, and $\exp(-\tilde{H}^k)$ are the probability density of the ahead energy. The partition function gives the digit of ahead energy as

$$\tilde{L}^h = \ln Z_L^h, \quad \tilde{K}^l = \ln Z_K^l, \quad \tilde{H}^k = \ln Z_H^k. \tag{47}$$

b) Statistical Functions

Table 10 lists the statistical functions of the particle system given by strict calculation [4]. Where Y_s is the elastic modulus scale, I_s is the rotary inertia scale, and M_s is the mass scale. The results show that the motion energy of the cluster is proportional to the logarithm of its volume. The order parameters of gas, solid, and liquid are the statistical functions of elastic modulus, rotary inertia, and mass of clusters, respectively.

Table 10: Statistical functions of the particle system

	Gas	Solid	Liquid
Energy quantum	$H_s = H/N = Y_s V_s = hv$	$L_s = L/N = I_s \omega_s^2 = lz$	$K_s = K/N = M_s u_s^2 = kT$
Partition function	$Z_L^h = \prod_{n=1}^{N} (\tilde{V}_{n\varphi}^h / \tilde{V}_{n\eta}^h)^{C_n^h}$	$Z_K^l = \prod_{n=1}^{N} (\tilde{V}_{n\varphi}^l / \tilde{V}_{n\lambda}^l)^{C_n^l}$	$Z_H^k = \prod_{n=1}^{N} (\tilde{V}_{n\varphi}^k / \tilde{V}_{n\kappa}^k)^{C_n^k}$
Vibration energy	$\tilde{H}^h = -\sum (C_n^h \cdot \ln \tilde{V}_{n\eta}^h)$	$\tilde{H}^l = -\sum (C_n^l \cdot \ln \tilde{V}_{n\eta}^l)$	$\tilde{H}^k = -\sum (C_n^k \cdot \ln \tilde{V}_{n\eta}^k)$
Rotation energy	$\tilde{L}^h = -\sum (C_n^h \cdot \ln \tilde{V}_{n\lambda}^h)$	$\tilde{L}^l = -\sum (C_n^l \cdot \ln \tilde{V}_{n\lambda}^l)$	$\tilde{L}^k = -\sum (C_n^k \cdot \ln \tilde{V}_{n\lambda}^k)$
Translation energy	$\tilde{K}^h = -\sum (C_n^h \cdot \ln \tilde{V}_{n\kappa}^h)$	$\tilde{K}^l = -\sum (C_n^l \cdot \ln \tilde{V}_{n\kappa}^l)$	$\tilde{K}^k = -\sum (C_n^k \cdot \ln \tilde{V}_{n\kappa}^k)$
Order parameter	$a^h = \frac{3}{4} \cdot \ln(2\pi \tilde{Y}_c)$	$a^l = \frac{3}{4} \cdot \ln(2\pi \tilde{I}_c)$	$a^k = \frac{3}{4} \cdot \ln(2\pi \tilde{M}_c)$
cluster correlation	$\ln \tilde{Y}_c = \sum (\rho_n^h \cdot \ln \tilde{Y}_n)$	$\ln \tilde{I}_c = \sum (\rho_n^l \cdot \ln \tilde{I}_n)$	$\ln \tilde{M}_c = \sum (\rho_n^k \cdot \ln \tilde{M}_n)$

c) Thermodynamic functions

(1) Motion energy. Because the three energy zones have even permutation symmetry for $\langle H, L, K \rangle$, we take the liquid zone $\mathbb{E}^k = \langle K^k, H^k, L^k \rangle$ as an example to give the calculation results.

For liquid, the major energy is translation energy K, the ahead energy is vibration energy H, the back energy is rotation energy L, and the energy quantum is $K_s = kT$. The ahead and back parameters are $a = H/K$ and $b = L/K$, respectively.

According to the relationship $C = bN$, we can decompose the motion energy by the number of particles N and the number of clusters C as

$$\begin{aligned} K &= NK_s = C\kappa, \qquad \kappa = b^{-1} K_s. \\ H &= aNK_s = C\eta, \qquad \eta = ab^{-1} K_s. \\ L &= bNK_s = C\lambda, \qquad \lambda = K_s. \end{aligned} \tag{48}$$

(2) Auxiliary energy. We can express the auxiliary energy by the particle number and the cluster number as

$$\begin{aligned} E &= N(a+b)K_s = C\varepsilon, \quad \varepsilon = (ab^{-1} + 1)K_s. \\ Q &= N(b+1)K_s = C\theta, \quad \theta = (1 + b^{-1})K_s. \\ J &= N(a-1)K_s = C\varphi, \quad \varphi = (a-1)b^{-1} K_s. \\ G &= N(b-a)K_s = C\gamma, \quad \gamma = (1 - ab^{-1})K_s. \end{aligned} \tag{49}$$

(3) Internal energy and enthalpy energy. We introduce two other auxiliary functions: internal energy U and enthalpy energy Y.

$$U \equiv Q - H = K + L - H, \quad Y \equiv Q + G = K + 2L - H. \tag{50}$$

We express the internal energy and enthalpy energy by the particle number and cluster number as follows

$$U = N(1 + b - a)K_s = Cv, \quad v = (1 + b - a)b^{-1}K_s. \tag{51}$$

$$Y = N(1 + 2b - a)K_s = C\psi, \quad \psi = (1 + 2b - a)b^{-1}K_s. \tag{52}$$

(4) Thermal entropy and chemical entropy. We define the thermal entropy S and the chemical entropy Z as

$$S \equiv Q/T = (b + 1)Nk, \quad Z \equiv G/T = (b - a)Nk. \tag{53}$$

The thermal entropy σ and chemical entropy ζ of the cluster is

$$\sigma = \frac{S}{C} = \frac{\theta}{T}, \quad \zeta = \frac{Z}{C} = \frac{\gamma}{T}. \tag{54}$$

According to Boltzmann entropy formula $S = k \cdot \ln \Omega$, we find the thermodynamic probability Ω.

$$\Omega = \exp(S/k) = \exp[(b + 1)N]. \tag{55}$$

d) Thermodynamic equations

Table 11 lists the energy relations and basic equations of thermodynamics [4,9]. The energy function corresponds to the characteristic function of classical thermodynamics. The basic equations are derived from the differential of cluster energy [4]. They contain the basic laws of classical thermodynamics (the first law and the second law).

Table 11: The Energy relations and equations of the liquid

Energy	Relation	Equation
Vibration energy	$H = J + K = L - G = Q - U$	$dH = SdT + q_l dV - \gamma dC$
Rotation energy	$L = H + G = Q - K, \ L = q_l V$	$dL = SdT + q_l dV + Cd\gamma$
Translation energy	$K = H - J = Q - L = U - G$	$dK = TdS - q_l dV - Cd\gamma$
Thermal energy	$Q = L + K = H + U, \ Q = ST$	$dQ = TdS + Vdq_l - Cd\gamma$
Chemical energy	$G = L - H = U - K, \ G = C\gamma$	$dG = -SdT + Vdq_l + \gamma dC$
Internal energy	$U = Q - H = K + L - H$	$dU = TdS - q_l dV + \gamma dC$
Enthalpy energy	$Y = Q + G = K + 2L - H$	$dY = TdS + Vdq_l + \gamma dC$
Zero	$0 = Q - Q = L - L = G - G$	$0 = SdT - Vdq_l + Cd\gamma$

e) Important conclusions

(1) Thermodynamics of real physics is a theory based on the statistics of the cluster ensemble. In a cluster ensemble, the number of particles is conserved, but the number of clusters is variable. The statistics of the cluster ensemble are a complete and accurate statistical method.

(2) The elastic particle system has three kinds of balance states. They are the thermal (translation) equilibrium, magnetic (rotation) equilibrium, and radiative (vibration) equilibrium. The zeroth law of thermodynamics claims the situation of thermal equilibrium (heat balance).

(3) The positivity of motion energy $\{H > 0, L > 0, K > 0\}$ demands the positivity of equilibrium parameter $\{v > 0, z > 0, T > 0\}$. The third law of thermodynamics claims the situation $T > 0$ (Absolute zero kelvin is unreachable).

(4) The thermal energy (Q) is a state function. The internal energy $(U = Q - H)$ is the difference between the thermal energy (Q) and the vibration energy (H). $dU = dQ - dH$ is a form of the first law of thermodynamics. Where the heat is the difference of the thermal energy (dQ), and the work done by the system comes from the reduction of the vibration energy $(-dH)$.

(5) The entropy of a thermodynamic system includes thermal entropy and chemical entropy. Thermal entropy is always positive, and chemical entropy can be positive or negative. The formula $S \equiv Q/T = (b + 1)Nk$ shows

that the thermal entropy is proportional to the number of particles and the back parameter, which reflects the disorder degree of the system.

(6) The motion energy and auxiliary energy contain all characteristic functions of the classical thermodynamics, and have definite meanings. For example, Helmholtz free energy is the negative vibration energy $(-H)$, and grand potential is the negative rotation energy $(-L)$.

(7) The equation $SdT - Vdq_l + Cd\gamma = 0$ is equivalent to the Gibbs relation of classical thermodynamics.

(8) The motion energy of clusters is proportional to the volume logarithm, which reveals the relationship between the motion and volume of objects. The larger the size of an atom is, the larger the energy it contains. The energy released by splitting a heavy atom is the motion energy of particles inside the nucleus, not the loss of mass.

Conclusive remark

Salute, classical physics; goodbye, modern physics; welcome, real physics !

References Références Referencias

1. Z. C. Liang, The origin of gravitation and electromagnetism. *Theoretical Physics*, 4, 85-102 (2019). DOI:10.22606/tp.2019.42004.
2. Z. C. Liang, Essence of light: particle, field and interaction. in *Proc. SPIE*. 10755, 1075501-10755014 (2018). DOI:10.1117/12.2316422.
3. Z. C. Liang, Motion, energy and state of body particle system. *Theoretical Physics*, 4, 66-84 (2019). DOI:10.22606/tp.2019.42003.
4. Z. C. Liang, Cluster ensemble statistics of body particle system. *New Horizons in Mathematical Physics,* 3, 53-73 (2019). DOI:10.22606/nhmp.2019.32002.
5. Z. C. Liang, Motion of elastic particles and spectrum of hydrogen atoms. *Global Journal of Science Frontier Research,* 19(4F), 18-28(2019). DOI:10.34257/GJSFRFVOL19IS4PG19.
6. Z. C. Liang, Modeling of real particles. *Journal of Physics(Conf. Ser.)*, 1391, 012026(2019). DOI:10.1088/1742-6596/1391/1/012026.
7. Z. C. Liang, Energy, state and property of nanoparticle system. The 27th Annual International Conference on Composites or Nano Engineering, ICCE-27 July 14-20 (2019), Granada, Spain.
8. Z. C. Liang, Nanoparticle modeling and nanomaterial properties. Bit's 9th International Congress of Nano Science & Technology, Oct. 20-22(2019), Suzhou, China.
9. Z. C. Liang, *Physical Principles of Finite Particle System* (Scientific Research Publishing, 2015). DOI:10.13140/RG.2.1.2409.8004.