The Dynamic System of Photons and the Large-scale Structure of Universe

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Abstract

As shown in the development history of physics, serious unsolved problems will once again require modifications to our established scientific description of the physical world. By re-examining the motion law of photons, this study identified the geometric curve corresponding to the starlight geodesic and ascertained the relation between the polarization, wave, and spin of elementary particles. As a result, the dynamic equation $c = \frac{1}{\sqrt{\varepsilon_0 \mu_0}} = \sqrt{g_{\mathrm{U}} r_{\mathrm{U}}} = \sqrt{\frac{P_{vac}}{\rho_{vac}}} = \frac{h/m_\gamma}{4\pi} \int_0^\pi \frac{\sin\theta \mathrm{d}\theta}{r}$ $(rm_\gamma c = \frac{h}{2\pi}$, where $m_\gamma = \frac{h\nu}{c^2}$ is not a rest mass but an energy factor) of photons is discovered, and several crucial cosmological constants of the large-scale universe without dark energy can be derived directly from fundamental theories. Furthermore, the paper preliminarily discusses the properties of the candidate particles of gravitons and dark matter, and thoroughly clarifies the relativistic geometric interpretation of spacetime that has puzzled the public. This article simplifies the physical model of the large-scale universe and the elementary-particle spin, and bridges the quantum-level system and the macroscopic system, which can be considered a preface to the theory of everything (TOE).

keywords: cosmology; Large-scale Structure of Universe; photons; spin; gravity; relativity

Competing Interests

The author has no relevant financial or non-financial interests to disclose.

Contents

1. Introduction: the Geodesic of Starlight

The photon was a puzzle that Einstein pondered all his life, but he did not find a satisfactory solution (see his letter to Michele Besso in 1951). Moreover, Einstein never ceased contemplating the ether and did not outright deny its existence [1]. Of course, the vacuum once named after the ether is not empty, as verified by the Casimir effect, high-energy colliders, and vacuum phonon heat transfer [2]. Besides, there are still many mysteries of the universe that cannot be explained by established theories (meaning that **the established theories need to be perfected or even superseded**). Therefore, from the perspective of the unity of the operating mechanism of nature, the key to deciphering the photon may well be to reintroduce the **continuum model of the vacuum** that has been a great success in Fresnel's optics and Maxwell's electromagnetism (see subsections 2.2, 2.3, and 2.4). Furthermore, an attempt should be made to re-examine the motion rules of photons through Newton's laws of motion.

In a homogeneous and isotropic cosmos, observers on any planet should be located at the center of their observable universe, and their cosmological horizons have the same radius (Copernican principle). Imagine a **cubic model** of the local cosmic space with volume $n^3 R_{\mathrm{U}}^3$ (R_{U} is the observable radius of Universe), which applies to the observer on any planet as Newton's law of gravitation does. As a result, the flat universe has neither a center nor an edge, and the so-called inflation neither needs nor should occur (the so-called accelerated expansion of Universe can be clarified by Eq. 5). Of course, for a homogeneous spherically symmetric system with radius r, density ρ, and escape speed v, the Friedman equation $\left(\frac{v}{ar}\right)^2 + k\left(\frac{v}{ar}\right)^2 - \frac{\Lambda}{3} = \frac{8\pi G}{3}\rho$ $(a = 1,\ k = 0,\ \Lambda = 0)$ that it approximately satisfies, like Newton's law of gravitation $\left(\frac{v}{r}\right)^2 = \frac{8\pi G}{3}\rho$, is not suitable to describe the so-called expansion evolution of an infinite universe. (**Note**: Most of the self-explanatory physical quantities in this paper are not stated; see Refs. [3] and [4] for the relevant constants.)

When a photon is launched and successfully escapes (with accompanying kinetic-energy consumption and redshift), will it travel in a straight line or a great circle with a vast radius? Since starlight **can be deflected** by gravity, but it **cannot be accelerated or decelerated** by gravity in the tangential direction and always **remains weightless** in gravitational fields, its uniform motion should be a **uniform circular motion** along the geodesic of the large-scale spherically symmetric space (whose max radius is r_{U}; $R_{\mathrm{U}} = 2r_{\mathrm{U}}$ is the observable radius of the boundless universe; see subsection 2.7 for a simple and intuitive solution to the gravitational deflection of starlight). If the action $\int_{t_1}^{t_2} E_\gamma \mathrm{d}t$ of a photon satisfies $\delta\left(\int_{t_1}^{t_2} E_\gamma \mathrm{d}t\right) = E_\gamma\,\delta\int_{t_1}^{t_2}\mathrm{d}t = 0$, its maximum motion period is $T_{\max} = \frac{2\pi r_{\mathrm{U}}}{c}$. Theoretically, the large-scale spherically symmetric space should obey **Newton's shell theorem** and have a maximum effective gravitational radius for photons ($c = \sqrt{\frac{G\rho_{\mathrm{U}}V}{r_{\mathrm{U}}}} = \sqrt{\frac{4\pi G\rho_{\mathrm{U}}}{3}}r_{\mathrm{U}}$ is an intrinsic property of infinite space, while r_{U} is determined by the interaction distance between gravitons, like the force range between medium molecules).

Considering the principle of least action, the finiteness of stellar radiation flux, and the superposition of galaxies' gravitational and electromagnetic fields, we can infer that starlight follows only one great circle path (ignoring

local gravitational lenses) from one galaxy to another within the great circle. Accordingly, it is more reasonable to judge that the **cosmological redshift** is only a tangential-direction gravitational redshift of starlight, which is caused by the gravitation of the spherically symmetric space (constrained by the speed of gravitation) centered on the spatial starting point of escaping starlight (escape consuming kinetic energy $\frac{1}{2}h\mathrm{d}\nu = -\boldsymbol{F}\cdot\mathrm{d}\boldsymbol{r}$, where $|\boldsymbol{F}| = \frac{G(\rho_{\mathrm{U}}V)\left(h\nu/c^2\right)}{r^2} \propto \rho_{\mathrm{U}}r$), depending on the average cosmic density ρ_{U} and the starlight's displacement amount $r = 2r_{\mathrm{U}}\left|\sin\frac{ct}{2r_{\mathrm{U}}}\right|$ rather than the mutual recession between galaxies.

From the geodesic lines of starlight as described above, not only can a more elegant model of the universe be deduced, but it can inspire us to further simplify the physical theories that have puzzled the public. Next, the paper will discuss the following topics: 2.1 the large-scale structure of Universe; 2.2 the constancy of the speed of light; 2.3 spin and the dynamic equation of photons; 2.4 the nature of gravitation; 2.5 time dilation; 2.6 the precession of Mercury's perihelion; 2.7 the gravitational deflection of starlight.

2. Results and Discussion

2.1 The large-scale structure of Universe

Under Newton's second law of motion, Newton's shell theorem, the principle of least action, the constancy of the speed of light, the weightlessness of photons, and the homogeneity of the large-scale universe, we can see that starlight driven by radial gravitation should travel along a great circle of the spherically symmetric space with a radius $r_{\mathrm{U}} = \frac{G\rho_{\mathrm{U}}V}{c^2} = \sqrt{\frac{3c^2}{4\pi G\rho_{\mathrm{U}}}}$. Naturally, the diameter of the great circle is precisely the observable radius of the infinite universe.

Based on the Copernican principle, Pascal's law, the ideal gas law, and the minimum potential energy principle, it can be inferred that large-scale space media (no center, no edge, homogeneous and isotropic) are approximately isobaric, isopycnic, and isothermal ($P_{\mathrm{U}} = w_{\mathrm{U}} = \rho_{\mathrm{U}}c^2 = n_{\mathrm{v}}kT \approx \frac{n}{V}\left(\frac{\alpha^4}{6}m_{\mathrm{e}}c^2\right)$, where the last term is an approximative example). Accordingly, the universe as a whole should be in a ground state.

The gravitational correction term for the Bohr energy of ground-state hydrogen atoms is $E^G_{a_0} = -\frac{1}{2}\frac{Gm_{\mathrm{p}}m_{\mathrm{e}}}{e^2/4\pi\varepsilon_0}\frac{Gm_{\mathrm{p}}m_{\mathrm{e}}}{a_0}$, and there are correlations among numerous fundamental physical constants. Consequently, we can boldly and rationally judge (a genius finding with **more correct conclusions**) that the mass ratio of the great spherically symmetric space (radius $r_{\mathrm{U}} = \frac{Gm_{\mathrm{U}}}{c^2}$) to an electron should be

$$\frac{m_{\mathrm{U}}}{m_{\mathrm{e}}} = \frac{Gm_{\mathrm{U}}m_{\mathrm{e}}/r_{\mathrm{U}}}{\frac{Gm_{\mathrm{p}}m_{\mathrm{e}}}{a_0}\cdot\frac{Gm_{\mathrm{p}}m_{\mathrm{e}}}{e^2/4\pi\varepsilon_0}} = \left(\frac{\hbar c}{Gm_{\mathrm{p}}m_{\mathrm{e}}}\right)^2 = \left(\frac{M_{\mathrm{P}}^2}{m_{\mathrm{p}}m_{\mathrm{e}}}\right)^2. \tag{1}$$

This equation can also be attained from $\frac{GM_{\mathrm{P}}^2}{r_{\mathrm{U}}} = \frac{Gm_{\mathrm{p}}^2}{\lambda\!\!\!^{-}_{\mathrm{C}}}$ and $c^2 = \frac{Gm_{\mathrm{U}}}{r_{\mathrm{U}}}$, reflecting the relationship between the fundamental constituent particles of atoms and the large-scale structure of the universe: $m_{\mathrm{e}} = \frac{1}{c^2}\left(\frac{M_{\mathrm{P}}}{m_{\mathrm{p}}}\right)^2\frac{GM_{\mathrm{P}}^2}{r_{\mathrm{U}}}$, $m_{\mathrm{p}} = \frac{1}{c^2}\sqrt{\frac{m_{\mathrm{U}}}{m_{\mathrm{e}}}}\frac{GM_{\mathrm{P}}^2}{r_{\mathrm{U}}}$. As a gravitational energy factor (not rest mass), Planck mass M_{P} is closely related to quantized

negative-energy **gravitons** that can neither annihilate nor participate in electromagnetic interactions but determine the centripetal directionality of gravity ($\frac{GMm}{r} = mc^2 = \frac{rmc^2}{r} = -\frac{\hbar c}{r} \Rightarrow m_{\min} = -M = -\sqrt{\frac{\hbar c}{G}} = -M_{\rm P}$; see subsections 2.3 and 2.4).

Now, we can smoothly calculate the following constants:

The observable-universe gravitational **mass** (including dark matter, which should be **the benchmark for the results obtained by various evaluation models** [5, 6, 7])

$$M_{\rm U} = 2^3 m_{\rm U} = 8\left(\frac{M_{\rm P}^2}{m_{\rm p} m_{\rm e}}\right)^2 m_{\rm e} \approx 7.043 \times 10^{53}\ \text{kg}, \tag{2}$$

the observable-universe **radius** (that is, the so-called Hubble length [5, 6, 7])

$$R_{\rm U} = 2r_{\rm U} = 2\frac{Gm_{\rm U}}{c^2} = 2\left(\frac{M_{\rm P}}{m_{\rm p}}\right)^2 \lambda\!\!\!^{-}_{\rm C} \approx 1.3 \times 10^{26}\ \text{m}, \tag{3}$$

the average universe **density** (see [5, 6, 7]; energy density $w_{\rm U} = \rho_{\rm U} c^2 = P_{\rm U}$)

$$\rho_{\rm U} = \frac{M_{\rm U}}{4\pi R_{\rm U}^3/3} = \left(\frac{m_{\rm p}}{M_{\rm P}}\right)^4 \frac{3c^2}{4\pi G \lambda\!\!\!^{-2}_{\rm C}} \approx 7.52 \times 10^{-26}\ \text{kg}\cdot\text{m}^{-3}, \tag{4}$$

the **cosmological redshift** (derived from $r = R_{\rm U}\left|\sin\frac{ct}{R_{\rm U}}\right|$ and $h\mathrm{d}\nu = -\frac{2G(\rho_{\rm U}V)\left(h\nu/c^2\right)}{r^2}\frac{\sqrt{R_{\rm U}^2 - r^2}}{R_{\rm U}}\mathrm{d}r$; note that the derivative of $Z_{\rm U}$ below **clarifies the so-called accelerated expansion** of Universe)

$$Z_{\rm U} = \exp\left\{\frac{8}{3}\left(1 - \left|\cos^3\frac{ct}{R_{\rm U}}\right|\right)\right\} - 1 < 13.4, \tag{5}$$

and the **Hubble time** (not the so-called cosmic age [5, 6, 7]. Since energy cannot be created or destroyed, the universe can only be timeless)

$$t_{\rm H_0} = \frac{R_{\rm U}}{c} \approx 4.36 \times 10^{17}\ \text{s} \approx 13.82\ \text{Gyr}. \tag{6}$$

By calculating the **elastic-deformation** energy (total potential energy $\mu_{\rm B} B_{a_0}$) and precession energy (precession frequency $\frac{1}{2\pi}\frac{eB_{a_0}}{2m_{\rm e}}$) of the electron spin magnetic moment, the surface temperature of an isolated ground-state hydrogen atom can be obtained from

$$T_0^{\rm H} \approx \frac{2}{3k}\left(\frac{1}{2}\mu_{\rm B} B_{a_0}\right) = \frac{2}{3k}\left(\frac{1}{2}h\frac{eB_{a_0}}{4\pi m_{\rm e}}\right) = \frac{2}{3k}\frac{1}{2}\left[\frac{1}{2}\frac{(\mu_0 e\alpha c)^2}{4\pi\mu_0 a_0}\right] \approx 2.80257\ \text{K}, \tag{7}$$

where $B_{a_0} = \mu_0\frac{\mu_0 e\alpha c}{4\pi\mu_0 a_0^2} = \frac{\alpha^4 m_{\rm e} c^2}{2\mu_{\rm B}}$. We can define $q_m = \mu_0 q v$ as a **magnetic charge**; the line current will induce a magnetic field $\mathrm{d}\boldsymbol{H} = \frac{\mathrm{d}q_m}{4\pi\mu_0 r^2}\vec{\boldsymbol{e}} = \frac{\mu_0 v\mathrm{d}q}{4\pi\mu_0 r^2}\vec{\boldsymbol{e}} = \frac{vI\mathrm{d}t}{4\pi r^2}\vec{\boldsymbol{e}} = \frac{I\mathrm{d}\boldsymbol{l}\times\boldsymbol{r}}{4\pi r^3}$ ($\boldsymbol{\nabla}\cdot\boldsymbol{H} = 0$; Lorentz force $\boldsymbol{F_L} = q_m H\vec{\boldsymbol{e}} = \mu_0 q\boldsymbol{v}\times\boldsymbol{H} = q\boldsymbol{v}\times\boldsymbol{B}$). As we all know, the electrostatic and magnetic fields are the gradient and curl fields caused

by electric charges in vacuum dielectrics, respectively (see subsection 2.2). Technically, the so-called **magnetic monopole** is redundant to nature and cannot exist in the universe.

In a comprehensive view, it can be inferred that the cosmic microwave background (CMB) is closely related to the average energy density of cosmic space. The **CMB** undoubtedly originates from the electron magnetic moment oscillating of ground-state hydrogen atoms extensively distributed in vacuum media. Indeed, the direction flip of the proton magnetic moment relative to the electron magnetic field in neutral hydrogen atoms also produces the famous 21-cm line in astronomy. Moreover, although the vacuum has no discrete energy levels (no radiation), it possesses constant permittivity (originating from the spin oscillating of positive-negative virtual electron pairs), and its electromagnetic oscillation corresponds precisely to an energy level of 2.71015 K [8]. (Note that $2.725\ \mathrm{K} \approx 2.80257\ \mathrm{K} \times 16\% + 2.71015\ \mathrm{K} \times 84\%$ appears to reflect the ratio of visible matter to dark matter in the universe.)

Rationally, the planet is not the cosmic center, so there is no need for an inflation theory to explain the flatness of the flat centerless universe (**without dark matter**). Furthermore, the conservation laws of energy and momentum will prevent the boundless universe from being governed by any energy to expand. Newton's shell theorem and the conservation of angular momentum should also prohibit the spaceless universe from collapsing under gravity. Naturally, the timeless universe ruled by constants has only the laws of energy–matter cycling and particle–particle interacting, **no genesis, no end, no center, no edge, no directionality, and no purpose**. (All the unmentioned evidence for the Big Bang, such as the abundance of cosmic light elements and the redshift dependence of the astronomical Lyman alpha absorption, should have a more natural account.)

In addition, infinite as the universe is, starlight driven by gravitation travels along a great circle with a finite radius. Thus, the galaxy numbers observed by any observer in all directions are limited and approximately equal (**Olbers paradox**). Moreover, intelligent species are almost incapable of communicating across galaxies, let alone interstellar travel confined by scarce driving energy and strict survival conditions (**Fermi paradox**).

2.2 The constancy of the speed of light

The vacuum has a constant permittivity and can transmit energy (photons) and fundamental interactions at a constant speed (vacuum waves obey $\frac{\partial^2 f(x,t)}{\partial x^2} = \frac{1}{c^2}\frac{\partial^2 f(x,t)}{\partial t^2}$ and $\frac{\partial x^2}{\partial t^2} = \left(\frac{\mathrm{d}x}{\mathrm{d}t}\right)^2 = c^2$). Moreover, the speed of photons (quantized energy particles) in a vacuum is independent of their frequencies. Accordingly, **the vacuum can be entirely considered a linear, non-dispersive, and isotropic medium** composed of invisible particles (gravitons and positive-negative paired virtual electrons) spinning at the speed of light. The reintroduction of this continuum model, which is extremely natural in classical mechanics, is also particularly advantageous to further our understanding of the constancy of the speed of light, the quantization of the vacuum, and the non-contact fundamental interactions.

When observing the same point charge, observers in different motion states can observe different electromag-

netic fields that do not interfere with each other. Hence, the magnetic field necessarily arises from the vorticity field caused by a velocity field of moving charges in the still vacuum dragged by observers. Ignoring the retarded potential ($\frac{v^2}{c^2} \ll 1$), a moving charge ($q_m = \mu_0 q v$) will engender a **circumferential magnetic field**

$$\boldsymbol{B}_{\perp \boldsymbol{v}} = \frac{q_m}{4\pi r^2}\vec{\boldsymbol{e}} = \frac{\mu_0 q v}{4\pi r^2}\vec{\boldsymbol{e}} = \frac{1}{c^2}\left(\boldsymbol{v} \times \frac{q}{4\pi\varepsilon_0 r^2}\vec{\boldsymbol{e}}\right) = \frac{\mu_0 q}{4\pi r}\cdot\frac{1}{2}\boldsymbol{\nabla}\times\boldsymbol{v} \quad (r > r_{\mathrm{e}})\,, \tag{8}$$

where $\boldsymbol{\nabla}\times\boldsymbol{v} = \frac{2v}{r}\vec{\boldsymbol{e}}$ is the vorticity of negative-positive virtual electron pairs induced by the moving charge (observed in the observer's stationary reference frame). According to electrodynamics (magnetic vector potential), there is $\boldsymbol{\nabla}\cdot\boldsymbol{v} = 0$, so **vacuum media should be incompressible fluids** that can overlap or fuse indefinitely (which is similar to multiple laser beams intersecting without scattering). If the vortex of this invisible vacuum fluid can store energy in non-discrete energy levels, it must be the main component of **dark matter**.

Just like a moving point charge whose stationary reference system always drags its electrostatic field, and like the sun always carries its stationary gravitational field (including the astronomical objects in which and the light signals between them), **all observers are also dragging their respective resting vacuum media at any moment**. Thus, the observable speed (that is, energy-transport speed) of photons in any observer's static vacuum is constant, and the principle therein is completely unified with the constancy of the mechanical wave speed of any homogeneous and isotropic medium. Of course, just like the different electromagnetic fields induced by the same point charge, **photons only have observable meaning when they interact with the vacuum** dragged by observers.

Since the speed of light measured in a static vacuum is constant, photons radiated from the same light source will occur different refraction when entering and interacting with the vacuum dragged by different reference frames. For example, from the passenger perspective, the lamplight on a high-speed train is traveling in the resting vacuum medium dragged by the train; when observed on the platform, the speed of the train will cause its lamplight to be blueshifted or redshifted and produce a deflection angle similar to **stellar aberration**. In the phenomenon of stellar aberration, **the star is equivalent to a moving light source relative to Earth's stationary reference frame**, and the starlight travels at the light speed c along the tilt direction of the *resting telescopic optical tube* (rather than the direction pointing toward Earth from the star's "actual position").

As shown in $c_n = \frac{c}{n} + \left(1 - \frac{1}{n^2}\right)v = \frac{c - v/n}{n} + v$, Fizeau's empirical formula can also be interpreted by the Galilean transformation, indicating that the vacuum ($n = 1$) dragged by moving objects does not influence the speed of light measured in the observer's reference frame. Additionally, the starlight within the heliosphere will inevitably undergo refraction related to the earth's revolution speed when entering the vacuum medium of the earth's Hill sphere (or magnetosphere). So undoubtedly, such refraction is the leading cause of annual aberration.

If a laser source (whose stationary coordinate system is X'-Y') moves with speed v along the X-axis of an X-Y plane-coordinate system, its horizontal laser beam (at an angle α to the X'-axis) will deflect towards its moving direction by an angle β (observed in the X-Y reference frame, resulting from the initial impulse $\boldsymbol{p}\sin\alpha$ to which the

photon is subjected in the radial direction, as shown in stellar aberration phenomena):

$$\sin\beta = \frac{v\sin\alpha}{c} \quad \left(0 \le \alpha \le \pi,\ \ 0 \le \beta \le \frac{\pi}{2}\right). \tag{9}$$

This formula manifests that the laser light perpendicular to the X-axis ($\alpha - \beta = \frac{\pi}{2},\ \alpha > \frac{\pi}{2}$) is also redshifted (due to the photon being subjected to the tangential impulse $\boldsymbol{p}\cos\alpha$). Moreover, the laser light emitted perpendicular to the X'-axis will engender a deflection angle of $\beta = \arcsin\frac{v}{c}$ (**which has been verified** by stellar aberration and easily proved experimentally) after entering the X-Y reference frame, and its speed (component) perpendicular to the X-axis is $c\cdot\cos\beta = c\sqrt{1 - v^2/c^2}$ instead of c (**note projection distance and time** $ct\cos\beta = ct_0$, see Eq. 16). Apparently, stellar aberration, bremsstrahlung, and some relativistic effects (e.g., time dilation, energy-momentum relation) are mainly caused by this relative deflection of photons (and sometimes including neutrinos). In addition, the **Lorentz transformation** is essentially a radial deflection of photons or a circumferential rotation of moving particle systems (whose translation relative to external flat space **still follows the Galilean transformation**).

Because high-energy electron-positron collisions can create various leptons and hadrons [9], we can infer that when a polar particle (e.g., electrons, nucleons) and its antiparticle annihilate, **the released charges will be paired into a positive-negative virtual electron pair and fuse into the vacuum dielectric**. In fact, the relativistic superposition maximum of the velocities of two particles with non-zero mass only means the relative eddying speed (surrounding the particle) of the correlative vacuum medium **related to moving-particle system energy**:

$$\begin{aligned} v &\approx \frac{m_{\mathrm{v}}\left(v_1 - v_2\cos\theta\right)}{m_{\mathrm{v}}\left[c^2 + \frac{1}{2}\left(v_1 - v_2\cos\theta\right)^2 - \frac{1}{2}\left(v_1^2 + v_2^2\cos^2\theta\right)\right] \Big/ c^2} \\ &= \frac{1}{1 - \frac{v_1 v_2\cos\theta}{c^2}}\left(v_1 - v_2\cos\theta\right) \le c \quad (0 \le \theta \le \pi), \end{aligned} \tag{10}$$

where m_{v} is an energy factor of polar vacuum medium particles (vvirtual electrons, whose positive-negative combination pairs should be **dark matter particles** [8]). As for **virtual electrons**, their directed polarization (gradient) presents an electric field, while their directed vortex (vorticity) exhibits a magnetic field; moreover, their high-speed eddying fields can capture (or circumferentially deflect) photons, which leads to an exponential increase in the energy carried by near-light-speed particles. For a moving particle ($m_0 \neq 0$), its self-energy **periodic action projection** follows $\frac{m_0c^2}{E}m_0c^2T = m_0c^2T_0$, where $T_0 = T\cos\beta \approx T\sqrt{1 - \frac{v^2}{c^2}}$ (see subsection 2.5).

Frankly, **relativity's misinterpretation** of the constancy of the light speed in a vacuum hindered Einstein himself and us from understanding nature more naturally.

2.3 Spin and the dynamic equation of photons

Indeed, Bohr magneton $\mu_{\mathrm{B}} = \frac{e\hbar}{2m_{\mathrm{e}}} = \frac{e(\alpha c/n)}{2\pi(na_0)}\left[\pi(na_0)^2\right] = \frac{1}{2}\left|n\boldsymbol{a_0} \times e\left(\frac{1}{n}\alpha\boldsymbol{c}\right)\right|$ is akin to the circular-current magnetic moment and the revolving-charge angular momentum. Furthermore, the electron orbiting the proton of

ground-state hydrogen atoms satisfies $|\boldsymbol{a_0} \times m_{\mathrm{e}}(\alpha \boldsymbol{c})| = \hbar$, but its orbital angular momentum equals zero. As for the photon, both its wavelength and diffractive ability are negatively correlated to its frequency, and its circular polarization seems to be the spiral motion that the spin direction is parallel or antiparallel to the translation. Therefore, we can ingeniously identify that **the classical counterpart of elementary-particle spin is circular motion**. Naturally, the energy $E_\gamma = h\nu_\gamma = p_\gamma c = 2E_k^\gamma$ of a photon is jointly contributed by its light-speed spin and light-speed translation, while the spin radius r and its **de Broglie wavelength** λ follow $\lambda = 2\pi r$.

In essence, the **Planck constant** $h = \frac{E}{\nu} = \frac{pv}{\nu} = \frac{mv^2}{\nu}$ (where m includes both rest mass m_0 and energy factor m_γ) describes the vortex and periodic action (mv^2T) of elementary particles spinning in a vacuum fluid:

$$h = \int_0^{\lambda/v} mv^2 \mathrm{d}t = \oint_0^{2\pi r} mv\mathrm{d}l = \iint_0^{\pi r^2} m\Omega \mathrm{d}A \quad \left(\Omega = |\boldsymbol{\nabla} \times \boldsymbol{v}| = \frac{2v}{r}\right), \tag{11}$$

which reveals the equivalence between spin circulation and spin-vorticity flux, mirroring the fluid properties of space and **the one-way characteristics of time** (as Heraclitus famously said, "No man ever steps in the same river twice."). The Planck constant (action) $h = mv^2T = m\Omega A_T$ is equivalent to the elementary energy-vorticity flux ($mc^2\Omega A_T > 0$), closely associated with the one-way directivity of the same interaction force (energy flowing). For example, apples fall from trees to the ground, boiling water cools spontaneously in low-temperature environments, and chicks hatch from eggs, but such sequences can never be reversed.

Combined with the Biot-Savard law in fluid mechanics, **the speed of light** in the vacuum (dielectrics and gravitational media) can be expressed as

$$c = \frac{1}{\sqrt{\varepsilon_0\mu_0}} = \sqrt{g_{\mathrm{U}} r_{\mathrm{U}}} = \sqrt{\frac{P_{vac}}{\rho_{vac}}} = \frac{h/m_\gamma}{4\pi} \int_0^{\pi} \frac{\sin\theta \mathrm{d}\theta}{r} \quad \left(rm_\gamma c = \frac{h}{2\pi}\right), \tag{12}$$

unveiling the dynamic system of photons' uniform motion, spin, and weightlessness (note that a photon has zero charges and zero magnetic moments). Moreover, this formula delineates that the large-scale universe possesses an observable radius of $2r_{\mathrm{U}}$, and clarifies that **wave-particle duality** is a phenomenon in which particles translate in a fluid and are accompanied by circular spin (linear polarization is a cycloid motion).

2.4 The nature of gravitation

The formula (12) also indicates that non-contact interactions arise from the energy-density gradient of space media and are transferred by the momentum of light-speed vacuum particles:

$$\boldsymbol{F} = \frac{\mathrm{d}\boldsymbol{p}}{\mathrm{d}t} = \frac{\mathrm{d}(\rho_r V c)}{\mathrm{d}t}\vec{\boldsymbol{e}} = \frac{\mathrm{d}\left[\rho_r \left(Act\right) c\right]}{\mathrm{d}t}\vec{\boldsymbol{e}} = \rho_r c^2 \boldsymbol{A} = \iiint_V \boldsymbol{\nabla}\left(\rho_r c^2\right)\mathrm{d}V, \tag{13}$$

where $\rho_r c^2$ is the energy density of the spatial medium resonating with the force-applying object and acting on force-bearing objects. For gravitation, there is $\rho_r \approx \frac{m_1}{4\pi r^2 (Gm_2/c^2)}$. Unquestionably, this is in perfect agreement

with Newton's second law of motion and illuminates the mechanism (including the inverse square law) of non-contact fundamental interactions in a unified and natural way.

Since gravitation always points to the centroid of objects, the gravitational medium necessarily has an extreme negative energy density. **Gravitational flux** $\Phi_G = -4\pi mG = -4\pi \frac{m}{M_\mathrm{P}} \frac{2\pi l_\mathrm{P}^2 c}{T_\mathrm{P}}$ $\left(T_\mathrm{P} = \frac{2\pi l_\mathrm{P}}{c}\right)$ can be perceived as **graviton (or graviton pair) flux** (unified with electric flux $\Phi_E = \frac{q}{\varepsilon_\mathrm{o}}$ and electrostatic force $F_E = \Phi_E \frac{Q}{4\pi r^2}$), and gravitation is given by

$$F_G = \Phi_G \sigma_M = -4\pi mG \frac{M}{4\pi r^2} = -\frac{GMm}{r^2} \tag{14a}$$

$$= -\rho_r c^2 A_m^G = -\frac{Mc^2}{4\pi r^2 (Gm/c^2)} \left[4\pi \left(\frac{Gm}{c^2}\right)^2\right] \quad \left(r \gg \frac{Gm}{c^2}\right). \tag{14b}$$

The **gravitational energy density** of vacuum media is approximately

$$w_\mathrm{g} \approx -\frac{M_\mathrm{P} c^2}{4\pi l_\mathrm{P}^3/3} = -\frac{M_\mathrm{P}^6}{m_\mathrm{e}^2 m_\mathrm{p}^4} w_\mathrm{U} \approx -6.9 \times 10^{131}\ \mathrm{eV \cdot m^{-3}}, \tag{15}$$

which cannot be directly observed because gravitons are well-distributed ($\boldsymbol{\nabla} w_\mathrm{g} = 0$) and un-shieldable (immune to matter interactions). Although quantum theory [10] calculates the zero-point energy to be of the same order of magnitude as w_g, it misses the minus sign by failing to comprehend gravitational media with negative energy (hence it is incapable of elucidating gravitation, either).

Conceivably, the negative energy density of a gravitational medium is partly diluted by its resonance with the energy carrier of objects, thus inevitably presenting a centripetal gravitational field through the spatial energy-density gradient around the object.

2.5 Time dilation

As shown in subsection 2.1, many cosmological parameters of the large-scale universe can be expressed as the combination of constants, meaning that the universe is most likely the Newtonian cosmos. Moreover, the photon that keeps spinning and frequency shifting (observable changes) necessarily experiences time elapse, indicating that the cosmic background time should be the absolute, true, and mathematical Newtonian time. Indeed, the so-called time dilation (and space-time warp in relativity) can entirely be understood more intuitively and calculated more simply by Newtonian mechanics (**no relativistic description required**).

The Hafele-Keating experiment [11] shows that the atomic clocks carried by aircraft flying east along the equator are timed slower, while those heading west **become faster**. Hence, it can be inferred that the critical factor in the time dilation of the atomic clock is not its speed relative to observers but its revolving speed (or acceleration) relative to the resting center of the earth. (**Note**: Observed within the earth's Hill sphere, the stationary centroid of the earth approximates an absolute reference frame.) Besides, the high-speed muon with an extended lifetime

also has a greater spin centripetal acceleration (relative to the spin-vortex core) and higher spin frequency (or matter-wave frequency, **more rapid non-decay changes**). Is it logically self-consistent to ignore the shortening of the spin period of high-speed muons and regard the lengthening of their decay periods as evidence of time dilation?

In fact, like the cycle alteration of the same pendulum in different gravitational potentials, time dilation is also the period changing of characteristic motion (e.g., spontaneous decay, excited-state transition) of certain particles, closely related to centripetal acceleration (including eddying centripetal acceleration, that is, stress effects). In addition, special relativity alone is incapable of calculating the timing-period shift of clocks on GPS satellites. It is suitable for calculating the energy and momentum of near-light-speed (in which gravitation and lower initial spin acceleration can be neglected) particles with non-zero mass, only because the Lorentz transformation is an eddying-energy-related rotation (including the eddy of virtual electron pairs constituting vacuum dielectric).

As an example of time dilation, the period shift of atomic clock timing (by excited-electron transition) follows the acceleration relation (since the acceleration of the excited-electron vorticity field can deflect the photon by an angle $\beta = \arccos\frac{\sqrt{c^2-2Rg-ra}}{c}$ in radial directions):

$$T \approx \frac{\sqrt{c^2-2R_0g_0-r_0a_0}T_0}{\sqrt{c^2-2Rg-ra}} = \frac{\sqrt{c^2-(2R_0g_0+v_0^2)}}{\sqrt{c^2-(2Rg+v^2)}}T_0 \quad \left(0<2Rg+v^2<c^2\right), \tag{16}$$

suggesting that a photon captured by a given electron moves a **changeless projection distance** $cT\cos\beta = cT_0\cos\beta_0$ (the actual path is a curve including reflection and coordinate-system rotation) relative to the exit of a vorticity field (which can fetter energy) before being released. Undoubtedly, the atomic clock at different gravitational potentials ticking at different rates [12], which is in essence similar to the periodic variations $\frac{T_1}{T_2} \approx \frac{\sqrt{g_2}}{\sqrt{g_1}}$ of a mechanical pendulum clock at different gravitational potentials, reflecting the change in the motion state of objects when the force is altered rather than the change in the elapse speed of background time.

For the atomic clock on GPS satellites, $T_{\mathrm{G}} \approx \sqrt{\frac{c^2-2R_\oplus g_0-v_0^2}{c^2-3R_{\mathrm{G}}g_{\mathrm{G}}}}T_\oplus$ ($v_0 \approx 465\ \mathrm{m\cdot s^{-1}}$, $\sqrt{R_\oplus g_0} \approx 7905\ \mathrm{m\cdot s^{-1}}$, $\sqrt{R_{\mathrm{G}}g_{\mathrm{G}}} \approx 3885\ \mathrm{m\cdot s^{-1}}$) shows that its timing is faster by about $\left(1-\frac{T_{\mathrm{G}}}{T_\oplus}\right)\times 24\times 3600\ \mathrm{s} \approx 38\ \mu\mathrm{s}$ every day. The formula (16) also applies to particle's spontaneous decay, indicating that time dilation is purely a rhythm change of the internal motion of certain particles under forces (related to acceleration and energy).

2.6 The precession of Mercury's perihelion

For a free photon, the non-constant factors of its momentum $\boldsymbol{p}_\gamma$ and energy $h\nu_\gamma$ are one selfsame physical quantity $m_\gamma = \frac{p_\gamma}{c} = \frac{1}{c^2}h\nu_\gamma = \frac{1}{c^2}\left(2E_k^\gamma\right)$. We can define $m_\gamma = \frac{1}{c^2}\left(2E_k\right)$ as the **light-like mass**, which applies to all moving objects. Like photons that cannot be accelerated or decelerated by gravitation (disregarding black holes and general fluids) in the tangential direction, the potential energy of light-like mass in a star's gravitational field will embody as circumferential precession energy of planets or result in tangential redshift and radial deflection of light. Based on this understanding, Newtonian mechanics can more naturally address the periodic precession of

planetary orbits and the gravitational deflection of starlight.

For example, Mercury's light-like mass is $m_\gamma = \frac{1}{c^2}\,(2E_k^M)$, and its precession energy is $\Delta E_k = \frac{1}{2}m_\gamma v^2 + \frac{GM_\odot m_\gamma}{R}$. Therefore, the periodic (T_M) precession angle φ of Mercury's perihelion is

$$\begin{aligned}\varphi &\approx 2\pi\frac{\Delta a(T_\mathrm{M}^2/2\pi)}{a(T_\mathrm{M}^2/2\pi)} = 2\pi\frac{\Delta v^2/R}{v^2/R} = 2\pi\frac{\Delta E_k}{E_k^M} = \frac{6\pi GM_\odot}{Rc^2}\\ &\approx \frac{1}{2}\left[\frac{6\pi GM_\odot}{l(1+e)c^2} + \frac{6\pi GM_\odot}{l(1-e)c^2}\right] = \frac{6\pi GM_\odot}{l(1-e^2)c^2},\end{aligned} \tag{17}$$

where l and e are the long semi-axis and eccentricity of Mercury's orbit, respectively.

2.7 The gravitational deflection of starlight

As mentioned earlier, photons in the vacuum invariably travel along a great circle (geodesic) of large-scale spherical space, and its gravitational center of starlight is not the star. Like the saltation in velocity before and after refraction, the local provisional great-circle orbit will also adjust in an instant as starlight enters and exits a star's Hill sphere (or stellar wind sphere). Since starlight undergoes gravitational deflection as it passes by the sun, theoretically, the deflected path should be a great circle arc (with its center located very far away rather than at the sun's centroid).

Note that **the sun's gravity can deflect its own light radiated non-perpendicular to its spherical surface**, and that θ is inversely proportional to r in Eq. (18): If the sun's luminous volume becomes smaller (suppose its radius changes to $\frac{R_\odot}{1000}$ and mass occupies most of $M_\odot$), what would happen to its radius as observed from the earth? Now, suppose the star's rays are parallel to the straight line (X axis) connecting the earth with the sun's center and at a perpendicular distance of r (parallel to the Y axis), then when the ray (photon) skims (or even "pierces through") the sun and reaches the earth, the vertical projection variation of its energy is $\Delta E_\gamma = \int \boldsymbol{F}\cdot \mathrm{d}\sqrt{x^2+y^2}\vec{\boldsymbol{e}} \approx \int_{-\infty}^{+\infty}\frac{Gm_\odot m_\gamma r}{(x^2+r^2)^{3/2}}\mathrm{d}x \approx \frac{2GM_\odot m_\gamma}{r}$. Accordingly, it is simple to get the gravitational deflection angle of the starlight:

$$\theta = 2\frac{\theta}{2} \approx 2\tan\frac{\theta}{2} = 2\frac{\Delta E_\gamma}{E_\gamma} \approx 2\frac{2GM_\odot m_\gamma/r}{m_\gamma c^2} = \frac{4GM_\odot}{rc^2} \quad (r \gtrsim R_\odot)\,. \tag{18}$$

Of course, as for the horizontal starlight with both a horizontal and vertical distance r_U, its deflection angle when reaching the earth should be $2\arctan\frac{Gm_\mathrm{U}}{r_\mathrm{U}c^2} = \frac{\pi}{2}$.

3. Conclusions

In summary, this study re-established the eternal Newtonian universe model and absolute Newtonian space-time by simplifying (or unifying) established theories, and uncovered the link between quantum-level systems and macro systems by identifying the classical counterparts of spin. These findings will further enlighten more physicists

to ponder the nature behind fundamental phenomena or pursue a theory of everything and assist the public in understanding the universe more correctly. Settle scientific puzzles in the way Alexander unraveled the Gordian knot (allowed by basic natural laws), and we can grasp the universe like a wise king rules his kingdom.

Acknowledgements

I am thankful that Newton's physics thoughts still resonate with me today. Besides, Lorentz and Poincare never approved of the interpretation and development of their theory by special relativity, which once motivated me to pursue a more natural theory that both they and Einstein (and Minkowski) would embrace if they were alive.

Data Availability Statements

No new data were created or analysed in this study.

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Note: All the references not listed can be found in college physics textbooks.