

Beyond Relativity: The Velocity Field Physics

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Abstract

Because of the interconnection between the cosmic vacuum with non-zero energy density and moving particles, any dynamic system that does not include the cosmic vacuum can not be a closed one. Newtonian mechanics, analytical mechanics, and relativistic mechanics have all ignored the cosmic vacuum making them are all approximate theories effective only under specific conditions. The uniform motion of a charge or massive particle requires obtaining inertial mass from an electrically or gravitationally neutral vacuum, in order to generate a vector potential and corresponding vortex field—the velocity field with neutral massless quasi-bosons moving along with the charge or particle. The so called “relativistic effects” in electrodynamics and particle dynamics are not the spacetime effects of motion, but rather the physical effects of velocity fields generated by motion vector potentials in the flat cosmic background spacetime. The gravitational vector potential in flat spacetime is an appropriate approach to handle strong gravitational processes and gravitational wave radiation of dense celestial bodies. The gravitational vector potential of an annular material flow produces an axial magnetic gravitational dipole field. Numerous compact objects are likely to be gauge gravitational field accelerators of ultra-high energy cosmic rays. The velocity field of moving particles is also one of fundamental constituents necessary for constructing quantum field theory.

Keywords

Vacuum, Velocity Field, Quasi-Particle, Gauge Field, Gravitational Vector Potential

1. Cosmic Vacuum

1.1. Homogenous and Flat Cosmic Spacetime

Various astronomical observations have long shown that the universe is uniform

and isotropic on large scales. Since 1992, the *COBE*, *WMAP* and *Planck* satellites borne microwave antennas have successively carried out all-sky scanning observation of cosmic microwave background radiation (CMB). On the background temperature distribution after eliminating the contribution of foreground celestial objects in the equatorial coordinate system, there still exists a strong dipole anisotropy which is caused by the Doppler effect of a motion at a velocity

$$v_0 = 384 \text{ km/s}$$

towards to the point $(l_0, b_0) = (264^\circ, 48^\circ)$ on the celestial sphere [1]. Only after deducting the Doppler effect from the observed temperatures point by point, we can obtain the temperature distribution of CMB, which is an isotropic blackbody radiation with an average temperature of $T_0 = 2.725 \text{ K}$, and the deviation of the actual temperature T from the isotropy is only about one hundred thousandth

$$\Delta T/T_0 \sim \pm 10^{-5}$$

The strong dipole signal in observed whole sky microwave map and the isotropy blackbody spectrum of CMB indicate that “the universe around us does define a special preferred velocity” [2], and the CMB does a preferred homogenous and flat frame of reference for all objects in the universe.

1.2. Identity of Particles

If there is only one particle in the universe with proper mass m_0 which is the inertial mass of the particle at rest, the mass of the particle moving with a velocity v relative to the vacuum should be

$$m = \gamma m_0 \quad (1)$$

with the Lorentz factor

$$\gamma = 1/\sqrt{1-v^2/c^2} \quad (2)$$

On account of the conservation of energy the increase in energy, $\Delta m = (\gamma - 1)m_0$, should come from the cosmic vacuum with a nonzero density of energy, and the proper mass m_0 is the smallest mass that the particle can have. In the case, any motion of the particle should be an absolute motion and the cosmic vacuum an absolute rest frame of reference.

In quantum mechanics, elementary particles of the same type, e.g. electrons, have the same proper mass m_0 for all electrons rest in the vacuum background of the universe. In relativistic theory, any movement of an electron will increase its mass, *i.e.* for any moving electron, its mass $m > m_0$, so the proper mass m_0 is the smallest mass that any electron can possess. Therefore, the particle physics requires that the cosmic vacuum is a common stationary system of reference for all particles.

For two electrons, e1 and e2, uniformly moving in the cosmic vacuum with the Lorentz factor γ_1 and γ_2 respectively, from Equation (1) their motion masses should be

$$m_1 = \gamma_1 m_0 \quad (3)$$

and

$$m_2 = \gamma_2 m_0 \quad (4)$$

respectively. Substituting Equation (3) into Equation (4), we get

$$m_2 = \frac{\gamma_2}{\gamma_1} m_1 \quad (5)$$

However, in the rest frame of e1, m_1 is the rest mass of e1; denoting the velocity of e2 relative to e1 by v_{21} and $\gamma_{21} = 1/\sqrt{1-v_{21}^2/c^2}$, according to special relativity we have the inertial mass of e2

$$m_2 = \gamma_{21} m_1 \quad (6)$$

which is obviously in conflict with Equation (5). The conflict comes from that the background vacuum for Equations (1)-(5) is the cosmic vacuum of nonzero energy density and being physically connected with particles, but that for Equation (6) is just a empty void (mathematical vacuum).

We will explain in the next subsection that there is an energy connection between moving particles and the cosmic vacuum, and no particle or system of particles can be isolated to the cosmic vacuum. The so-called “relativistic effect” is only the physical effect of uniform translational motion relative to the cosmic vacuum which is an absolutely stationary frame of reference necessary for the complete expression of particle dynamic process, and so called “rest reference system” in relativistic dynamics can only be the cosmic vacuum.

The existence and expression of universal laws require that the fundamental spacetime frame of reference for constructing physical theory must be an inertial coordinate system in a flat and homogenous spatiotemporal space. For various physical systems including movements, interactions and transformations of different forms of matter/energy, the conservation law of energy, momentum, and moment of momentum are widely supported by experiments. Noether’s theorem indicates that conservation of energy is connected with uniformity of time, and conservation of momentum and angular momentum is connected with homogeneity and isotropy of spatial space: A physical system that follows conservation laws needs to be described in a uniform time and homogenous, isotropic spatial space. The homogeneously and isotropically expanded universe has no any global translational motion, then the vacuum comoving with the universe is a stationary inertial reference frame (χ, τ) composed of a three-dimensional Euclidean spatial space χ and cosmic time τ measured by cosmic temperature T or density ρ .

1.3. Quasi-Bosons Constituting Cosmic Medium

In order to explain the Planck blackbody radiation spectra of cosmic microwave background (CMB) measured by the *COBE* satellite [3], textbooks of cosmology interpret CMB as photons at early universe in thermal equilibrium with the hot dense luminous matter, they then began a free expansion with temperature T inversely proportional to the cosmological redshift z [4]. This kind of model us-

ing only a very small amount of electromagnetic radiation decoupled from the hot dense matter to represent the thermal history of the universe, does not explain why dense matter has a single temperature, and completely disregards the energy density or temperature of the expanding universe is inversely proportional to the cubic of cosmic scale, or proportional to the cubic of cosmological redshift.

The ordinary luminous matter constitutes only a small part of total mass in the universe, the majority of which is in the dark sector, including dark matter and dark energy, which are not coupled to photons. As shown by the perfect blackbody spectrum of CMB, the matter in our universe, including ordinary matter and dark sector, should be on the cosmic scale locked together in thermal equilibrium with the same temperature of the blackbody cosmic background radiation (CBR). However, only a very small fraction of CBR can be attributed to thermal photons, because most of the matter in the universe cannot get involved in electromagnetic processes at all. Most CBR should be coupled with the dark sector, which can only be involved in thermal processes through gravitational interaction. Thus a natural candidate for the main component of CBR should be the thermal gravitational radiation coupled with dark matter and dark energy through gravitational interaction [5] [6].

The electromagnetic waves detected by Hertz is a kind of non-thermal radiation, it can be produced by a single positive or negative charge moving in acceleration. On the other hand, thermal energy contained in an electrically neutral object of condensed matter composed of unit cells with interacting positive and negative charged particles in equilibrium, represents vibrational motion of the elastic structures. Phonons—neutral massless quasi-bosons as collective excitations of vibrations of elastic structures—play a major role in heat conduction in an object. Thermal phonons can be generated from different processes. For example, optical phonons are generated from vibrational modes involving oscillating electric dipoles while the center of mass of a unit cell remains static and the atoms within the cell vibrate against each other. Such phonons can be coupled directly with electromagnetic fields. An intrinsically different kind of phonons, the so called “acoustic phonons” or “elastic phonons”, are elastic waves from vibrational modes with all atoms in the unit cell vibrating in phase and with the same amplitude [7]. Basic thermodynamic properties in such an object are irrelevant to the particular nature, optical or acoustic, of phonons. Photons and different kinds of phonons can be coupled to each other in a condensed matter object.

The detected gravitational waves from accelerated motion massive objects should be a kind of non-thermal radiation. It has been thought that gravity cannot be thermalized [8], because only positive gravitational mass and only attractive interaction between masses exist in gravity, while in electromagnetism exist both positive and negative charges, and both attractive force (between opposite charges) and repulsive force (between the same charges). However, there exists dark energy with repulsive gravitation as another basic component of the universe besides matter with attractive gravitation. The dark energy can be seen as a kind of matter

with negative gravitational mass, and there are also both attractive gravitational force (between dark matters) and repulsive gravitational force (between dark matter and dark energy or between dark energies) in cosmological scales. The dark sector of the universe is constituted by two coupled fields, in which elastic structures at the microscopic scale can be formed from quantum fluctuations. The CMB radiation with most perfect blackbody spectrum ever observed in nature further demonstrates that the universe is in full thermal equilibrium, which requires that gravity must dominate the cosmological thermalization, particularly in the early universe. The two kinds of gravity, attractive force energized by matter and repulsive force by dark energy, like that of electromagnetic interaction by two opposite charges, can closely coupled to keep the universe in thermal equilibrium. Analogous to an electrically neutral object producing thermal phonons inside and radiating out thermal photons, the dark sector of the universe, being gravitationally neutral and thermally equilibrated, would produce cosmic thermal phonons, within which we, the observers, are immersed. Therefore, cosmic gravitational phonons as the global thermal carriers of the universe should coexist in CBR with thermal photons produced and traveled locally in bounded systems of baryonic matter.

1.4. Three Vacuums

The vacuum energy density is an important parameter in quantum field theory. There exists a major problem in fundamental physics—the cosmological constant problem [9]: the vacuum zero energy density ρ_V contributed by known quantum fields is much greater than the current cosmic vacuum energy density ρ_0 based on cosmological observations

$$\rho_V \approx 10^{120} \rho_0 \quad (7)$$

The cosmological constant problem indicates that the quantum field theory and macroscopic dynamics need different background vacuum—absolute rest vacuum and expansion vacuum, and these two vacuums coexist at the same time. Classical physics also requires the existence of a static vacuum with extremely high density of energy. To explain the problem of inertial force in classical mechanics — Newton’s bucket experiment, origin of inertia, counterforce of inertial force etc. are all necessary to consider the interaction between accelerated motion and background space. A macroscopic object composed of microscopic particles that can pass through virtual processes of particles in the static vacuum of extremely high density establish a global connection with the primordial universe, resulting in various physical effects of accelerating motion. The background vacuum of the expanding universe and the static vacuum of virtual processes of quantum field theory are both spaces with zero force field intensity, and the two vacuums can coexist without mutual interference.

In physics, there exists a third kind of vacuum that coexists with the primordial rest vacuum and the comoving vacuum of the expanding universe: the vacuum of

a gravitational system, e.g. the vacuum of the local group of galaxies. Physicists mistakenly confuse this electrically neutral vacuum dominated by baryonic matter with the gravitationally neutral vacuum of the expanding universe. In physics, positrons, antiprotons are merely “antimatter” particles in the sense of electromagnetic interaction. However, on the scale of an expanding universe, the “antimatter” corresponding to attractive matter should be “dark energy”. Therefore, the so-called greatest mystery in physics—“the lack of antimatter” or “the asymmetry between matter and antimatter”—is actually just a result of confusing different levels of vacuum.

The principle of relativity, or the principle of the irrelevancy of velocity, prohibits the existence of any privileged frame of reference. On the contrary, as stated in the above section the identity of elementary particles requires that their dynamics must be constructed relative to an absolutely stationary inertial frame, and cosmological observations have confirmed that the cosmic vacuum is indeed a uniform, isotropic, and flat system of reference. Next, we demonstrate in Section 2 that the uniform translational motion relative to the stationary vacuum is an absolute motion generating a velocity field with quasi-bosons, and in Section 3 the so-called “relativistic effects” are just physical effects of the velocity field.

2. Velocity Field of Uniform Motion

2.1. Retarded Potential and Velocity Field

Let (χ, τ) denote spatiotemporal coordinates in the frame of reference comoving with the expanding cosmic vacuum. Any charge of long-range force (electrical charge or gravitational mass) cannot be an isolated mechanical object, because any movement of it will exchange energy with the cosmic vacuum. Even if a charge moves at a constant speed relative to the cosmic vacuum it also produces the transverse electromagnetic field or transverse gravitational field—“velocity field” with a newly added inertial mass depending on the speed.

The propagation speeds of electromagnetic field and gravitational field in vacuum both are the speed c of light in vacuum, the retarded potential of a point charge q (electrical charge or gravitational mass) moving at a speed of \mathbf{v} in vacuum is [10]-[13].

$$\phi = k \frac{q}{r - \mathbf{v} \cdot \mathbf{r}/c} \quad \mathbf{A} = \frac{\phi}{c^2} \mathbf{v} \quad (8)$$

with the origin of the radial vector \mathbf{r} being the position where the charge of force is located. It can be seen from Equation (8) that any translational motion of a charge or massive particle will generate a vector potential \mathbf{A} and its vortex field $\nabla \times \mathbf{A}$ in vacuum. For a uniformly moving charge of force with $\mathbf{v} = \text{const}$, the intensities (irrotational field \mathbf{E} and vortex field \mathbf{B})

$$\mathbf{E} = -\frac{1}{c} \frac{\partial \mathbf{A}}{\partial t} - \nabla \phi \quad \mathbf{B} = \nabla \times \mathbf{A} \quad (9)$$

form a Haverside ellipsoid that moves with the charge (shown in **Figure 1**), known

as the “velocity field” with the inertial mass

$$m = \gamma m_0 \quad (10)$$

where m_0 is the inertial mass of the static charge in the co-moving frame.

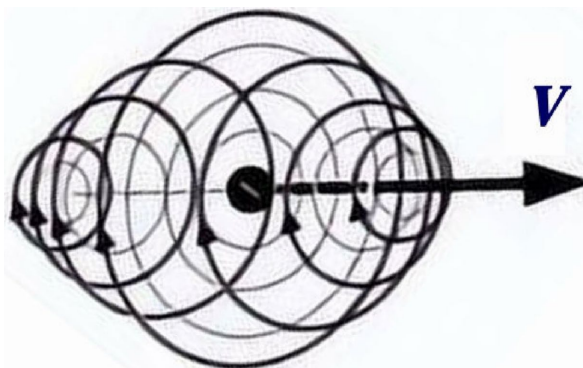


Figure 1. The transverse electromagnetic and/or gravitational field of a uniformly moving charge at a velocity V .

That the electromagnetic mass of a moving electric charge is proportional to the Lorentz factor was already discovered before the advent of relativity [14]. Experiments in particle physics have verified that Equation (10) is also valid for gravitational interaction, where m_0 is the proper mass of the particle. Therefore, the relativistic effect of mass is also the contribution of the velocity field.

2.2. Velocity Field as Displacement Current in Vacuum

After synthesizing the experimental laws of electricity and magnetism discovered by Coulomb, Gauss, Ampere, Faraday and introducing displacement current $\partial \mathbf{D} / \partial t$, Maxwell established the equation system of electromagnetic field in vacuum as

$$\begin{aligned} \nabla \cdot \mathbf{D} &= \rho \\ \nabla \cdot \mathbf{B} &= 0 \\ \nabla \times \mathbf{E} &= -\frac{\partial \mathbf{B}}{\partial t} \\ \nabla \times \mathbf{H} &= \mathbf{j} + \frac{\partial \mathbf{D}}{\partial t} \end{aligned} \quad (11)$$

with \mathbf{j} being the electric flux, $\mathbf{H} = k\mathbf{B}/c^2$ the magnetic field, $\mathbf{D} = \mathbf{E}/k$ the electric displacement, $k = k_e = 1/\epsilon_0$ and ϵ_0 the vacuum dielectric constant.

The most important contribution of Maxwell to electromagnetism is introducing the displacement current $\partial \mathbf{D} / \partial t$. Maxwell said his purpose is “to correct the equations of electric currents for the effect due to the elasticity of the medium” (quoted from [15]). Obviously, the “medium” Maxwell referred to is the vacuum, and the displacement current $\partial \mathbf{D} / \partial t$ is a physical process of the vacuum itself; That is to say, the vacuum medium itself and the processes within it are indispensable parts of electromagnetism.

From Maxwell’s Equation (11) the electromagnetic field equations in the vac-

uum without charge and electric current can be derived as

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t} \quad \nabla \times \mathbf{H} = \frac{\partial \mathbf{D}}{\partial t} \quad (12)$$

The above wave equations show that the displacement current $\partial \mathbf{D} / \partial t$ is a necessary condition for the existence of electromagnetic waves as well.

Although Maxwell once proposed a complicated model of molecular vortices to explain the displacement current, its physical origin is still unclear. Different from the electric current \mathbf{j} , the displacement current $\partial \mathbf{D} / \partial t$ should be electrically neutral current in the vacuum. Schwartz ([16] §3-4) has proved that the electrically neutral current generated by the opposite movement of positive and negative charges can produce a vector potential and consequently a magnetic field. The velocity field that moves along with an electric charge is a neutral current relative to the vacuum, it can naturally become the physical counterpart of the mystery displacement current and generate the magnetic field \mathbf{H} in the vacuum.

Therefore, to fully describe electromagnetic processes, it is not only necessary to consider the connection with the background vacuum through the velocity field, but also to take into account physical processes in the vacuum itself.

2.3. Quasi-Bosons Constituting Velocity Field

A static long range force in Euclidean vacuum that can be described by Faraday's lines of force must obey the inverse square law, that is, the field intensity generated at distance r from a point source of charge q

$$\mathbf{E}(\mathbf{r}) = k \frac{q}{r^2} \mathbf{r}_0 \quad (13)$$

where \mathbf{r}_0 is the unit vector in the direction of the line connecting the point source, and k is the medium constant of the vacuum; for electric field $k = k_e = 1/\epsilon_0$, for gravitational field $k = k_g = -4\pi G$ with G being the gravity constant. The two long-range force fields, the electric field of a static point charge and the gravitational field of a static massive particle, both follow the inverse square law, indicating that the comoving vacuum is indeed a flat and homogenous Euclidean space. The inverse square property of long range forces is determined by the geometric symmetry of the Euclidean space: Faraday force lines with a non-inverse-square force field cannot be drawn in uniformly isotropic space, or any long-range action with a non-inverse-square law cannot survive in a uniformly isotropic space.

The field of a static charge (electric charge or gravitational charge) in vacuum is an inverse square field (Coulomb field). The rest mass m_0 of charge is the inertia (inertial mass) of the spherically symmetric Coulomb field which can't be quantized. An external force applied to the charge will cause it accelerated motion and emit a radiation field composed of photons and/or gravitons, the work done by the external force is converted into the directionless energy (in three physical dimensions) and momentum parallel to the external force (in one physical dimension) for the moving charge system and radiation field. As the quantum of the

electromagnetic field, a photon with frequency ω possesses not only the energy $\hbar\omega$, but also the corresponding momentum $\hbar\omega/c$.

In Part I of Applications of Electrodynamics in Theoretical Physics and Astrophysics [10] Ginzburg emphasized that the velocity field of a moving charge as a transverse field can and also needs to be quantized, but the quanta do not reduce to photons, he called them “virtual-photons” or “pseudo-photons”:

For the transverse field carried along with a moving charge, $\omega = k \cdot v$, where v is the charge’s velocity. If we consider the respective quanta with the energy $\hbar\omega$, we can classify them as pseudophotons forming what is sometimes referred to as the ‘coat’ of the moving charge.

In order to distinguish the quanta in the velocity field from the “virtual-particles” or “pseudo-particles” arising from quantum fluctuations of the primordial stationary vacuum with zero temperature in quantum field theory of elementary particles, we tend to refer to them as “quasi-particles” which are quite similar with the quasi-bosons—phonons—in condensed matter field theory with non-zero temperature. Both are neutral massless quasi-bosons and have nothing to do with the virtual process. For example, the generation process of a particle-antiparticle pair in quantum field theory involves virtual processes in zero temperature vacuum, while the velocity field of a resulting free particle is composed of quasi-bosons with the same temperature as the ambient vacuum.

Unlike the mathematical vacuum corresponding to the inertial frame of reference in relativity, the primordial stationary vacuum, comoving vacuum, and other local vacuum in the observable universe are all homogeneous physical media with non-zero energy density. Phonons in solid state physics are used to describe the collective motion behavior in the medium of a condensed matter system with the condensed matter system’s temperature [17], and quasi-bosons of velocity field to describe the collective motion behavior in local cosmic vacuum with a temperature being the same as cosmic thermal phonons of the expanding cosmic vacuum described in Subsection 1.3.

In quantum field theory, virtual particles do not necessarily follow the law of energy conservation, but quasi-particles are physical entities and, like particles in mechanics, they all obey the law of conservation. The key difference between particles and quasi-particles is that they have different dispersion relationships—relationships between energy and momentum. The two kinds of quasi-bosons both no longer hold the momentum formula in mechanics

$$p = mv \tag{14}$$

and don’t carry physical momentum.

When bringing together relativity and Maxwell’s equations there exist difficulties associated with the concepts of electromagnetic energy and momentum, e.g. the 4/3 problem (see [11] §11.2.3, [14] Vol.2 §28, [18]). The field momentum p of a moving charge at a velocity v can be calculated, then with the momentum formula (14) the electromagnetic mass m can be derived as follows

$$m = \frac{4}{3}\gamma m_0 \quad (15)$$

which differs the relativistic Equation (10) by a factor of 4/3. This paradox has been the subject of much debate over the years. Up to now, quite a few calculations for the electromagnetic mass of a moving charge by applying interaction force between the charge and its field in accordance with the principle of relativity all result in the appearance of this excess factor of 4/3.

Bopp [19] used modified Maxwell's equations to overcome the difficulty, but his theory could not guarantee that the energy remained positive. Poincaré [20] once pointed out that if some non-electromagnetic interaction (Poincaré stresses) could be introduced then the relativistic relationship could be satisfied, however he did not propose any new physical mechanism. The force-free non-mechanical interaction between vacuum and uniformly moving charge through quasi-bosons could be exactly the non-electromagnetic interaction that Poincaré wanted.

For a moving charge at a constant velocity its inertial energy $m = \gamma m_0$ exists in the massless quasi-bosons of the velocity field. Quasi-bosons constituting the velocity field come from the vacuum medium, which must be electrically neutral and/or gravitationally neutral to meet the requirement of charge conservation. In mechanical dynamics, movement of objects and change of mechanical energy are caused by forces. An external force will endow a particle with momentum parallel to its velocity (one physical dimension) and undirected energy (three physical dimensions). Similar to processes of heat transfer but different from that in mechanical dynamics, conversion processes from static Coulomb fields to velocity fields and that of velocity fields from slower to faster are force-free processes. The motion mass m is the total inertial energy of a velocity field composed of quasi-particles without physical momentum and corresponding mechanical energy, which is the redundant $\gamma m_0/3$ in Equation (15).

Therefore, the velocity field physics is necessary to construct the theory of accurately expressing laws of motion. Just like the electron cloud in a closed circular orbit around an atomic nucleus and the Coulomb-type spherically symmetric field, the ellipsoidal transverse velocity field composed of quasi-bosons of a particle in uniform translational motion is another fundamental physical entity as well. In next sections we will show that the existence of velocity fields composed of quasi-bosons is essential for explaining many physical phenomena which are difficult to be, e. g. length contraction and time dilation in special relativity (Section 3), anomalous magnetic moment of electrons in quantum field theory (Subsection 5.5), and electromagnetic-gravity connection (Subsection 5.6), which are difficult to understand by rotation or bending of space-time.

3. Velocity Field and Special Relativity

3.1. Velocity Field Effects in Space-Time

A static charge q in the co-moving frame of the expanding vacuum is surrounded by a globally symmetric electric field with the scalar potential

$$\phi_0 = k_e \frac{q}{r} \quad (16)$$

When the charge being accelerated by an external force it will radiate electromagnetic waves propagating at the speed c of light in the vacuum, where c is a medium parameter that describes the physical property of the vacuum; when the acceleration process ended, the charge will be uniformly moving at a speed of v and surrounded by an ellipsoid velocity field with the scalar potential ϕ and vector potential A as shown in Equation (8), where the charge q is the same as that in Equation (16) because the invariance of gauge charge.

The velocity field Equation (8) of a moving charge follows the motion of the charge as the 'coat' of the moving charge [10], where the transverse field described by the vector potential A is the motion effect of charge. In the charge rest coordinate frame, $v = 0$, the vector potential A in Equation (8) is disappeared, the velocity field ('stationary velocity field') degenerated into a globally symmetric field with the scalar potential of (16), *i.e.* the scale of the 'stationary velocity field' is magnified by a factor of γ times in the direction of motion compared to the ellipsoid of the velocity field, or the scale in the motion frame is reduced by a factor of γ times (Lorentz contraction). A moving charge q in its rest coordinate frame just like a static charge q in the co-moving frame of the expanding vacuum surrounded by a globally symmetric electric field with the same scalar potential of (16) and during processes of acceleration by external forces may emit free photons into the vacuum at the velocity c —the velocity of light being independent of the motion of the light source.

The 'stationary velocity field' no longer has momentum, but still retains the energy (inertial mass) determined by Equation (10). The 'stationary velocity field' like a 'moving Ether' with inertia, it makes classical mechanics no longer able to accurately describe mechanical motion; but its mechanical inertia does not affect the propagation of light in vacuum, which is the physical reason for the constancy of the speed of light.

In classical mechanics and relativistic mechanics, all inertial reference frames of spacetime coordinates (x, t) are established in a mathematical vacuum—empty space of nothing. As shown in Subsection 1.2 of this article, the comoving frame (χ, τ) of the expanding cosmic vacuum is an absolutely stationary frame of reference, one can construct an inertial frame of reference (x', t') moving along the direction of χ_1 -axis at the velocity v , its x'_2 and x'_3 axes are parallel to χ_2 and χ_3 respectively, the x'_1 -axis coincides with χ_1 -axis, and on $\tau = t' = 0$ the origins coincide. The Lorentz contraction and invariance of light speed cause the two sets of coordinates in the rest frame (χ, τ) and moving frame (x', t') follow the following space transformation

$$x'_1 = \gamma(\chi_1 - v\tau) \quad x'_2 = \chi_2 \quad x'_3 = \chi_3 \quad (17)$$

and time transformation

$$t' = \gamma\left(\tau - v\chi_1/c^2\right) \quad (18)$$

where $\gamma = 1/\sqrt{1-v^2/c^2}$ is a parameter completely describing the Haverside ellipsoid of the transverse field of the moving charge at velocity v in the cosmic vacuum.

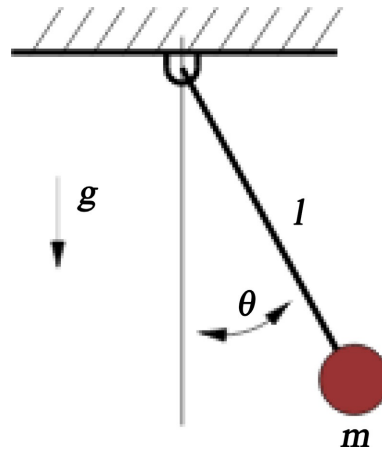


Figure 2. A single pendulum.

The energy and momentum possessed by the velocity field of a mechanical system affect physical processes of the system, thereby affect the measurement of spatiotemporal coordinates. For example, if time is calibrated in units of the period of small vibrations of a single pendulum shown in **Figure 2**, in the comoving vacuum (χ, τ) , the small vibration period of a single pendulum with a length l is $P = \sqrt{l/g}$. In the inertial frame moving relative to the comoving vacuum at velocity v , the motion mass of the velocity field increases the inertia of the swinging system by times of γ , while the gravitational mass remains unchanged, which is equivalent to a decrease in the gravitational acceleration of a simple pendulum to $g^* = g/\gamma$, thereby increasing the unit of time measurement in the motion frame. Because of Lorentz contraction, the measurement result of length l in the motion frame should be $l^* = \gamma l$, then the time scale unit in the motion frame should be $P^* = \gamma P$ (time dilation).

In classical mechanics, spacial interval Δl and time interval Δt are invariant in Galilean coordinate transformations. The effects of velocity field, such as change of its geometric scale resulting in Equation (17), and change of its inertial mass described resulting in Equation (18), make the Galilean relativity invalid and then intervals Δl and Δt no longer invariant, but the spacetime interval

$$\Delta s^2 = \Delta l^2 - c^2 \Delta t^2 \quad (19)$$

is invariant under the spatiotemporal coordinate transformation between moving inertial frame and absolute rest frame.

3.2. Approximate Nature of the Postulate of Relativity

The constancy of the light speed and the principle of relativity are two basic postulates of the special theory of relativity. The principle of relativity holds that rest and uniform linear motion have only relative meaning, or that all inertial frames

of reference moving rectilinearly and uniformly relative to one another are equivalent, and there is no superior rest frame. The special relativity replaces the comoving frame (\boldsymbol{x}, τ) of cosmic vacuum with the particle rest frame (\boldsymbol{x}, t) , and asserts that the spacetime interval (19) remains invariant under the following Lorentz transformations: the space transformation

$$x'_1 = \gamma(x_1 - v\tau) \quad x'_2 = x_2 \quad x'_3 = x_3 \quad (20)$$

and time transformation

$$t' = \gamma(t - vx_1/c^2) \quad (21)$$

with $\gamma = 1/\sqrt{1 - v^2/c^2}$ and v the velocity of the moving frame (\boldsymbol{x}', t') relative to the particle rest frame (\boldsymbol{x}, t) .

However, the principle of relativity can be held only for closed systems [12]. It has been pointed out in Subsection 2.3 that due to neglecting the velocity field of uniform motion in vacuum, the special theory of relativity fails to correctly handle the quasi-particle nature of the velocity field medium in vacuum and the non-force nature of its connection with the moving charge. As a result, a serious error of an excess factor of 4/3 appears in Equation (15) for the motion mass.

Even if we bypass the 4/3 problem by using Equation (10) instead of Equation (15) to calculate motion masses, the special theory of relativity can be effective only under specific condition.

It must be noted that in the previous subsection “Velocity Field Effects in Space-Time” the values of v and γ in the transformations (17) and (18) are relative to the comoving frame (\boldsymbol{x}, τ) of cosmic vacuum (absolute rest frame), while in (20) and (21) relative to the particle rest frame (\boldsymbol{x}, t) (relative rest frame).

In an inertial reference frame, measuring spatial intervals using the propagation law of light does not require the use of clocks [12]. The “Lorentz contraction” of the interval between a rod in the moving frame relative to the rest frame is the simple consequence of the geometric scale change of the velocity field. As mentioned in the previous subsection, since the transverse field of a moving charge is merely a motion effect, its field in the charge rest frame is the same as that of a rest charge in the co-moving frame of the cosmic vacuum—both are the same isotropic scalar field. Therefore, the Lorentz contraction described by Equation (20) is valid, or in other words, the postulate of relativity is valid in kinematics.

But the time transformation Equation (21) is not precisely valid. Because the change of time scale of a moving system comes from that of inertial mass of the velocity fields, the rest frame in the time transformation Equation (21) must be the comoving vacuum, not particle rest frame, and v is the velocity relative to the absolute rest frame.

In general, the relativity of kinematics can't be expanded to dynamics. The mass m_0 in Equation (1) and Equation (10) is the proper mass of a particle, and any peculiar motion of the particle relative to the co-moving vacuum will obtain inertial mass from the vacuum to generate a velocity field, and make the inertial mass of the particle in its rest system (rest mass) greater than its proper mass; In Equ-

tion (10), the rest frame can only be the absolute static frame for the particle. Particles of the same kind have the same proper mass and charge. From the discussion on “Identity of Particles” in Section I we see that velocity fields and the identity of particles require that the absolute static frame of reference of all particles should be the same one—the co-moving vacuum of the expanding universe.

For any dynamic process, the static cosmic frame (χ, τ) is a superior rest inertial frame of reference, any dynamic law must be expressed relative to the absolute static frame (χ, τ) , for example, in Equation (1) or Equation (10) of moving particle mass, $m = m_0 / \sqrt{1 - v^2/c^2}$, the rest mass m_0 can only be that in the static cosmic vacuum, and v the particle’s velocity in the comoving frame of reference. But in the theory of relativity, m can be the mass of a particle moving in any inertial frame at velocity v , and m_0 the mass in the particle rest system.

Therefore, the special relativity is an approximate theory effective under the condition of the relative velocity v between the two frames being much greater than $v_0 \sim 10^{-3}c$ which is the speed of the Earth relative to the expanding cosmic vacuum, *i.e.* the Doppler velocity observed by the CMB dipole anisotropy [1].

4. Long-Range Gauge Fields

We demonstrate in this section that for long-range force fields (electromagnetic field and gravitational field), the gauge invariance (conservation of charge) not only requires that the cosmic vacuum be uniform, isotropic, and flat, but also ensures that the gauge conditions guarantee the cosmic vacuum being stationary and neutral (electrically neutral and/or gravitationally neutral). The scalar potential (describing irrotational fields) and vector potential (vortex fields) are sufficient and necessary mathematical tools for dealing with vector fields in flat spacetime, and the vector potential of gravity is a necessary and effective tool for dealing with strong gravitational fields in astrophysics.

4.1. Helmholtz Decomposition Theorem

The static long-range force field with continuous distribution of charge density ρ is an irrotational field, its field strength \mathbf{E} can be described by using a scalar potential

$$\mathbf{E} = -\nabla\phi \quad (22)$$

and the divergence of the strength of the field $\nabla \cdot \mathbf{E} = k\rho$, then the equation of the static field described by the scalar potential is

$$\nabla^2\phi = -k\rho \quad (23)$$

There is only irrotational fields in a coordinate frame where charges of long-range forces being static, and any motion relative to the static system, including uniform linear motion, must produce a vortex field. In a coordinate frame, the vortex field can be used to judge whether the frame is moving, so the static frame and the moving frame have different weights. Similarly, a static point charge of long-range force only produces an irrotational field, while its motion must pro-

duce a vortex field: uniform motion has definite physical effects.

For various dynamic systems including motion, interaction and transformation of different matter/energy forms, the conservation law—conservation of energy, momentum and angular momentum—is a universal law supported by extensive experiments. Noether's theorem shows that the conservation of energy reflects the uniformity of time, and the conservation of momentum and angular momentum reflect the uniformity and isotropy of spatial position space, respectively. A physical system following the law of conservation needs to be described in uniform time and uniform and isotropic spatial position space.

The background space-time of classical mechanics is the Galilean space consisted of the three dimensional Euclidean space χ and uniform passage time τ . The time component τ of the Galilean space is independent with the spatial space χ . Precise measurements of the CMB radiation show that the expanding universe satisfies the cosmological principle, it is indeed highly homogeneous and isotropic. In describing peculiar motions of objects relative to the uniform and isotropic expansion of the universe, the comoving coordinate system expanding along with the universe can be regarded as a inertial frame in Galilean space, it is a stationary inertial frame for any local system in the universe, and its time component τ can be measured by the temperature or energy density of the expanding universe.

Two different reference frames S and S' can be used to describe the motion of the same free particle in Galilean space, where S' relative to S along χ_1 direction moves at a speed of v . (χ, τ) and (χ', τ') are the spatial position and time coordinates measured by the particle in S and S' respectively. If coordinates of the particle in S' and S obey Galileo transformation

$$\begin{aligned}\chi'_1 &= \chi_1 - v\tau & \chi'_2 &= \chi_2 & \chi'_3 &= \chi_3 \\ \tau' &= \tau\end{aligned}\tag{24}$$

then Newton's laws of motion will have the same form in two coordinate frames, that is, Newtonian mechanics is Galilean covariant.

In Galileo transformation, the uniform translational motion of an inertial coordinate frame only results in changes of spatial position coordinates of objects; Galileo relativity is interpreted as the static or translational motion of an inertial frame has only a relative meaning, and within an inertial frame, it is impossible to determine whether the frame is static or moving. The translational motion of an inertial frame will change the motion speed of a particle, so the static or uniform motion of a particle has only a relative meaning.

However, the effect of translational motion is not only changing spatial coordinates of particle position. For vector analysis of Euclidean space, there is Helmholtz theorem: In a finite region V , any bounded continuous vector function (vector field) that is uniquely determined by its divergence, curl and boundary conditions, can be expressed as

$$\mathbf{F}(\mathbf{r}) = -\nabla\phi(\mathbf{r}) + \nabla \times \mathbf{A}(\mathbf{r})\tag{25}$$

with

$$\phi(\mathbf{r}) = \frac{1}{4\pi} \int_V \frac{\nabla' \cdot \mathbf{F}(\mathbf{r}')}{|\mathbf{r} - \mathbf{r}'|} dV' - \frac{1}{4\pi} \oint_S \frac{\mathbf{n}' \cdot \mathbf{F}(\mathbf{r}')}{|\mathbf{r} - \mathbf{r}'|} dS'$$

$$\mathbf{A}(\mathbf{r}) = \frac{1}{4\pi} \int_V \frac{\nabla' \times \mathbf{F}(\mathbf{r}')}{|\mathbf{r} - \mathbf{r}'|} dV' - \frac{1}{4\pi} \oint_S \frac{\mathbf{n}' \times \mathbf{F}(\mathbf{r}')}{|\mathbf{r} - \mathbf{r}'|} dS'$$

where both ∇' and \mathbf{n}' are calculated for the coordinate of the source point \mathbf{r}' [21].

Helmholtz theorem (25) shows that vector fields generated by different physics processes in Euclidean space can be expressed as a sum of two components: irrotational field—the gradient of a scalar potential ϕ (zero-order tensor), and vortex field—the curl of a vector potential \mathbf{A} (first-order tensor).

For a finite system, the motion of the reference frame will cause the kinetic energy T of the system to increase, but the potential energy V will not change, breaking the condition of energy conservation. Moreover, the vortex field is not a conservative force field. In classical dynamics, no isolated system can exist. For any mechanical system, the process of generating the vortex field from the movement of a force charge must be accompanied by the mutual transformation of the charge and other material/energy forms. Classical mechanics ignores the vortex field generated by motion, and also ignores the existence of other material/energy states except the point force charge and its mechanical motion, making classical mechanics only a quasi-static approximation of particle dynamics at low speed.

4.2. Helmholtz Theorem in Lorentz Space

The geometric symmetry of Euclidean space determines that static long-range forces must follow the inverse square law Equation (13). The electromagnetic and gravitational interactions are both local interactions with a finite propagation speed in vacuum c . For a charged or massive particle moving in the comoving frame, the dynamic force field is the velocity field Equation (8)—a combination of irrotational and vortex fields determined by the retarded scalar potential ϕ and vector potential \mathbf{A} which are formed from the connection between the cosmic vacuum and the long-range force charge plus the finiteness of the force propagation speed.

The construction history of electrodynamics shows that for dynamic systems with charge density ρ and current intensity \mathbf{j} , we can take the 4-vector potential including the speed of light and imaginary unit

$$A = (\mathbf{A}, i\phi/c) \quad (26)$$

as generalized coordinates, and construct Lagrangian density of free field as

$$\mathcal{L} = -\frac{1}{2} \left(\frac{\partial A_\mu}{\partial x_\nu} - \frac{\partial A_\nu}{\partial x_\mu} \right) \frac{\partial A_\mu}{\partial x_\nu} \quad (27)$$

then the principle of least action can be used to derive the motion equation of a free field in vacuum

$$\begin{aligned} \left(\nabla^2 - \frac{1}{c^2} \frac{\partial^2}{\partial t^2} \right) \phi &= -k\rho \\ \left(\nabla^2 - \frac{1}{c^2} \frac{\partial^2}{\partial t^2} \right) \mathbf{A} &= -\frac{k}{c^2} \mathbf{j} \end{aligned} \quad (28)$$

and the field equations for the irrotational field \mathbf{E} and vortex field \mathbf{B} are as follows

$$\mathbf{E} = -\nabla\phi - \frac{\partial\mathbf{A}}{\partial t} \quad \mathbf{B} = \nabla \times \mathbf{A} \quad (29)$$

which can be seen as Helmholtz theorem in Lorentz space: the vector field of a local long-range interaction system is determined by the scale potential ϕ and vector potential \mathbf{A} .

4.3. Gauge Conditions: Neutrality and Stationary of Vacuum Medium

In Lorentz space—four-dimensional local configuration space (ict, \mathbf{x}) , the field strength of a long-range force (electromagnetic force or gravitational force) can be described by a second-order tensor

$$F_{\mu\nu} = \frac{\partial}{\partial x_\nu} A_\mu - \frac{\partial}{\partial x_\mu} A_\nu \quad (30)$$

The field strength vectors \mathbf{E} and \mathbf{B} are components of the field strength tensor $F_{\mu\nu}$. The force field $F_{\mu\nu}$ is a gauge field: for any spatiotemporal function λ , it remains invariable under the vector potential gauge transformation $\mathbf{A} \rightarrow \mathbf{A} + \partial\lambda$, *i.e.* the transformations

$$\phi \rightarrow \phi - \frac{1}{c} \frac{\partial\lambda}{\partial t} \quad (31)$$

and

$$\mathbf{A} \rightarrow \mathbf{A} + \nabla\lambda \quad (32)$$

The gauge invariance of long-range force field corresponds to the conservation of force charge (electric charge or gravitational mass) of a mechanical system.

It is generally believed that additional gauge conditions can be arbitrarily chosen in order to determine the gauge invariant equation of a long-range field. However, the sign and value of a scalar potential at any spatial position should be measured relative to the zero scalar potential rather than to a scalar potential at an arbitrary position in space. Therefore, the background space describing long-range force systems should be the vacuum of zero scalar potential with no net charge of force—the electrically and gravitationally neutral vacuum.

For the scalar potential ϕ measured relative to the neutral vacuum, in the gauge transformation (31) the derivative of the scalar function λ with respect to time should be zero, *i.e.*

$$\frac{\partial\lambda}{\partial t} = 0 \quad (33)$$

The Coulomb gauge condition is usually adopted for the three-dimensional vector potential, it is required

$$\nabla \cdot \mathbf{A} = 0 \quad (34)$$

The Coulomb gauge requires that any scalar function λ in the gauge transformation (32) must be satisfied

$$\nabla^2 \lambda = 0 \quad (35)$$

The Coulomb gauge is a reasonable physical condition, that is, the vector potential describes the source free field produced by motion and variation of force source, excluding the field by fixed charge of force described by scalar potential.

For a long-range force field, the background space for scalar potential and that for vector potential should be the same neutral background vacuum. Like the scalar potential, the vector potential of the background vacuum should also be zero. Otherwise, the axial symmetry of magnetic-type vortex field generated by the vector potential will cause anisotropy in background space and destroy the inversion symmetry of space. There is another gauge condition—the Lorentz gauge

$$\frac{\partial \phi}{\partial t} + \nabla \cdot \mathbf{A} = 0 \quad (36)$$

Which requires that in the background space of gauge fields there is not only no conduction current of positive or negative charge, but also no current of neutral medium — no displacement current: the vector potential should be everywhere zero.

In addition to gauge invariance (conservation of long-range force charge) and gauge conditions, that cosmological observations (Subsection 1.1), the identity of elementary particles (Subsection 1.2), the velocity field of uniformly motion and its quasi-bosons (Section 2) and the absoluteness of dynamics (Subsection 3.2) all require the cosmic vacuum being a resting inertial frame of reference with neutral medium of high density of energy. Furthermore, the neutrality of the medium of cosmic vacuum is not only a necessary condition for the two long-range forces, electricity and gravity, to meet the conditions of gauge invariance, but also a prerequisite for the establishment of a model of cosmology satisfying the principle of cosmology.

Electrical charge and gravitational mass are gauge charges in flat spacetime, and the gauge invariance requires the conservation of force charges. For conserved charges (gauge charges), the gauge invariance requires the background inertial frame being not only a neutral vacuum of force-free field with positive and negative charges balanced to each other, but also a stationary frame of reference. The neutral cosmic vacuum provides a common stationary spacetime framework for various physical processes.

Special relativity confuses the inertia (motion mass) of a velocity field with the gauge charge of electricity or gravity, breaking gauge invariance; General relativity not only equates inertial mass with gravitational mass, but also bends spacetime, breaking gauge invariance, making gravity unable to be quantized and thermal-

ized, and fundamentally breaking the conditions for the establishment of physical conservation laws. The special relativity not only does it exclude the cosmic vacuum from mechanical systems and replace physical effects of velocity fields with so called ‘space-time conversion’, making relativistic dynamics only an approximate theory, but as shown in Subsection 2.3 of this article, it also leads to serious inconsistency in special relativity by mistaking non-force effects of quasi-bosons in the velocity field of uniform motion.

4.4. Vector Potential of Gravity

The general relativity equates inertial mass with gravitational mass, assumes the cosmic vacuum to be a curved spacetime dominated by attractive gravity, and abandons vector potential (first-order tensor) without reason, then describes the gravitational field by a nonlinear equation about the metric $g_{\mu\nu}$ (second-order tensor) as

$$G_{\mu\nu} = -8\pi G T_{\mu\nu} \quad (37)$$

where $T_{\mu\nu}$ is the energy-momentum tensor, and the Einstein tensor

$$G_{\mu\nu}(g_{\mu\nu}, \dot{g}_{\mu\nu}, \ddot{g}_{\mu\nu}) = R_{\mu\nu} - \frac{R}{2} g_{\mu\nu} \quad (38)$$

with $R_{\mu\nu}$ being the Ridge tensor with trace R and $g_{\nu\mu} = g_{\mu\nu}$.

The highly nonlinear equations (37) of general relativity, which contain 10 unknown independent functions for four dimensional variables of space-time $g_{\mu\nu}$, and 40 first-order derivatives and 100 second-order derivatives that describe how $g_{\mu\nu}$ changing from space and time, cannot be solved accurately. The only solution can be derived from the field Equation (37) of general relativity is the schwarzschild solution for the completely central symmetric field of gravity, and even the most simple two-body problem also cannot be solved accurately with the equation of general relativity.

By analyzing the high quality data of earth tide observed from the Shiquanhe earthquake station in Tibet and Wushi station in Xingjiang during the total solar eclipse in July 2009, Tang Ke-Yun and his collaborators [22] found that the propagation velocity of gravitational interaction is $(0.93 - 1.05)c$ with relative error $\sim 5\%$, showing that like electricity, gravity is also a local interaction. For two long-range forces—electricity and gravity, their static fields are both inverse-square fields Equation (13), and their dynamic fields of uniform translational motion relative to the comoving frame are both ellipsoidal transverse field described by the retarded potential—velocity field (see Equation (8) and **Figure 1**). In the condition that the connection between the background vacuum and dynamic charges of gravity being not ignored, and realizing that all forms of energy possess corresponding inertial masses and the so called “gravitational mass” is only the charge of gravity, then, just like in electromagnetism, the linear Equation (29) of 4-vector potential A can also be used to describe the gravitational field, including the velocity field of uniform motion and the radiation field of force propagators.

It has been recognized that, except Mercury's precession, all other so-called effects of curved spacetime in general relativistic can and can only be treated with the linear field equations of gravity. For example, in the textbook "Gravitation and Spacetime" written by Ohanian and Ruffini [23], the quantitative treatments for so called "effects of general relativity" such as gravitational time dilation, deflection of light, time delay of light, gravitational lenses, Lense-Thirring effect, gravitational time dilation and gravitational waves have already been completed in Chapter 4 and Chapter 5, while the general theory of relativity and Einstein's field equation were not introduced until Chapter 7. Furthermore, Zhou Zai has derived out the linearized equation of the Einstein field Equation (37) being exactly the same with Maxwell Equation (28) where $k = -4\pi G$ ([6] Appendix 1 "Linearized Gravitational Field Equation").

However, even for Mercury's precession problem, Hu Jian has proved that Mercury's orbit is really closed in the curved Schwarzschild Field without any precession, the result of 43 "/century for Mercury's precession can be derived only after linearising the Schwarzschild geometry ([6] Appendix 2 "Track Stability in the Schwarzschild Field"), and Tang Ke-Yun calculated the precession of Mercury's perihelion by using the linearized field equation of general relativity and retarded potential of gravity, obtained the same result of 43 "/century ([6] §2.4.1).

So far, all the so-called "effects of general relativity" that have been observed and confirmed are actually just the effects of gravitational vector potential. Therefore, processes of "relativistic gravity" and that of "relativistic electrodynamics" both are physical processes of transverse velocity fields described by vector potentials (first-order tensor) of moving long-range forces. The linear Maxwell equations are effective theoretical expression for both relativistic electrodynamics and relativistic gravity. The linearization and post Newtonian approximation used for weak fields in general relativity really just reduce the second-order tensor in curved spacetime to the first-order tensor (vector potential) in flat spacetime. For strong gravitational field processes in astrophysics, such as the process of celestial bodies merging to generate gravitational waves or compact object process, the gravitational field Equation (28) or Equation (29) in flat spacetime can be and should be directly used to handle them.

4.5. Gravitational Waves

From Maxwell Equation (29) for gauge fields the field equations of gravitation in vacuum are as follows

$$\begin{aligned}
 \nabla \cdot \mathbf{g} &= -k\rho_m \\
 \nabla \cdot \mathbf{b} &= 0 \\
 \nabla \times \mathbf{g} &= -\frac{\partial \mathbf{b}}{\partial t} \\
 \nabla \times \mathbf{b} &= \frac{1}{c^2} \left(k\mathbf{j}_m + \frac{\partial \mathbf{g}}{\partial t} \right)
 \end{aligned} \tag{39}$$

where \mathbf{g} is the irrotational electric-type gravity strength, \mathbf{b} the vortex mag-

netic-type gravity strength, ρ_m the density of gravitational mass, j_m the density of mass flux, and $k = k_g = -4\pi G$.

Let $\rho_m = 0$ and $j_m = 0$ in Equation (39), we get the gravitational wave equation in vacuum

$$\begin{aligned}\nabla \cdot \mathbf{g} &= 0 \\ \nabla \cdot \mathbf{b} &= 0 \\ \nabla \times \mathbf{g} &= -\frac{\partial \mathbf{b}}{\partial t} \\ \nabla \times \mathbf{b} &= \frac{1}{c^2} \frac{\partial \mathbf{g}}{\partial t}\end{aligned}\quad (40)$$

Whether the existence of gravitational waves can be deduced from the field Equation (37) of general relativity is a controversial question that has been debated for a long time, and even Einstein himself has vacillated between two opposing views [24]. Although gravitational waves have been successfully detected, their fundamental conflict with the principle of general relativity has not been resolved. Similar to Mercury precession, the nonlinear Equation (37) of general relativity must be linearized in the analysis and interpretation of detection data of gravitational waves. However, the existence of gravitational waves is an inevitable consequence of the gauge field Equation (39) of gravity in flat spacetime. When dealing with gravitational waves, linear Equations (39) and (40) can be and should be directly applied without artificially bending spacetime first and then linearizing it through tedious calculations of post-Newtonian approximation.

An objection to dealing with gravitational waves in flat spacetime is the existence of electric dipole moment for electromagnetic waves, but there is no dipole moment in waves of gravity. In fact, the non-existence of mass dipole has nothing to do with the gravitational field Equation (37) of general relativity. The electromagnetic waves and gravitational waves observed so far are localized waves propagating in the vacuum medium of the local supercluster, which is electrically neutral but not gravitationally neutral, and this physical condition dictates that the multipole expansion of gravitational waves can only begin with mass quadrupole moment.

4.6. Accretions, Jets and Cosmic Rays

The most luminous objects in the universe, such as close binary neutron stars or stellar black holes, active galactic nuclei and quasars are powered by gravity through accretion. The collapse process of forming dense celestial bodies is inevitably accompanied by changes in the form of the collapsed material. After all protons are converted into neutrons, causing electromagnetic effects to disappear, further collapse will transform matter into dark matter with only gravitational effects. If the collapsing high-density matter can push dark energy to the center of a dense celestial body, its outward repulsive ultra-high pressure can prevent the formation of a singularity, then a dense celestial body can have a repulsive hard core without singularity.

A long-standing difficulty with existing supernova explosion mechanisms is the need for an unknown mechanism to produce an outward impact in order to achieve an explosion. If a high-density dark energy core is formed during the collapse of the star, it can provide a more powerful outward ram, thus solving the difficulties of the supernova explosion mechanism.

The space motion of pulsars is generally thought to be due to the recoil of asymmetric material ejections during supernova explosions. China's Five-hundred-meter Aperture Spherical radio Telescope FAST [25] obtained for the first time the rotation direction of the pulsar PSR J0538+2817 in three-dimensional space and space motion direction. The difference is only about 5 degrees. The model of collapsing mass impacting the central hard core during supernova explosion may reproduce the above unexplained directional association phenomenon.

The existence of jets is a common feature of compact objects. For example, the observed jet Porphyron [26] moving at close to the speed of light with the amount of energy released being equivalent to that of trillions of suns remains straight at a distance more than ten million light-years. Attempting to explain such a huge energy flow of matter with almost completely parallel continuous emission by electromagnetic mechanism, the required conditions such as large-scale, regular, polar and strong magnetic fields that are almost impossible to achieve in practice.

However, both the accretion disks of dense objects and the rapidly rotating objects themselves are extremely dense annular material flows. As a general feature of dense celestial systems, it is the jets that indicate the existence of super-strong gravitational vector potentials.

Accretion process forms density j_m of mass flux and vector potential A of gravity near a compact celestial object

$$\left(\nabla^2 - \frac{1}{c^2} \frac{\partial^2}{\partial t^2} \right) A = -\frac{k}{c^2} j_m \quad (41)$$

The gravitational vector potential A of an annular material flow will produce the axial magnetic gravitational dipole field

$$\mathbf{b} = \nabla \times A \quad (42)$$

The axial gravitational dipole field of a compact celestial body not only can limit the lateral movement of mass in jet through its induced annular material flow, but also, according to Lenz's law, the direction of axial magnetic gravitational dipole of the compact body caused by accreting clumps is opposite to that of induced gravitational dipole in jet, their repelling each other could also accelerate material movement of jet, it is consistent with observed jet flows being usually bilateral.

The Chinese X-ray astronomical satellite *insight*-HXMT has conducted long-term observations to the black hole binary MAXI J1820+070, the obtained power density spectra in different energy bands of 1-250 keV and structures of high-energy X-ray oscillations near the black hole event horizon present a feature that collapsing mass blocks impinge on the black hole's hard core causing jet precession [27]. The observation of MAXI J1820+070 by *insight*-HXMT also shows that

during the explosion, the hot plasma (corona) near the black hole binary escaped from the attraction of the black hole and moved outward at high speed, and the closer to the black hole, the faster its escape speed [28]. This picture suggests that, in addition to the spherically symmetric attractive field produced by the black hole, there is probably a strong magnetic-type gravitational field in the direction of revolving axis of the accretion disk and the black hole, challenge the jet model based on electrodynamics and magnetohydrodynamics.

Along with the flow of accretion material spiraling infinitely toward the core of a compact object, the density j_m of mass flow will increase infinitely, and the axial magnetic gravitational force will accelerate outflow particles infinitely. The Tibet As- γ experiment [29] and the Large High Altitude Air Shower Observatory LHAASO [30] have detected cosmic photons with energies up to PeV in the direction of neutron stars and black holes in the Milky Way, indicating that countless compact objects in the universe are likely to be gravitational field accelerators of ultra-high energy particles.

5. Quantum Processes with Velocity Fields

5.1. Physical Pictures of Microprocesses

From Subsection 1.2 “Identity of Particles” we know that the microscopic processes must be described relative to the co-moving reference frame of the expanding universe. An electron at rest in the co-moving vacuum is not a point-like particle, its spatial position is just the location of its charge q , and all its energy—proper mass or proper inertia m_0 —is diffusely distributed in a Coulomb field which is a globally symmetric field and can’t be quantized independently.

A uniformly moving electron is also not a point particle, its energy $m = \gamma m_0$ is diffusely distributed in the Havenside ellipsoid of velocity field which is moving with the charge of the electron and composed of quasi-bosons.

With the velocity field the wave nature of a moving electron is easy to understand. The velocity field can be expanded into plane waves in vacuum [31]. As shown in **Figure 3**, the moving electron always exists in the form of diffused

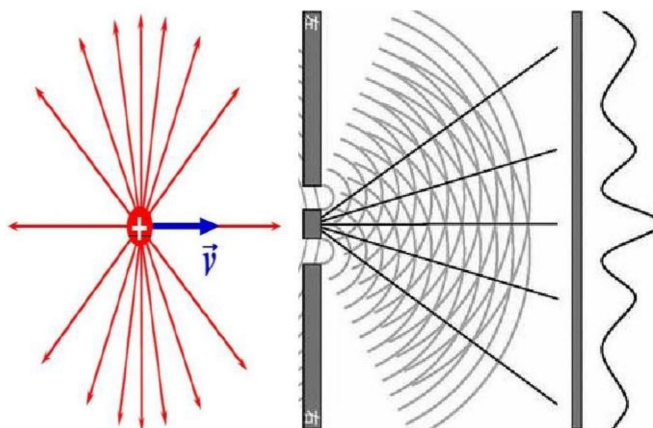


Figure 3. Electron two-slit experiment.

waves until its position being measured by the fluorescent screen (detector) and collapsing into a point-like particle on the screen. Therefore, what passes through the slits is the wave packet—velocity field, not a point-like particle, and what propagate between the slits and the screen is also not a point-like particle, but diffracted waves. The point-like particle only appear after the process of diffracted waves collapsing, which is different from the pilot-wave theory of deBroglie and Bohm [32], where a particle moves along a deterministic trajectory under the influence of the wave function ψ .

With the physics of velocity field composed of quasi-bosons, the wave function ψ describes the motion of the velocity field—spatial distribution of intensities of velocity field that varies over time. It is generally believed that a microscopic particle moves together with its energy. However, in the physics of velocity field, the energy of the moving particle is distributed in the particle's wave packet, and the energy of the wave packet comes from the local vacuum energy. The energy density at each point of the wave packet depends on the phase distribution of harmonics consisting of the packet at that point. That is to say, the transport of particle energy depends on the transmission of the phase of the wave packet. The process of the wave packet collapsing onto the screen is a random process. Different to the motion randomness of a Brownian particle caused by collisions with molecules of the surrounding medium, the randomness of wave packet's collapse is the manifestation of its own wave nature and fluctuations in quantum-level. The conservation law of energy and normalization of probability make that the probability distribution of particle spatial position on the screen after collapse should be proportional to $|\psi|^2$.

5.2. Two Kinds of Vacuum Fluctuations

There are two types of vacuum fluctuations in the two vacuums: quantum fluctuations in zero temperature stationary vacuum and temperature fluctuations in expanding vacuum. The proper parameters of quantum particles are formed through the former, while CMB anisotropy is a manifestation of the latter.

The quadrupole of CMB anisotropy announced by the *WMAP* group is significantly lower than that predicted by the standard cosmology model, and oddly aligned along the scan pattern of the satellite called the “axis of evil”. We pointed out that the “axis of evil” is due to the effect of the absolute motion of satellites relative to the comoving vacuum, the contamination from the Doppler dipole in observed data has not been fully removed, and proposed an approach to remove the residue scan-induced anisotropy [33]; after removing the residue dipole contamination we finally obtained a negative result of CMB quadrupole $Q = -3.2 \pm 3.5$ [34]. The CMB quadrupole corresponds to the temperature fluctuation power at $\sim 90^\circ$ angular scale or at the very early epoch with a redshift of $z \sim 90$. The zero quadrupole does not indicate that there were no quantum fluctuations in the very early universe, but rather that the vacuum of the very early universe was a zero temperature vacuum without temperature fluctuations.

Local long-range interactions with a finite propagation speed, as well as particles and physical systems of various scales, are all generated during the uniform isotropic expansion of the universe. Understanding the generation and interaction of particles not only requires field theory based on quantum fluctuations of the zero temperature vacuum, but also need to consider fluctuations in the thermal process of the expanding vacuum.

5.3. Quantization: Radiation Field and Velocity Field

For the gravitational field in flat spacetime we only need to take gravitational mass as charge of long-range force and interaction strength parameter as $k = k_g = -4\pi G$, then the equations of long-range force field in Lorentz space—the Lagrange density (27), four-dimensional vector potential Equation (28), field strength equation (29)—become equations for gauge gravitational field of U(1). The gauge gravitational field equation can be quantized by just following the steps of realizing the quantization of electromagnetic field, so that all interactions in the macro and micro fields can be attributed to the gauge field based on Lie group.

After the quantization of the gauge gravitational field, in addition to photons γ in the standard particle model, gravitons γ_m should be added to gauge bosons transmitting long-range interactions. For a charged particle with a gravitational mass of M , in addition to the interaction between electric charge and electromagnetic field, there are also the interaction between gravitational mass and gravitational field. In the international system of units, the fine structure constant that characterizes the strength of electromagnetic interaction ($e-\gamma$ coupling) is

$$\alpha = \frac{1}{4\pi\epsilon_0} \frac{e^2}{\hbar c} \quad (43)$$

Then the constant characterizing the coupling strength of $M-\gamma_m$ should be

$$\alpha_m = G \frac{M^2}{\hbar c} \quad (44)$$

Since the gravitational constant G is very small, it is difficult to detect the interaction of graviton γ_m with quantum particles.

5.4. Thermalization: Velocity Field

In condensed matter field theory, there are two kinds of quasi-particles (elementary excitations), optical phonons (electromagnetic waves) and acoustic phonons (elastic waves), electrons can also be treated as quasi-particles, interactions between them and between them and other particles cannot be ignored, it is necessary to use methods of quantum field theory for temperature greater than zero [35]. Almost all quantum field theory used in the particle standard model are for temperature being zero: identical substantial particles are generated by quantum fluctuations (virtual processes) in the ground state of vacuum at zero temperature. However, particles were generated in the very early stage of the expanding universe. At that time, the vacuum was not only high in energy density, but also high

in temperature. The gauge nature of gravitation in flat spacetime allows it to be fully expressed by vector potential, to be quantized and thermalized, and to generate thermal phonons in the same way as electricity. The cosmic vacuum with non-zero temperature should be composed of thermal phonons generated by gauge long-range force fields. Otherwise, the temperature of the vacuum cannot be defined. In cosmic dynamics, thermophonons generated by gauge long-range force fields in the cosmic vacuum must be considered to explain the thermal equilibrium of the universe, explain the extremely accurate blackbody spectrum of the cosmic background radiation, and maintain the energy conservation of the universe as well. Due to the fact that charged particles are only a small part of the cosmic matter/energy composition, the main component of the radiation dominated early universe should be gravitational thermal phonons (see [6] Chapt. 5 “Thermal Equilibrium Universe”).

The accelerated motion of gauge charges (electric charge and/or gravitational charge) is a physical process that realizes the quantization of gauge interactions: emitting radiation field composed of free photons and/or gravitons; whereas the uniform translational motion realizes both the quantization and thermization of gauge interactions: generating the velocity field composed of massless quasi-bosons (quasi-photons for electric charge, quasi-gravitons for gravitational mass, both quasi-photons and quasi-gravitons for charged particle) with the same temperature as the background vacuum composed of thermophonons.

5.5. Radiative Correction from Velocity Field

The spin magnetic moment of electron from Dirac equation is

$$\mu_0 = \frac{e\hbar}{2m_e c} \quad (45)$$

Because the Dirac moment is less than the observed value μ_e^* of electron magnetic moment, the electron magnetic moment μ_e should be

$$\mu_e = \mu_0 + \Delta\mu_e \quad (46)$$

where $\Delta\mu_e$ is called “the anomalous magnetic moment of the electron”.

After calculating the radiative correction to mass of electron, Schwinger J. [36] obtained the anomalous magnetic moment as $\Delta\mu_e = (\alpha/2\pi)\mu_0$, and the electron magnetic moment

$$\mu_e' = \left(1 + \frac{\alpha}{2\pi}\right)\mu_0 \quad (47)$$

However, after the radiative correction the moment is a little bigger than the observed value, $\mu_e' > \mu_e^*$, which might be caused by that the parameter α in Equation (47) is not a suitable parameter to represent the strength of the radiative correction. The fine-structure constant α (43) characterizes the interaction strength between electron and free photon ($e-\gamma$ coupling). But any moving electron is surrounded by quasi-bosons γ^* of its velocity field. For the radiative correction to a moving electron, the interaction with surrounding quasi-particles

($e-\gamma^*$ coupling) with a strength α^* should be considered firstly, then the electron magnetic moment should be

$$\mu_e = \left(1 + \frac{\alpha^*}{2\pi}\right) \mu_0 \quad (48)$$

With the observed value μ_e^* of electron magnetic moment and Equation (48), we can estimate the coupling parameter α^* between electronic charge and quasi-boson of velocity field

$$\alpha^* = 2\pi \left(\frac{\mu_e^*}{\mu_0} - 1\right) \quad (49)$$

Substituting the high precision measurement result μ_e^* [37] into Equation (49), we get

$$\frac{\alpha^*}{\alpha} = 0.998486708310 \quad (50)$$

It needs to be pointed out that any velocity field has a non-zero temperature, then different with the fine-structure constant α , the value of the parameter α^* in Equation (48) should be related to the ambient temperature T^* of the moving electron, $\alpha^* = \alpha^*(T^*)$.

In addition to the magnetic moment of the electron, in issues of muon magnetic moment and W boson's mass the velocity field effect should also be considered firstly.

The quantum electrodynamics (QED) with Feynman path integral technique ignores the existence of velocity fields at all and replaces the real process of radiative correction to electron by quasi-boson of the velocity field with countless virtual processes of virtual photons and virtual particle-antiparticle pairs with zero-temperature fields in the sub-quantum level. In QED, the magnetic moment μ_e of the electron is calculated by the following perturbation formula

$$\mu_e = \left[1 + c_1 \frac{\alpha}{\pi} + c_2 \left(\frac{\alpha}{\pi}\right)^2 + c_3 \left(\frac{\alpha}{\pi}\right)^3 + c_4 \left(\frac{\alpha}{\pi}\right)^4 + \dots\right] \mu_0 \quad (51)$$

Equation (48) with the interaction strength parameter α^* between electron and quasi-boson, and Equation (51) with the interaction strength parameter α between electron and free photon, both can be used to accurately calculate the magnetic moment μ_e of the electron. But what surrounds a moving electron are quasi-bosons in the velocity field, not free photons, then Equation (48) is the correct formula for calculating the radiative correction effect on the moving electron. Whereas Equation (51) is essentially a fitting formula that is based on too many fictitious virtual processes and has too many undetermined parameters. The capability of the perturbation formula (51) to high precision fit for μ_e^* result from mathematical tricks: quite a few artificial and controversial rules for renormalization; the higher the order of the term of $\frac{\alpha}{\pi} \sim 2 \times 10^{-3} \ll 1$, the smaller it is, etc.

5.6. Quasi-Electron with Velocity Field

In condensed matter physics, electrons themselves are also quasi-particles: a quasi-electron is a composite diffused entity composed of the electron and phonons surrounding it. The quasi-particle nature of electrons in metal is the key to understanding superconductivity: attractive interaction between electrons due to the exchange of phonons—quasi-bosons [38].

An electron moving in vacuum is surrounded by the velocity field, it may also possess some characteristic of quasi-particles.

A noteworthy example is the effects of terrestrial tides on charged particle beams in circular accelerators [39] [40]. **Figure 4** shows the change in the circular path length (COD) of electrons in the accelerator storage ring SPring-8 with 1.4 km orbital circumference and beam energy 8 GeV: in the dispersion regions (with magnetic field), similar to Newtonian tidal forces the horizontal COD changes exhibited a 12 hour quasi-periodic variation with amplitude of $\sim 56 \mu\text{m}$ corresponding beam energy variation of $\sim 7 \text{ MeV}$, while no similar changes were observed in the non dispersion regions (without magnetic field). It is usually believed that the change in COD is due to the influence of Newtonian tidal forces on the shape of the Earth: the stretching of the ground causes a change in the shape of the beam orbit ring composed of the bent magnet and beam position detector fixed on the ground, resulting in a distortion of the closed orbit COD of charged

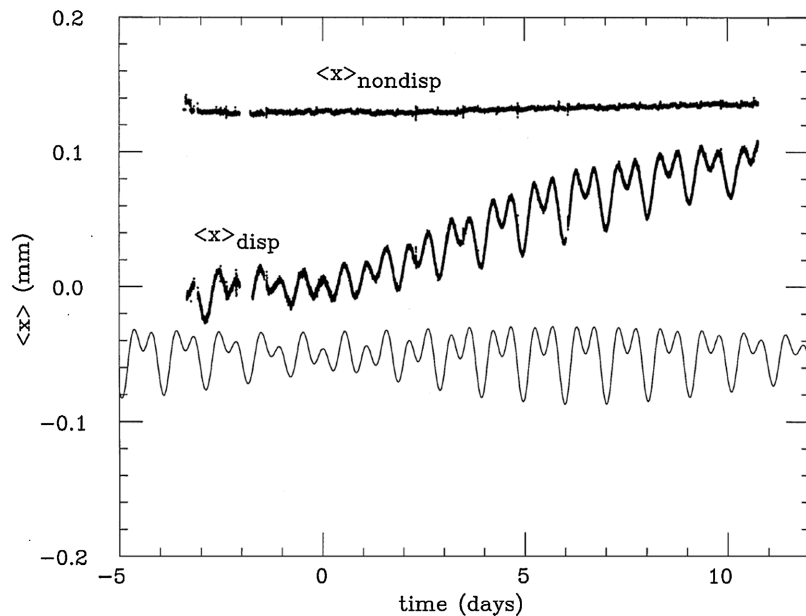


Figure 4. Tidel effect on electron beam in the SPring-8 storage ring of Japan Synchrotron Radiation Research Institute [40]. Average of the horizontal Closed Orbit Distortion (COD) in the nondispersive regions (upper points, without magnetic field) and the dispersive regions (lower points, with magnetic field) plotted against time. The data for the nondispersive regions are shifted upward by 0.1 mm by a technical reason of drawing. The data were taken for every 30 s during a term from 4 to 18 December, 1997. The origin of time on the horizontal axis is at 00:00:00 on 8 December 1997. The solid curve is the theoretical expectation for phases and relative strengths of changes in x_{disp} .

particles, which should also exist in the non dispersion regions, but it has not been detected. The response of charged particles to gravity has been attempted to be explained with gravitational waves by Dong D. and Huang C.G. [41] and with electro-gravitational induction by Dong D. and Dong J.Y. [42]. A more natural explanation for the observed correlation between electron motion and lunar motion might be the interaction between quasi-bosons of the lunar velocity field and quasi-electrons in the accelerator storage ring.

5.7. What is Mass?

At the end of his book “QED: The Strange Theory of Light and Matter” [43] Feynman exclaimed:

there remains one especially unsatisfactory feature: the observed masses of the particles, m . There is no theory that adequately explains these numbers. We use the numbers in all our theories, but we don't understand them — what they are, or where they come from. I believe that from a fundamental point of view, this is a very interesting and serious problem.

The main reason for the problem above-mentioned by Feynman is that the term “mass” has been overused. There are various physical quantities called ‘mass’ in physics: proper mass, gravitational mass, electromagnetic mass, mechanical mass, inertial mass, rest mass, motion mass, etc.

Firstly, it is necessary to distinguish between charge (electric charge, gravitational charge, etc.) and mass. In relativistic mechanics, the motion of a particle follows the special theory of relativity, regardless of whether its proper mass (or rest mass) m_0 is a purely electromagnetic mass, or purely gravitational mass, or a combination of both as well. For the first one of the above three cases, m_0 is the inertia of the inverse square electric field of a static charge; for the second case, it is the inertia of the squared inverse gravitational field of a static gravitational charge; for the third case, it is the inertia of the combination of the above two cases.

As shown in Subsection 2.1, for a moving particle with proper mass m_0 , its motion mass $m > m_0$ is the inertia of the velocity field composed of neutral massless quasi-bosons: quasi-photons for the particle of a pure electric charge, or quasi-gravitons of a pure gravitational charge, or a combination of quasi-photons and quasi-gravitons for an electrically charged massive particle (like phonons in condensed matter is a combination of optical phonons and elastic phonons).

All the word “mass” mentioned above is actually the inertia possessed by the field of a particle of different type in a stationary or motion state. These quantities labeled as mass, including the so-called gravitational mass, cannot be confused with charge of interaction force. Unlike inertia, in physical processes the gauge charges—electric charge and gravitational charge—are conserved quantities. For a moving electrically or/and gravitationally charged particle, the inertia (inertial mass) of its velocity field increases with the increase of charge velocity, but the particle's charge (electric charge or/and gravitational charge) remains unchanged.

Many scholars explain the relativistic relationship between mass and energy as to each energy E there corresponds a mass

$$m = \frac{E}{c^2} \quad (52)$$

and further claim that the equivalence of mass and (any kind of) energy is a fundamental principle (e.g. [12]). However, the reality is that there are various forms of energy, and each energy possess inertia. For any form of energy, E and m in Equation (52) both correspond to the inertia of that energy, only in different units. The mass-energy relationship of special relativity, Equation (52), only states the relationship between energy E and its inertia m .

The masses m_0 and m in Equation (10), and the mass m in the relativistic mass-energy relation (52), all are inertial masses. The mass m_0 is the inertia possessed by the energy of an absolute rest charge or gravitational mass, and motion mass m is the inertia of the velocity field of a moving electric charge or gravitational mass; The gain of inertial mass is input from energy in the neutral vacuum, where the charge or gravitational mass in the system does not increase. Only in the absolutely stationary frame — the co-moving vacuum of the expanding universe, the inertial mass of a neutral massive particle can be equal to its gravitational mass.

In physics, the “gravitational mass” should refer to gravitational charge; and other so-called “mass”, such as proper mass, rest mass, motion mass, electromagnetic mass, inertial mass, etc., are actually almost all inertia. Calling the inertia of various forms of energy as “mass” has caused inconsistencies and confusion in physics theories. Mixing the mass that expresses inertia with gauge charge can lead to destruction of gauge invariance and cause the infinity puzzle in the self-interaction of a charged particle and in so called radiative correction processes. From the principle of equivalence of general relativity—the equality of gravitational and inertial mass, all energy should be a source for the gravitational field, it further undermines the conditions under which any conservation law could exist.

To date, all the mechanical theories have ignored velocity fields of uniform motion, non-mechanical interactions between velocity field’s quasi-bosons and gauge charges, as well as that between two velocity fields’ quasi-bosons. This has further increased the difficulty in clearly defining basic physical concepts such as mass.

6. Discussion

6.1. New Cosmology

Particle physics, electromagnetism and particle dynamics must all be based on a homogeneous, flat and neutral cosmic vacuum. Cosmology should also be based on a correct understanding of the composition of the cosmic medium and its interactions. The expanding universe consists of a neutral vacuum of coupled dark matter—dark energy with temperature T and the cosmic background black-body phonons in thermal equilibrium with it. The luminous matter constitutes only a small portion of the total cosmic matter, which can and should be ignored

in the zero-order approximation of cosmology. When studying CMB, all signals of luminescent material structures must be carefully removed [33], but the motion equation of relativistic cosmology model Λ CDM, the Friedmann equation, is based on the assumption of the cosmic medium being a perfect fluid of ordinary matter, and the so-called matter-dominated era, radiation-dominated era, recombination and last scattering etc. in current textbooks of cosmology are all describing processes of luminescent materials, not the thermal history of the universe at all.

Only the universe can be regarded as an isolated system. The expansion of the universe is a homogeneous and isotropic motion of three-dimensional vacuum, with no translation relative to any reference frame then no velocity field associated with a translation motion. We have proposed the Drak Energy-Matter-Codensed (DEMC) model of the universe [6], where the motion equation for stationary expansion is derived with Lagrangian mechanics, and that for phase transition period with Landau mean-field theory. In DEMC, the Lagrangian of the universes with the radius R is

$$\mathcal{L} = M_1 \dot{R}^2 / 2 + M_1 G M_g R^{-1} \quad (53)$$

where the total inertial mass M_1 measured in the co-moving system is

$$M_1 = (M_m + M_\lambda) + E_{rad}$$

with M_m and M_λ are the total inertial mass of attractive matters and repulsive dark energies respectively, and E_{rad} the total energy of cosmic thermal radiation, and M_g is the net gravitational mass of cosmic medium

$$M_g = M_m - M_\lambda$$

The observation data of cosmic expansion rate verses redshift can be well fitted by the Lagrangian motion equation derived from Equation (53) and the Landau theory on continuous phase transition [6].

Recently, observations of the Dark Energy Spectroscopic Instrument (DESI) [44] [45] strengthen the evidence for dynamics of dark energy which is favorable for the DEMC model. The DEMC model quantitatively provides the evolution of attractive matter density ρ_g and dark energy density ρ_λ with the expansion shown in **Figure 5**, which can be quantitatively tested by further cosmological observations.

In Λ CDM, the expanding universe originates from a Big Bang, and the anisotropies in the CMB are caused by the quantum fluctuation during the Big Bang. Different from Λ CDM, in DEMC there was no Big Bang, the cosmic expansion and its acceleration or deceleration originate from cosmic phase transition with mutual conversion between attractive matter and dark energy, and the anisotropies of CMB are caused by the temperature fluctuation during the cosmic phase transitions. These two cosmological models provide completely different expectations for the evolution of temperature T and age τ of the expanding universe with cosmological redshift z showing in **Table 1**.

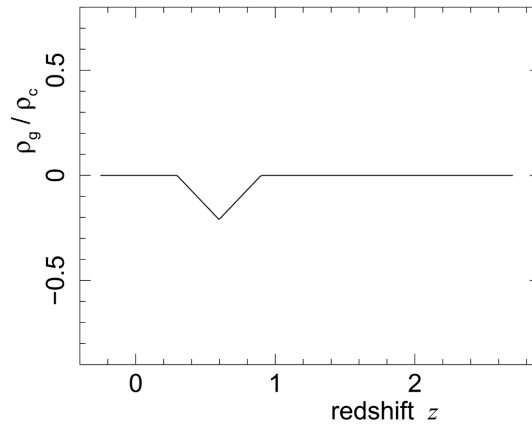


Figure 5. The evolution of relative gravitational mass density ρ_g/ρ_c of the universe (taken from [6]).

Table 1. Temperature T and Age τ at Redshift z Expected by Two Models of Cosmolog.

Red Shift z :		90	30	10	1	0
Age τ (10^9 ys):	Λ CDM	0.01	0.1	4	5	14
	DEMC	2×10^{-4}	1	2.5	14	28
Temp. T (K):	Λ CDM	2×10^2	84	30	5.4	2.7
	DEMC	2×10^6	8×10^4	4×10^3	22	2.7

Recently, the surprising finds of the James Webb Space Telescope JWST about the early universe seriously challenge the standard model of cosmology Λ CDM. For example, in Λ CDM the cosmic age is about 14 billion years, but JWST has discovered a few mature galaxies already in place just 3 - 5 billion years after the Big Bang; but in the neutral universe model with coupled dark energy and matter DEMC, the current cosmic age would be 28 billion years, there is enough time to form these galaxies. Other difficult problems in cosmology, such as Hubble tension, large-scale anomaly etc. can also be naturally explained in DEMC [46]. More and more observations support a neutral, uniform, isotropic, and thermal equilibrium cosmological model.

6.2. Principle of Least Action

It is much easier to theoretically describe a physical system by using the principle of least action than by constructing a complete theory that can only be done after a thorough understanding of all the constituents of the system and their interactions. Although many theorists believe that action has replaced equations of motion in modern basic physics, however, the theory derived by the principle of least action for a non-isolated system can only be incomplete and only approximately valid under specific conditions.

In analytical mechanics based on the variational principle, for a mechanical sys-

tem with generalized coordinates q_i ($i = 1, \dots, n$) in the configuration space, kinetic energy T , and potential energy V , the Lagrangian is defined as

$$L = T - V \quad (54)$$

the action

$$I = \int_{t_1}^{t_2} L(\mathbf{q}, \dot{\mathbf{q}}) dt \quad (55)$$

For a conservative system that

$$T + V = \text{const} \quad (56)$$

the real path of motion in the configuration space between t_1 and t_2 makes the action integral (55) to be stationary (its variation to be zero), that is, the path is the geodesic line in the configuration space; then the motion equation of the system (Lagrangian equation) can be derived as

$$\frac{d}{dt} \left(\frac{\partial T}{\partial \dot{q}_i} \right) - \frac{\partial T}{\partial q_i} = Q_i \quad (57)$$

where Q_i is the generalized force defined from generalized coordinate and generalized velocity.

In the field of a fixed point particle the Lagrangian (54) of a moving particle is the difference between its kinetic energy T and potential energy V . For the trajectory of a particle in the configuration space composed of potential, the role of kinetic energy T and potential energy V is different: The motion pulled by potential energy has a smaller distance in the spatial space, but the trajectory in the configuration space is curved with the gravitational potential; The kinetic energy of particles increases, and it takes less time to pass the same distance, but the path between two fixed points is more curved. The actual trajectory of the particle is determined by mutual checks and balances between kinetic energy and potential energy. The sum of kinetic energy and potential energy—mechanical energy—is constant, while the Lagrangian L (54) is the difference between the two, which can include the effect of mutual checks and balances between kinetic energy and potential energy in the motion under the constraint of mechanical energy conservation, so that the principle of least action can be satisfied.

The principle of least action represents the relationship between the law of conservation of energy and the geometric property of the motion trajectory. Only for a conservative system that satisfy the law (56) of conservation of mechanical energy, can the above Lagrangian mechanics express its true laws of motion. For a non conservative system, it is also possible to artificially construct a Lagrangian to meet the variational principle, thereby establishing a theoretical expression of analytical mechanics for it. Such a theory based on a local non-conservative system cannot truly express the laws of motion, but only indicates the existence of laws of motion, then the conservation law can hold in a larger system.

In relativistic mechanics the kinetic energy of a moving particle of mass m at velocity v is

$$T = (\gamma - 1)mc^2 \quad (58)$$

The relativistic formula of the particle moving in a field with potential V can also be derived by the principle of least action with a relativistic Lagrangian $L = T - V$ where the ‘kinetic energy term’ must be redefined as [12]

$$T = -mc^2/\gamma \quad (59)$$

Why is the ‘kinetic energy term’ T (59) in the relativistic Lagrangian not the relativistic kinetic energy T (58)? The system of a uniformly moving particle plus velocity field is not a conservative system, the vacuum medium injects inertial energy into it through the velocity field: as the velocity increases, the inertia of the system increases, but the kinetic energy of the particle’s mechanical motion remains unchanged. Therefore, the so called kinematic energy T in Equation (58) of special relativity is actually not the kinetic energy, but the inertia energy of the moving particle. The relativity mechanics ignores the energy correlation between vacuum and moving particles, thus the Lagrangian in Galileo space—the difference between kinetic energy and potential energy $T - V$, cannot correctly reflect the energy composition that balances the motion of particles. In the Lagrangian of special relativity, the symbol of “kinetic energy” T in Equation (59) being negative is necessary to take into account the influence of the inertia of the velocity field on the particle’s motion—the increase in inertia is equivalent to the decrease in kinetic energy. The same reason—ignoring the velocity field’s inertia—leads to the negative-energy paradox in the relativistic energy-momentum relationship $E^2 = p^2 + m_0^2$ and Dirac relativistic wave equation.

The velocity field not only increases the particle’s inertial energy, but also is a collection of plane waves in the vacuum medium. The existence of the velocity field makes it impossible for any local dynamical system to be a purely mechanical one, but a system closely coupled to the cosmic vacuum and modulated by the medium and its wave nature through force-free connection. It is the velocity field that makes both electrodynamics and particle dynamics must be expressed in the Lorentz space (\mathbf{x}, ict) or $(A, i\phi/c)$ —a configuration space with generalized parameters including the parameter c of vacuum medium and the imaginary unit i to reflect the wave nature of the velocity field. Excluding the physical process of the vacuum itself, it is impossible to derive a theory that completely describes the motion law of a local system only from the principle of least action. The theory of relativity is established based on the principle of least action with ignoring the energy correlation between vacuum and local systems, where the time t , positional space \mathbf{x} , energy E , kinetic energy T etc. are only generalized physical quantities and cannot be equated with the basic concepts of physics, caution is needed when applying them.

General laws of physics are valid only for isolated systems. The principle of least action cannot replace the law of conservation of energy to be regarded as the first principle of physics, although it can be used for a non isolated system to construct an effective theory which can even have rather good power to predict. Newtonian mechanics, analytical mechanics, and relativistic mechanics have all ignored the cosmic vacuum and its connection with particles, although they all can be derived

by using the principle of least action, but all just be approximate theories effective only under specific conditions.

6.3. Foundations of Physics

The conservation of energy, momentum, and angular momentum requires that the background spacetime reference frame of a mechanical system must be a uniform and isotropic inertial frame. The general theory of relativity denies that gravity is a gauge interaction between matters, and instead replaces the flat spacetime background required by physical processes in different levels and types with a so-called “curved spacetime”. The negation of the existence of any absolute stationary inertial frame and the destruction of gauge invariance destroys the basic condition for the existence of conservation laws, isolates the gravitational interaction, and hinders the development of fundamental physics.

The physics of the translational motion of a charged or massive particle is essentially the physics of the velocity field composed of massless quasi-bosons moving in the cosmic vacuum. Excluding the cosmic vacuum, no moving charge, object or local system can be an isolated mechanical system. Both classical mechanics and special relativity ignore the connection between thermal phonons of cosmic vacuum and quasi-bosons of the velocity field, as well as the connection between quasi-bosons of the velocity field and the moving particle. The special relativity replaces the real physics of velocity field in electromagnetism or particle dynamics with a fictional “space-time conversion” or Minkowski spacetime geometry and mistakes the non-mechanical interconnection between vacuum and moving electric/gravitational charge via quasi-bosons for force between field and charge, that hinder the development of mechanics into an accurate, complete, and self-consistent theory.

Physics is the natural science that deals with the structure of matter and the interactions between the fundamental constituents of the observable universe (Encycloaedia Britannica). Therefore, for a studied system, to understand its constituents and their interactions should be the primary task of physics research. A complete physical theory must account for all the constituents involved and as well as their interrelationships and transformation laws, where cosmic vacuum with thermal phonons and velocity field of moving charge with quasi-bosons are indispensable fundamental constituents of the observable universe.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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