The Theory of Observational Relativity
Serial Report 1: A New Theory with New Discoveries and New Insights

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Abstract: This article reports a new theory in physics: the theory of Observational Relativity (OR). The theory of OR has discovered that all spacetime models and theoretical systems in human being's physics must be branded with observation. The theory of OR has uncovered the root and essence of the relativistic effects of matter motion and matter interactions presented in spacetime: All relativistic effects are observational effects and apparent phenomena. The speed of light is not really invariant; Spacetime is not really curved. The Galilean transformation and Newtonian mechanics are the product of idealized observation with the idealized agent OA_∞, presenting us with the objective and real physical world; The Lorentz transformation and Einstein relativity theory are the product of optical observation with the optical agent OA(c), presenting us with only an optical image of the physics world, not exactly the physical reality. The theory of OR is a theory of the general observation agent OA(η) ($0<\eta<\infty$; $\eta\to\infty$), which has genralized and unified classical mechanics and Einstein relativity theory: as $\eta\to\infty$, the spacetime transformation of OR strictly converges to the Galilean transformation, and the theory of OR strictly reduces to Newtonian mechanics; as $\eta\to c$, the spacetime transformation of OR strictly converges to the Lorentz transformation, and the theory of OR strictly reduces to Einstein relativity theory. The unity of Newton and Einstein in the theory of OR, from one aspect, confirms the logical self-consistency and theoretical validity of OR. This article will report to readers the establishment of OR theory and its significant discoveries, and at the same time, attempt to clarify that the theory of OR not only is the product of logic and theory, but also has empirical basis, supported by observations and experiments. Now, mankind needs to re-examine his physics and reshape his view of nature.

Key Words: relativity theory, the invariance of light speed, spacetime curvature, the principle of correspondence, the principle of locality, observational locality

1 Introduction

Hawking ever remarked in his book A Brief History of Time [1]: "If we discover a complete theory, it would be the ultimate triumph of human reason -- for then we should know the mind of God."

What this article presents to readers, the theory of **Observational Relativity** (OR for short), is exactly Hawking's so-called **Complete Theory**.

In 1887, following Maxwell's proposal [2], American physicists Michelson and Morley performed an experiment to search for the ether [3]. They failed to capture the ether and encountered a problem: Galileo's speed-addition law appeared to be invalid.

The Michelson-Morley experiment showed that the speed of light c plus the orbital speed v of the earth remained the speed of light c. To explain the Michelson-Morley experiment, FitzGerald proposed a hypothesis that the space of a moving object would contract by a factor of $\sqrt{(1-v^2/c^2)}$ along the line of motion [4]. Afterwards, Lorentz added a hypothesis that the time of a moving object would dilate by a factor of $1/\sqrt{(1-v^2/c^2)}$ [5-7]. Thus, the Lorentz transformation, or the FitzGerald-Lorentz transformation, was born.

In 1905, Einstein seemed to have grasped the true meaning of the Michelson-Morley experiment, and proposed the principle of the invariance of light speed. It is based on the principle of the invariance of light speed that Einstein theoretically deduced the Lorentz transformation and established his theory of special relativity [8], revealing the relativistic effects of inertial spacetime and inertial motion, the effect of **Time Dilation and Length Contraction** the most talked. In 1915, on the basis of special relativity, Einstein established his theory of general relativity [9], revealing the relativistic effects of gravitational spacetime and gravitational interaction, the effect of **Spacetime Curvature** the most talked.

Einstein's theory of relativity, both the special and the general, has been established for over a century. However, even today, we still do not know why the speed of light is invariant and why spacetime is curved.

The principle of the invariance of light speed is the indispensable logical premise of Einstein theory of relativity including the special and the general, and is the root of all relativistic effects in Einstein theory of relativity, including **Time Dilation and Length Contraction** and **Spacetime Curvature**.

According to the incompleteness theorem of the great logician Gödel [10,11], an axiom of a theoretical system is a logical proposition that cannot be proven or disproven by the theoretical system itself. As a logical premise or an axiom, the principle of the invariance of light speed cannot be proven or disproven by Einstein's theory of relativity. Therefore, Einstein could not explain why matter motion and gravitational interaction exhibited relativistic effects in his theory, including why the speed of light was invariant and why spacetime was curved.

From the cause-and-effect relationship or causal logic,

the Invariance of Light Speed (ILS), as a principle and the fundamental logical premise of Einstein theory of relativity, is indeed puzzling:

(1) The ILS is not self-evident and lacks the logically basic features as a principle or an axiom;

(2) The ILS does not have any connection with other theories or principles in physics and cannot be mutually confirmed;

(3) The ILS is not like a cause but more like an effect, confusing cause and effect.

It is such logical speciousness that leads us to know what the relativistic effects are, but not to know why they presented in spacetime, so that we have had many specious concepts, specious spacetime models, and even specious doctrines or theories.

Now, the theory of OR as a new theory has had new discoveries, new insights, and new ideas.

The theory of OR has uncovered the root and essence of the relativistic effects of matter motion and matter interactions presented in spacetime: All relativistic effects are observational effects and apparent phenomena -- **The speed of light is not really invariant**; **Spacetime is not really curved**.

The theory of OR has discovered that all spacetime models and theoretical systems in physics must be branded with observation. The Galilean transformation and Newtonian mechanics are the product of idealized observation with the idealized agent OA_∞, presenting us with the objective and real physical world; the Lorentz transformation and Einstein relativity theory are the product of optical observation with the optical agent OA(c), presenting us with only an optical image of the physical world, not exactly the physical reality.

The theory of OR originates from more basic logical premises and is a theory of the general observation agent OA(η) ($0<\eta<\infty$; $\eta\to\infty$). So, it has a broader perspective, and therefore, has generalized and unified classical mechanics and Einstein relativity theory: as $\eta\to\infty$, the spacetime transformation of OR strictly converges to the Galilean transformation, and the theory of OR strictly reduces to Newtonian mechanics; as $\eta\to c$, the spacetime transformation of OR strictly converges to the Lorentz transformation, and the theory of OR strictly reduces to Einstein relativity theory. In fact, Newtonian mechanics and Einstein relativity theory are only two special cases of OR, i.e., what Hawking referred to as **Partial Theories**. Whereas the theory of OR has become what Hawking referred to as a **Complete Theory**.

So, Newtonian mechanics and Einstein theory of relativity, the two great theoretical systems of human being's physics, have been generalized and unified accidentally by the theory of OR in the same theoretical system under the same axiom system.

The theory of OR, as a scientific research report submitted to Academic Committee of Beijing University of Technology [12-15], has already formed a complete theoretical system, consisting of two parts: Volume I, **Inertially Observational Relativity** (IOR); Volume II, **Gravitationally Observational Relativity** (GOR). As the first part of OR serial reports, this article focuses on reporting: (1) the logical deduction of OR and the establishment of OR; (2) the unity of Newton and Einstein; (3) the significant discoveries of OR.

And then, this article will clarify the logical self-consistency of the OR and the theoretical correctness of OR, as well as, the empirical basis of OR and the observational and experimental evidences of OR.

2 The Original Intention of OR

The theory of OR is not deliberately designed and manufactured, it is merely an unexpected scientific discovery. But anyway, it is the product of logic and theory, and the product of empiricism and speculation.

According to the dialectical materialist view of nature, each entity is a unity of contradictions: the universe being that of spacetime and matter, spacetime being that of space and time, and matter being that of mass and energy. The contradictory parties are independent with each other, interdependent with each other, and under certain conditions, transform into each other.

In a sense, Einstein's theory of relativity is an excellent interpretation of the dialectics of nature and the dialectical materialist view of nature.

As the fundamental premise of Einstein theory of relativity, however, Einstein's principle of the invariance of light speed leads to two specious inferences:

(i) The speed of light is the ultimate speed of the universe that cannot be exceeded; and

(ii) Photons have no rest mass.

According to Einstein's mass-speed relation:

$$m = \frac{m_o}{\sqrt{1 - v^2/c^2}} \quad \left(\lim_{v\to c} m_o = 0 \ \text{ or } \ \lim_{v\to c} m = \infty \right),$$

if an object P travels at the speed of light c, then its rest mass m_o is zero or its relativistic mass m is infinite.

According to the principle of physical observability, an infinite physical quantity is unreal. So, Einstein had to set the rest mass m_o of photons to zero.

It is puzzling that, according to Einstein's mass-speed relation, the identical observed object P appears to have different relativistic mass m to different observers. Therefore, people subconsciously believe that the relativistic mass m is unreal, and only the rest mass m_o is the objective and real mass of P, that is, the intrinsic mass of matter.

The absence of rest mass in photons is tantamount to the absence of mass in photons. Then, without mass, what would the energy of a photon depend on?

So, it became the original intention for the theory of OR to give photons a little bit of mass.

Originating from the innate view of nature, great physicists such as Feynman [16], De Broglie [17,18], and Schrödinger [19,20] also did not accept the absence of rest mass in photons, and ever spent much time and effort attempting to determine the rest mass of photons through observations or experiments. Until today, many experimental physicists still attempt to determine the rest mass of photons through observations and experiments.

Unlike determining the rest mass of photons by observation or experiment, the author of OR attempts to theoretically give photons a little bit of rest mass and establish a theoretical model of photons having rest mass.

The author of OR originally thought that **The Ultimate Speed** of the Universe was perhaps not the speed of light *c*, but that it should be defined as Λ: the speed at which the matter-wave frequency of material particle *P* tends to infinity. Although the frequency of light is very high, it is still limited. According to the definition of Λ, the speed of light *c* should be lower than Λ: $c<\Lambda$. In this way, a photon could obtain its own rest mass:

$$m_o = m\sqrt{1-c^2/\Lambda^2} > 0 \quad (c<\Lambda,\ 0<m<\infty).$$

So, what would be exactly the ultimate speed Λ?

The author of OR originally thought that Λ, not *c*, would be the invariant speed, i.e., the true ultimate speed of the universe, and could not be surpassed or reached by any material particles including photons.

Based on this idea, the author of OR set out to establish an axiom system, expecting to derive a model of spacetime transformation that could give photons rest mass.

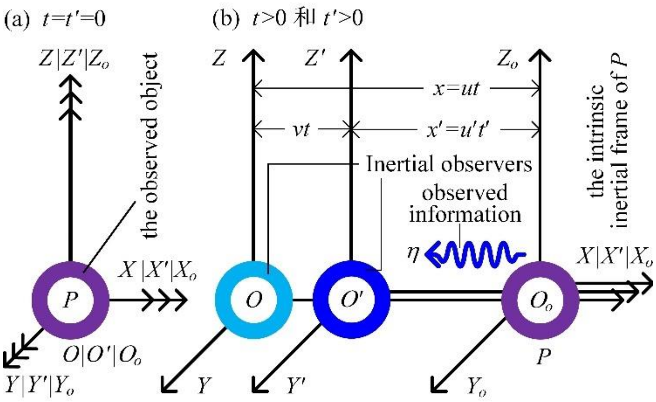

Figure 1 The Spacetime Transformation of $O'\to O$ and Observation

(1) *P*: the observed object; (2) *O* and *O′*: inertial observers; (3) (X,Y,Z), (X',Y',Z'), and (X_o,Y_o,Z_o): the coordinate systms of *O*, *O′*, and *P* (or *P*'s intrinsic observer O_o), respectively; (4) (x,t,u) and (x',t',u'): the information on *P*'s space, time and speed observed by *O* and *O′*, respectively; (5) η: the intrinsic transmitting speed of observed information; (6) A problem: How would the observed information on *P* be transmitted from *P* to *O* and *O′*?

As depicted in Fig. 1, the author's logical deduction and theoretical derivation needed a physical quantity which has a clear and definite physical significance: the speed of the information on the observed object *P* relative to the observer, being denoted as η for the time.

3 Observation and Observational Locality

The theory of OR discovers that all spacetime models and all theoretical systems in human being's physics are linked to certain observation media or observation systems, and must be branded with observation. This is the origin of the name of **Observational Relativity** (OR).

Throughout history, however, human being's physics has never clarified the indispensable role and status of observation in spacetime models or physical theories.

3.1 Three Important Concepts of OR

Observation is to perceive the objective world and to obtain the information about the objective world.

As depicted in Fig. 1, the information about the observed object *P* must be transmitted by a certain observation medium at a certain speed from the observed object *P* to the observer *O*, so that the observer *O* can perceive the observed object *P*.

However, physicists, including Newton and Einstein, do not seem to be aware of such problems involved in their spacetime models or theoretical systems:

(i) Who is transmitting the information about the observed object *P* to the observer *O* (*O′*)?

(ii) At what speed is the observed information about *P* transmitted from *P* to *O* (*O′*)?

In order to clarify the role or status of observation and observation media in spacetime models and theoretical systems of physics, the theory of OR has coined three important concepts related to observation.

(i) **Observation Agent**: An observation system $(P, M(\eta), O)$ that employs the specific observation medium $M(\eta)$ with the specific speed η to transmit the information about the observed object *P* to the observer *O*, denoted as OA(η).

(ii) **Information Wave**: the matter wave of the observation medium of OA(η) that transmits the observed information.

(iii) **Informon**: the material particles that consist of the information wave of OA(η).

Železnikar once employed **Informon** to refer to an information entity and analogized it with an electron [21].

In theory, all forms of matter motion, not just light or photons, can serve as observation media to transmit the information on observed objects for observers.

All matter waves, including sound wave, light wave, electric wave, water wave, seismic wave, and gravitational wave, can serve as information waves; all matter particles, including photons, electrons, neutrons, protons, atoms, molecules, and even a rock, can serve as informons.

Table 1. Mankind could perceive the objective world through different observation agents

Observation Agent OA(η) ($0<\eta<\infty;\eta\to\infty$)	Information Waves (Medium $M(\eta)$)	IW Speeds (η (m/s))
OA(v_S): bat agent	air ultrasonic wave	$\eta=v_S\approx340$
OA(v_U): dolphin agent	underwater ultrasonic	$\eta=v_U\approx1450$
OA(c): optical agent	light or EM interaction	$\eta=c\approx3\times10^8$
OA(κ): gravity agent	gravitational wave	$\eta=\kappa>7\times10^6c$
OA_∞: idealized agent	Idealized IW	$\eta\to\infty$

Note: (1) OA(η) ($0<\eta<\infty$; $\eta\to\infty$): the general observation agent including the realistic and the idealized; (2) All realistic observation agents have the observational locality ($\eta<\infty$), leading to the delay of observed information -- the lower the IW speed η, the more significant the observational locality of OA(η) and the relativistic effects it exhibits in observation are; (3) the idealized observation agent OA_∞ has no observation locality, and therefore, no relativistic effects or apparent phenomena.

Nature is equipped with various observation agents for mankind, such as: the ear being human acoustic agents; the eye being human optical agent. Human perception of the objective world may employ different observation agents. All spacetime models and theoretical systems of human being's physics, including Galileo's doctrine and Newton's mechanics, as well as Einstein's theory of relativity, imply their respective specific observation agents.

3.2 The Observational Locality of Mankind

Locality, or the locality principle, plays an important role in modern physics. both Newton and Einstein believed that there was no action at a distance in the universe.

Einstein's concept of locality is linked to his hypothesis of the invariance of light speed: matter could not move faster than the speed of light. In 1935, based on his concept of locality from the ILS, Einstein and his colleagues Podolsky and Rosen conceived a famous thought experiment called **the EPR Paradox** [22] to question the completeness of quantum mechanics.

However, an increasing number of EPR experiments have shown [23,24] that quantum entanglements do exist in the physical world. This indicates that there indeed exist the forms of matter motion that exceed the speed of light in the physical world. But this does not mean that there exists **spooky action at a distance** in the universe.

Under the principle of physical observability, locality or the principle of locality is beyond doubt.

The Principle of Physical Observability (PPO) [12-15]: In short, infinite physical quantities are unobservable; the universe have no infinite physical quantity.

Actually, the principle of locality is just a logical inference from the principle of physical observability: the speed of any form of matter motion must be finite or limited; it takes time for both matter and information to cross space. However, this does not mean that the speed of light cannot be surpassed. It only means that there is no matter motion with infinite speed in the universe.

Since the speed of matter motion is limited, the transmitting speed of observed information must also be limited. This can be expressed as a principle.

The Principle of Observational Locality (POL) [12-15]: According to the principle of locality, the information-wave speed η of a realistic observation agent OA(η) must be finite or limited ($\eta<\infty$), and it takes time for the information wave of OA(η) to cross space.

The principle of observational locality means that all realistic observation agents must have the observational locality: $\forall$OA(η) $\eta<\infty$.

Human perception of the objective world is restricted by the observational locality: when you hear a bird chirping as it flies across the sky, it is no longer in the place where it was chirping; when you see its image, it is no longer in the place where it was flying.

The theory of OR has discovered that all relativistic effects are observational effects and apparent phenomena: the root and essence of relativistic effects lie in the observational locality ($\eta<\infty$) of the observation agent OA(η).

3.3 The Principle of General Correspondence

In 1920, Bohr formally established the principle of correspondence, commonly known as Bohr Correspondence Principle [25]. Actually, the basic idea of Bohr correspondence principle can be traced back to 1913. Based on the basic idea of his correspondence principle, Bohr established his atomic model and atomic theory [26-28].

The Basic Idea of Bohr correspondence principle: There must be an intrinsic corresponding relationship between quantum mechanics and classical mechanics, and under certain conditions, quantum mechanics and classical mechanics can be transformed into each other.

There are various interpretations of Bohr correspondence principle. The most common are two limiting forms:

(i) The limit of Bohr quantum number n: $n\to\infty$;

(ii) The limit of Planck constant h: $h\to 0$.

Actually, Galilean relativity principle is also a type of correspondence principle.

The Basic Idea of Galilean Relativity Principle: Spacetime is symmetrical, and therefore, all observers are equal or have equal rights, in other words, a physical law or a spacetime model must take the same form in different reference frames [29,30].

The principle of relativity implies an intrinsic corresponding relationship between different reference frames: a physical law or a spacetime model of physics in different reference frames has the same form or structure, being **Isomorphic** or **Isomorphically Consistent**, possessing the corresponding relationship of isomorphic consistency.

Galileo's principle of relativity implies the equality of observers of different reference frames; whereas Bohr's principle of correspondence implies the equality of observers of different observation agents, the optical agent OA(c) and the idealized agent OA$_\infty$.

Now, the theory of OR further clarifies that **All Observation Agents are Equal**.

The Principle of General Correspondence (PGC) [12-15]: Spacetime is symmetrical, and so, all observers, regardless of reference frames or observation agents, are equal or have equal rights, the idetical physical law or spacetime model must take the same form in different reference frames with different observation agents, being isomorphic or isomorphically consistent, possessing the corresponding relationship of isomorphic consistency.

Based on the PGC principle, the theoretical systems of different observation agents OA(η_1) and OA(η_2) can be isomorphically and uniformly transformed into each other by following PGC logical paths as below.

PGC Logical Path 1:

Based on the PGC principle, by directly replacing the η_1 of OA(η_1) with the η_2 of OA(η_2), the observed physical quantities of OA(η_1) will be correspondingly transformed into the observed physical quantities of OA(η_2), the physical models of OA(η_1) will be isomorphically and uniformly transformed into the physical models of OA(η_2).

PGC Logic Path 2:

Firstly, based on the PGC principle, transform the axiom system of the theoretical system of OA(η_1) isomorphically and uniformly into that of OA(η_2). Secondly, based on the transformed axiom system, following or analogizing the logic of the theoretical system of OA(η_1), one can deduce the theoretical system of OA(η_2) that must be isomorphically consistent with that of OA(η_1).

It is the fundamental idea of PGC principle that: **One physical world, One logical system**.

The PGC principle is originally a logical shortcut developed by the theory of OR specifically for the theory of GOR. Actually, it is a universal logical law for physics, providing an important ideological foundation and guiding principles for development of new theories and the unification of old theories in physics, as well as, for the test of the logical consistency and self-consistency of theoretical systems in physics.

4 The Establishment of OR

A theory in physics could make us know both the physical phenomena and the physical essence, only if it could be built on the most basic logical premises or the most basic axiom system,

However, cause and effect are a contradictory unity, both opposed and unitive, and under certain conditions, can be transformed into each other: a cause must be an effect of other causes; and an effect must be a cause of other effects. So, the cause-and-effect chain of logic has no beginning and no end, and there is no absolute the first principle or the most basic logical premise.

Nevertheless, compared to Einstein's theory of relativity, the theory of OR has more basic logical premises or a more basic axiom system.

4.1 IOR: Axiom System and Logical Deduction

We all know that Einstein's theory of special relativity has two major logical premises: the second, the principle of relativity; the third, the principle of the invariance of light speed. However, there is also the first that is little known: the principle of simplicity. Such **Three Principles** constitute the axiom system of Einstein special relativity. But only the principle of the invariance of light speed is indispensable, whereas the principles of simplicity relativity are only two auxiliary logical premises.

Up to today, however, the principle of the invariance of light speed as the logical premise of Einstein's theory of special relativity remains merely a specious hypothesis that is rather baffling. Einstein's theory of special relativity based on the principle of the invariance of light speed has led to numerous misconceptions in physics regarding the relativistic effects of inertial spacetime and inertial motion, including the invariance of light speed and the effect of time dilation and length contraction.

The theory of IOR is founded on a more basis axiom system, and the logical deduction of IOR is rooted from more basic logical premises.

4.1.1 The Axiom System of IOR

Compared to Einstein's special relativity, the theory of **Inertially Observational Relativity** (IOR) has more basic logical premises and a more basic axiom system.

IOR Axiom System [12-15]

The First: The Principle of Physical Observability

The Second: The Conditions of Wave-Particle Duality

(1) The Principle of Frequency-Speed Relation

(2) The Definition of the Ultimate Speed

(3) The Principle of OR Speed Addition

The Third: The Definition of Time

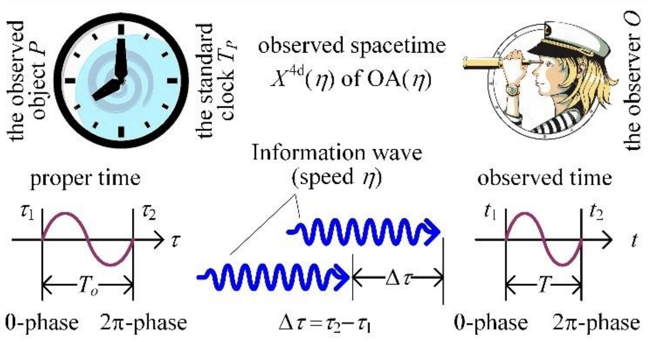

Figure 2 The Standard Clock: Proper Time τ and Observed Time t

(1) The standard clock: Let a periodic signal source T_P be the observed object P, define the intrinsic period T_o and intrinsic frequency f_o of P or T_P as the basic units for measuring time; if P is stationary in free spacetime S_F, then T_P is the standard clock. (2) The intrinsic time (proper time) τ: According to the definition of OR time, it is the time observed by the intrinsic observer O_o of P or by the idealized agent OA$_\infty$ -- Einstein called it the standard time; (3) Observational or observed time t: Constrained by the observational locality of the realistic observation agent OA(η) ($0<\eta<\infty$), the observed time t of a realistic observer O is not the objective and real time τ (proper time) -- Einstein called it the coordinate time.

Definition 1. Time: Suppose there are a periodic signal source T_P and an observer O armed with a specific observation agent OA(η); T_o and f_o are respectively the intrinsic period and frequency of T_P. If O observes N periods of T_P in the duration of Δt with OA(η), then $\Delta t = NT_o = N/f_o$, and Δt is referred to as **the observed time** of T_P relative to O or OA(η); in particular, if Δt is the observed value if O and T_P are relatively stationary in the free spacetime S_F or if OA(η) is the idealized agent OA$_\infty$, then Δt is referred to as **the intrinsic time** and denoted as $\Delta\tau$ ($=N_oT_o=N_o/f_o$), where N_o is the period number in the duration of the intrinsic $\Delta\tau$ when P is stationary in the free spacetime S_F.

The definition of time is the fundamental and indispensable logical premise of OR, both IOR and GOR, whereas the principle of physical observability and the conditions of wave-particle duality are only auxiliary logical premises of IOR.

Time is the most basic physical quantity in physics. To some extent, the definition of OR time in the theory of OR could be regarded as the first principle or the most basic logical premise.

4.1.2 The Logical Deduction of IOR

As depicted in Fig. 1 and Fig. 2, based on the axiom system of IOR, starting from the definition of OR time as the first principle, OR came into deducing the inertial-spacetime transformation, attempting to build a theoretical model that could give photons rest mass.

From the definition of OR time to the invariance of time-frequency ratio, and to the transformation of IOR time and the transformation of IOR space, the logical deduction and theoretical derivation of IOR theory have produced an interesting logical conclusion [12-15] (omitting the lengthy logical deduction of IOR): $\Lambda=\eta$!

This means that the so-called **Ultimate Speed** Λ of the universe is actually the speed η at which the observation medium transmits observed information, it depends on the observation medium of the observation agent OA(η) that is not necessarily be light.

Thus, the theory of OR has discovered that there is no really **invariant** or **insurmountable** ultimate speed in the objective physical world. The so-called ultimate speed of the universe is only an observational limitation of observers. When bats perceive the physical world with air ultrasound, the speed of air ultrasound will be the ultimate speed that bats cannot surpass observationally; when Einstein observed the physical world with light, the speed of light would be the ultimate speed that Einstein could not surpass observationally.

The theory of IOR has proven an important theorem:

The Invariance of Information-Wave Speeds -- $\forall \boldsymbol{u}\in(-\eta,\eta)\ \eta\oplus\boldsymbol{u}=\eta$ [12-15].

In theory, all matter motion or matter waves, not just light or electromagnetic interaction, could serve as observation media or information waves to transmit information about observed objects for observers.

Then, the author of OR seemed to understand why the Lorentz transformation and Einstein theory of relativity are linked to the speed of light c: it turns out that the invariance of light speed is only a special case of the invariance of information-wave speeds, which could be effective and valid only if the observer observes the physical world through light; it turns out that Einstein's theory of relativity is just a theory of human perceiving the objective physical world through light, that is, a product of optical observation, and what Hawking called a partial theory.

In this way, the theory of IOR has discovered that the speed of light is not really invariance.

Starting from the definition of OR time, under the general observation agent OA(η) ($0<\eta<\infty$; $\eta\to\infty$), based on the invariance of information-wave speeds, the theory of OR deduces a more general differential form of the transformation equation of OR inertial spacetime:

$$\begin{array}{ll} O'\to O: & O'\to O: \\ \mathrm{d}x=\Gamma(\mathrm{d}x'+v\mathrm{d}t') & \mathrm{d}x'=\Gamma(\mathrm{d}x-v\mathrm{d}t) \\ \mathrm{d}y=\mathrm{d}y' & \mathrm{d}y'=\mathrm{d}y \\ \mathrm{d}z=\mathrm{d}z' & \mathrm{d}z'=\mathrm{d}z \\ \mathrm{d}t=\Gamma\left(\mathrm{d}t'+\dfrac{v\mathrm{d}x'}{\eta^2}\right) & \mathrm{d}t'=\Gamma\left(\mathrm{d}t-\dfrac{v\mathrm{d}x}{\eta^2}\right) \end{array} \tag{1}$$

where $\Gamma=\Gamma(\eta,v)$ is the spacetime-transformation factor of the general observation agent OA(η):

$$\Gamma(\eta,v)=\left(1-v^2/\eta^2\right)^{-1/2}. \tag{2}$$

By setting the initial conditions for Eq. (1), one can obtain the algebraic form of the transformation equation of OR inertial spacetime, which can be referred to as **the general Lorentz transformation** that not only generalizes the Lorentz transformation but also generalizes the Galilean transformation, unifying the two great spacetime transformation of human being's physics.

In a sense, the Lorentz transformation represents Einstein's theory of special relativity, whereas the general Lorentz transformation represents the theory of IOR.

Just as Einstein had theoretically deduced the whole theoretical system of special relativity based on the invariance of light speed and the Lorentz transformation [8], OR has theoretically deduced the whole theoretical system of IOR based on the invariance of information-wave speeds and the general Lorentz transformation [12-15].

Finally, the whole theoretical system of IOR has generalized and unified Newton's inertial mechanics and Einstein's special relativity, and moreover, has integrated de Broglie's theory of matter waves in it, moving towards the unification of relativity theory and quantum theory (see Chapter 6 of the 1st volume IOR in [12-15]).

4.2 GOR: Axiom System and Logical Deduction

Einstein's theory of general relativity also has **Three Principles**: (1) the principle of equivalence; (2) the principle of general covariance; and (3) the principle of the invariance of light speed. However, it is strange that physicists are fond of talking about the equivalence principle and the covariance principle, yet often forget the principle of the invariance of light speed. Actually, the principles of equivalence and general covariance are only two auxiliary logical premises of Einstein general relativity, whereas the principle of the invariance of light speed is its fundamental and indispensable logical premise.

The speciousness of the principle of the invariance of light speed has further been amplified in Einstein's theory of general relativity, leading to numerous misconceptions about the relativistic effects of gravitational spacetime and gravitational interaction, including the relativistic effect of **spacetime curvature** and Einstein's prediction for **gravitational waves**. Based on Einstein's theory of general relativity, modern physics has further developed a few specious doctrine, including the **Big Bang**.

The theory of GOR is founded on a more basis axiom system, and the logical deduction of GOR is rooted from more basic logical premises.

4.2.1 The Axiom System of GOR

Based on the principle of general correspondence (PGC), the theory of **Gravitationally Observational Relativity** (GOR) can be deduced through either PGC logical path 1 or PGC logical path 2.

Compared to PGC logical path 1, deducing the theory of GOR through PGC logical path 2 is more conducive to our understanding of Einstein general relativity and its curvature of gravitational spacetime, and even to our comprehension of the root and essence of all gravitational relativistic phenomena. Meanwhile, it is more helpful for us to elucidate the logical thought of GOR.

Under the PGC principle, following PGC logical path 2, the theory of OR transforms the three principles of Einstein general relativity into the three principles of GOR.

GOR Axiom System

The First: The Principle of GOR equivalence
The Second: The Principle of GOR covariance
The Third: The Principle of Information-Wave Speeds

This constitutes the axiom system of GOR.

In the axiom system of GOR, the principles of equivalence and covariance proposed by Einstein remains valid. Furthermore, they acquire a more universal significance under the PGC principle: the observers could not only be those in different reference frames but also those in different observation agents. Under the PGC principle, Einstein's principle of the invariance of light speed has been transformed into the principle of the invariance of information-wave speeds, where the information-wave speed η of the general observation agent OA(η) replaces the speed of light c in the optical observation agent OA(c).

It should be pointed out that the principle of the invariance of information-wave speeds was originally a logical consequence of IOR, i.e., the theorem of the invariance of information-wave speeds. This implies that the theory of IOR is the foundation of GOR. In other words, the axiom system of IOR is also that of GOR; whereas the axiom system of GOR, in essence, just adds two auxiliary logical premises, the principles of GOR equivalence and GOR covariance, to the axiom system of IOR.

So, for the theory of GOR, only the principle of the invariance of information-wave speeds is fundamental and indispensable. All in all, for the theory of OR including IOR and GOR, only the definition of OR time is the fundamental and indispensable logical premise.

4.2.2 The Logical Deduction of GOR

Now, one can understand that, under the PGC principle, through PGC logical path 2, based on the three principles of GOR, following or analogizing the logic of Einstein general relativity, OR must be able to deduce the theory of GOR of the general observation agent OA(η) ($0<\eta<\infty$; $\eta\to\infty$), and ultimately, to establish the whole theoretical system of GOR that must be isomorphically consistent with Einstein's theory of general relativity.

Under the PGC principle, combining PGC logical path 1 and PGC logical path 2, OR extends the theory of IOR from inertial spacetime to gravitational spacetime, and extends Einstein's theory of general relativity from the optical agent OA(c) to the general agent OA(η). In this way, the theory of GOR could be established.

However, both PGC logical path 1 and PGC logical path 2 are logical shortcuts built on the basis of the principle of general correspondence.

It's worth noting that taking shortcuts comes at a cost.

It is because of following the logical shortcuts paved by Einstein specially for his theory of relativity that, until today, we still cannot understand why the speed of light is invariant and why spacetime is curved. Similarly, simply and directly applying the PGC principle may lead us to miss the correct understanding of the root and essence of gravitational relativistic phenomena.

Therefore, the logical deduction of GOR does not follow the logic of Einstein general relativity. In particular, the theory of GOR has abandoned Einstein's logic of **weak-field approximation** designed specially for his theory of general relativity, i.e., the so-called way of weak-field approximation. While applying the PGC principle, OR strives to deduce the theory of GOR from the most basic physical concepts and logical premises, elucidating the root and essence of gravitational relativistic effects or gravitational relativistic phenomena.

GOR Basic Way of Logical Deduction [12-15]

Step 1: Starting from the three principles of GOR;
Step 2: Analogizing the logic of Einstein's theory of general relativity;
Step 3: Taking advantage of the GOR logical way of idealized convergence.

Firstly, by analogizing the logic of Einstein's spacetime theory of general relativity, OR deduces the corresponding spacetime models of GOR and derives the GOR measuring formula of gravitational spacetime.

The Measurement of GOR Standard Time dτ:

$$\mathrm{d}\tau=\frac{\mathrm{d}s}{\eta}=\sqrt{g_{00}(\eta)}\mathrm{d}t=\sqrt{1+\frac{2\chi}{\eta^2}}\mathrm{d}t \tag{3}$$

where dt is the observed time of OA(η), χ is the Newtonian gravitational potential.

The Measurement of GOR Physical Space dl:

$$\mathrm{d}l^2=\gamma_{ik}(\eta)\mathrm{d}x^i\mathrm{d}x^k\quad\left(\gamma_{ik}(\eta)=\frac{g_{0i}g_{0k}}{g_{00}}-g_{ik}\right) \tag{4}$$

Then, by analogizing the logic of Einstein's gravitational field equation and motion equation of general theory, taking advantage of the GOR logical way of idealized convergence, OR deduces the gravitational field equation and motion equation of GOR.

GOR Gravitational-Field Equation:

$$R_{\mu\nu}(\eta)-\frac{1}{2}g_{\mu\nu}(\eta)R(\eta)=-\kappa_{\mathrm{GOR}}(\eta)T_{\mu\nu}(\eta) \tag{5}$$

where $R_{\mu\nu}(\eta)$ and $R(\eta)$ are respectively the Ricci tensor and Gaussian curvature of OA(η), $g_{\mu\nu}(\eta)$ and $T_{\mu\nu}(\eta)$ are respectively the spacetime metric and energy-momentum tensor of OA(η), and $\kappa_{\mathrm{GOR}}(\eta)$ is the coefficient of GOR field equation.

GOR Gravitational-Motion Equationof:

$$\begin{aligned}&\frac{\mathrm{d}^2x^\mu}{\mathrm{d}\tau^2}+\Gamma^\mu_{\alpha\beta}(\eta)\frac{\mathrm{d}x^\alpha}{\mathrm{d}\tau}\frac{\mathrm{d}x^\beta}{\mathrm{d}\tau}=0\quad(\mu=0,1,2,3)\\&\Gamma^\mu_{\alpha\beta}(\eta)=\frac{1}{2}g^{\mu\nu}(\eta)\left(g_{\alpha\nu,\beta}(\eta)+g_{\nu\beta,\alpha}(\eta)-g_{\beta\alpha,\nu}(\eta)\right)\end{aligned} \tag{6}$$

where x^μ (μ=0,1,2,3) is the 4d coordinates of the observed spacetime $X^{4\mathrm{d}}(\eta)$ of OA(η), $x^0=\eta t$ is the time axis and x^i (k=1,2,3) are the space axes, in the form of Cartesian coordinates, $x^1=x$, $x^2=y$, and $x^3=z$.

In a sense, Einstein field equation represent Einstein's theory of general relativity, whereas the GOR field equations represent the theory of GOR.

Just as Einstein had theoretically deduced the whole theoretical system of his general theory based on the invariance of light speed as well as his field equation and motion equation [9], OR has theoretically deduces the whole theoretical system of GOR based on the invariance of information-wave speeds as well as the GOR field equation and motion equation [12-15].

It should be pointed out that there is still one issue unaddressed here: How is the coefficient $\kappa_{\text{GOR}}(\eta)$ of the gravitational-field equation of GOR calibrated?

4.2.3 The GOR Idealized Convergence vs Einstein's Weak-Field Approximation

Einstein was adept at constructing logical shortcuts leading to the grand edifices of physics: To reach his theory of special relativity, Einstein designed the principle of the invariance of light speed; To reach his theory of general relativity, Einstein designed the principles of equivalence and general covariance.

In general relativity, in order to calibrate the coefficient κ_E of his field equation, Einstein needed to match his gravitational-field equation with Newton's law of universal gravitation in the form of Poisson equation. To this end, Einstein specifically constructed a logical shortcut: **the way of weak-field approximation**.

Actually, Einstein's way of weak-field approximation not just implies the hypothesis of weak-field approximation, but a set of five hypothetical logical premises:

- (i) Weak Gravitational Field: Metric $g_{\mu\nu}=\eta_{\mu\nu}+h_{\mu\nu}$ ($|h_{\mu\nu}|<<|\eta_{\mu\nu}|$), spacetime is approximately flat;
- (ii) Slow Speed: $|v|<<c$, the speed v of the observed object P is much lower than the speed of light c;
- (iii) Static Field: The spacetime metric $g_{\mu\nu}$ or $h_{\mu\nu}$ does not change over time;
- (iv) Spacetime Orthogonality: $g_{i0}=g_{0i}=0$, the time axis x^0 is perpendicular to the space axes x_i (i=1,2,3);
- (v) Harmonic Coordinates: $\Box x^\mu = 0$ (μ=0,1,2,3).

Taking advantage of his way of weak-field approximation, Einstein successfully calibrated the coefficient of his field equation: $\kappa_E=8\pi G/c^4$ where G is the gravitational constant in Newton's law of universal gravitation.

Thus, we mistakenly thought that Newton's theory of universal gravitation is only an approximation of Einstein's theory of general relativity under the conditions of low speed and weak field.

However, why is Einstein's field-equation coefficient κ_E associated with the speed of light c?

The theory of OR has discovered that Einstein's theory of general relativity is also a theory of the optical observation agent OA(c), and there is no direct corresponding relationship between Einstein's field equation of the optical agent OA(c) and Newton's law of universal gravitation of the idealized agent OA$_\infty$. Einstein's way of weak-field approximation has misled physics.

In order to calibrate the coefficient κ_{GOR}, the GOR gravitational-field equation also needs to be matched with Newton's law of universal gravitation in the form of Poisson equation.

However, as a gravitational theory of the general observation agent OA(η) ($0<\eta<\infty$; $\eta\to\infty$), the theory of GOR does not require the way of weak-field approximation.

The theory of GOR has proven an important theorem:

The Theorem of Cartesian Spacetime -- $h_{\mu\nu}\to 0$ as $\eta\to\infty$ [12-15].

The theorem of Cartesian spacetime clarifies that the curved metric $h_{\mu\nu}$ of gravitational spacetime is zero under the idealized observation scene of OA$_\infty$ ($\eta\to\infty$). This suggests that the objective and real gravitational spacetime is flat, rather than curved. The so-called spacetime curvature is only an observational effect and an apparent phenomenon, caused by the observational locality ($\eta<\infty$) of the realistic observation agent OA(η).

In this way, the theory of GOR has discovered that spacetime is not really curved.

So, the correspondence between the gravitational-field equation of GOR and Newton's law of universal gravitation does not require the so-called logic of weak-field approximation, but the logic of idealized convergence.

The GOR Logical Way of Idealized Convergence [12-15]: Let the information-wave speed η of the observation agent OA(η) be large enough, then the gravitational spacetime tends to be flat, and it holds true that

$$\begin{gathered} g_{\mu\nu}\left(x^\alpha,\eta\right)=\eta_{\mu\nu}+h_{\mu\nu}\left(x^\alpha,\eta\right) \\ \left(\left|h_{\mu\nu}\right|\ll\left|\eta_{\mu\nu}\right| \text{ and } \lim_{\eta\to\infty}h_{\mu\nu}\left(x^\alpha,\eta\right)=\mathbf{0}\right), \end{gathered} \tag{7}$$

particularly, as $\eta\to\infty$, $g_{\mu\nu}\to\eta_{\mu\nu}$, where $\eta_{\mu\nu}$ is the Minkowski metric: $\eta_{\mu\nu}$=diag(+1,–1,–1,–1).

It can be proven [12-15] that, under the GOR way of idealized convergence, the five conditions in Einstein's way of weak-field approximation must be satisfied.

Thus, the corresponding relationship between the GOR field equation and the Poisson equation of Newton's law of universal gravitation is no longer approximate but logically in the strict sense.

Taking advantage of the GOR logical way of idealized convergence, as the information-wave speed η of the observation agent OA(η) is large enough, the GOR gravitational-field equation reduces to:

$$\nabla^2 h_{00}=\kappa_{\text{GOR}}\rho\eta^2 \quad \left(h_{00}=2\chi/\eta^2\right) \tag{8}$$

where h_{00} is the 00-element of the curved metric $h_{\mu\nu}$.

By comparing Eq. (8) with the Poisson equation $\nabla^2\chi=4\pi G\rho$ of Newton's universal-gravitation law, the GOR field-equation coefficient κ_{GOR} can be calibrated:

$$\kappa_{\text{GOR}}\left(\eta\right)=\frac{8\pi G}{\eta^4}. \tag{9}$$

The calibration of GOR field-equation coefficient marks the formal establishment of GOR, that is, the so-called **Gravitationally Observational Relativity** or **General Observational Relativity**.

Finally, the whole theoretical system of GOR has generalized and unified Newton's theory of universal gravitation and Einstein's theory of general relativity.

4.3 The Different Logical Paths to OR

The theory of OR, both IOR and GOR, is the product of logic and theory, is rooted in the definition of OR time, and has a more basic axiom system than both Newton's classical mechanics and Einstein's relativity theory. It is based on more basic logical premises that the theory of OR has acquired a broader perspective, so that it has uncovered the root and essence of relativistic phenomena, and has generalized and unified Newton's classical mechanics and Einstein's relativity theory.

If one could not understand the logical deduction of OR based on the axiom system of OR, one could choose the following concise logical paths. The fact that different logical paths lead to the identical theory of OR can confirm the theory of OR and may be helpful for readers to understand the theory of OR.

4.3.1 From Time Definition to OR

As previously stated, in the axiom system of OR, only the definition of OR time is the fundamental and indispensable logical premise.

Actually, the principle of physical observability is implicitly taken as the logical premise underlying all theoretical systems in physics, including Galilean doctrine, Newtonian mechanics, Einstein relativity theory, and even quantum theory. Hence, the principle of physical observability could be regarded as a fundamental principle universally followed by all theoretical systems in physics. Meanwhile, the conditions of wave-particle duality in the axiom system of OR could be substituted with the principle of simplicity or the principle of relativity.

Even if one could not understand the OR conditions of wave-particle duality, based on the definition of OR time and the principle of relativity, or based on the definition of OR time and the principle of simplicity, one might also prove the theorem of the invariance of information-wave speeds (see 3.2.4-5 in Chapter 3 of the 1st volume IOR in [12-15]), derive the general Lorentz transformation, i.e., the OR spacetime transformation, and establish the whole theoretical system of OR, including IOR and GOR.

4.3.2 From Observational Limit to OR

Perhaps one could not understand the definition of OR time and the invariance of time-frequency ratio. But one must understand that: the speed of moving objects that bats can observe with their ears cannot exceed the air ultrasonic speed of 340 m/s; the speed of moving objects that dolphins can observe with their ears cannot exceed the water ultrasonic speed of 1450 m/s; the speed of moving objects that humans can observe with their eyes cannot exceed the light speed of 3×10^8 m/s.

This is what OR calls **Observational Limit**. Different observation agents have different observational limit.

One could express it as a principle.

The Principle of Observational Limit (POL): For an observation system $(P,M(\eta),O)$ or an observation agent OA(η), the information-wave speed η of OA(η), i.e., the speed of the observation medium $M(\eta)$ transmitting the information on the observed object P, is the observational upper limit of the observer O armed with OA(η): $|u|\leq\eta$ where u is the moving speed of P that can be perceived or observed by the observer O.

In fact, the principle of observational limit is equivalent to the principle of observational locality.

Since the speed η of the medium M transmitting information cannot exceeded observationally by the observer O with OA(η), the information-wave speed η of OA(η) must exhibit the invariance relative to the observer O.

Thus, based on the POL principle, one might also prove the theorem of invariance of information-wave speeds, and furthermore, by following the logic of Einstein relativity theory, establish the whole theoretical system of OR, including IOR and GOR.

4.3.3 From the Invariance of Information-Wave Speeds to OR

More simply, one can directly express the invariance of information-wave speeds as a basic principle of physics.

In the Michelson-Morley experiment [3], the speed of light exhibited the invariant phenomenon. It was based on the Michelson-Morley experiment that Einstein proposed the principle of the invariance of light speed, and consequently, established his theory of relativity, including the special [8] and the general [9]. Up to today, the mainstream school of physics still believe that the Michelson-Morley experiment is the empirical basis of the principle of the invariance of light speed.

In fact, however, as clarified in Sec. 7.2.2, the Michelson-Morley experiment is not the support for the principle of the invariance of light speed proposed by Einstein, but the support for the theorem of the invariance of information-wave speeds proven by the theory of OR.

So, one has every reason to express the invariance of information-wave speeds as a principle: **The Principle of the Invariance of Information-Wave Speeds**.

Thus, based on the principle of the invariance of information-wave speeds and by following Einstein's logic of relativity theory, one might also deduce the whole theoretical system of OR, including IOR and GOR.

4.3.4 Following PGC Logical Path 1 to OR

PGC logical path 1 paved on the PGC principle is the simplest and most direct way for one to extend Einstein's theory of relativity, both the special and the general, from the optical agent OA(c) to general observation agent OA(η) ($0<\eta<\infty$; $\eta\to\infty$).

By following PGC logical path 1, directly replacing the speed of light c in all the principles or axioms as well as all the theoretical models or formulae of Einstein theory of relativity (both the special and the general) with the information-wave speed η of the general observation agent OA(η) ($0<\eta<\infty$; $\eta\to\infty$), one might also acquire the whole theoretical system of OR, including IOR and GOR.

Now, one must be able to understand that Einstein's theory of relativity, both the special and the general, is the theory of the optical agent OA(c), that is, only a special case of OR. One must be able to predict that, as $\eta\to c$, the whole theoretical system of OR would strictly reduce to Einstein theory of relativity: IOR strictly reduces to Einstein special relativity (see Table A1); GOR strictly reduces to Einstein general relativity (see Table A2).

However, one might not be able to foresee and understand that (see Sec. 5 and Appendix A in this article): as $\eta\to\infty$, the whole theoretical system of OR would strictly reduce to Galileo-Newtonian classical mechanics -- IOR strictly reduces to Galileo-Newtonian inertial mechanics (see Table A1); GOR strictly reduces to Newton's theory of universal gravitation (see Table A2).

Perhaps, this would give one some insights into OR.

5 The Unite of Newton and Einstein in OR

In the theoretical system of OR, Newton's classical mechanics and Einstein's relativity theory are only two special cases representing different observation agents: Newton's mechanics is the theory of the idealized agent OA_∞; Einstein's relativity theory is the theory of the optical agent OA(c). Both are what Hawking called **partial theories**, whereas the theory of OR has become what Hawking called a **complete theory**.

The theory of OR is the theory of the general observation agent OA(η) ($0<\eta<\infty$; $\eta\to\infty$), which has generalized and unified Newton's classical mechanics and Einstein's theory of relativity: as $\eta\to\infty$, the theory of OR strictly reduce to Newton's mechanics; as $\eta\to c$, the theory of OR strictly reduce to Einstein's relativity theory. So, the theory of OR has unified the two great theoretical systems of human Being's physics in the same theoretical system under the same axiom system.

One physical world, One logical system.

Tables A1 and A2 in Appendix A list the basic relations of OR as well as the corresponding relations in Einstein's relativity theory and the corresponding relations in Galileo-Newtonian mechanics, demonstrating the corresponding relationships of strictly isomorphic consistency between the theory of OR and Einstein relativity theory (see Table A1), and that between the theory of OR and Galileo-Newtonian mechanics (see Table A2).

5.1 The Unity of Newton and Einstein in IOR

Tables A1 in Appendix A demonstrates the unification of Galileo-Newtonian inertial mechanics and Einstein theory of special relativity in the theory of IOR: as $\eta\to c$, the theory of IOR strictly reduces to Einstein theory of special relativity; as $\eta\to\infty$, the theory of IOR strictly reduces to Galileo-Newtonian inertial mechanics.

The following basic relations in IOR are demonstrated as a few typical examples, in which the corresponding relations in Einstein theory of special relativity and Galileo-Newtonian mechanics are familiar to everyone.

5.1.1 The IOR Factor of Spacetime Transformation

The IOR factor $\Gamma(\eta,v)=1/\sqrt{(1-v^2/\eta^2)}$ (Eq. 2) is the OR factor of inertial spacetime transformation under the general observation agent OA(η), also called **the inertially-relativistic factor**: the larger the value of Γ, the more significant the inertially relativistic effects exhibited by the observed object P in inertial spacetime would be.

The IOR factor of spacetime transformation $\Gamma(\eta,v)$ can be decomposed in terms of Taylor series:

$$\Gamma(\eta,v)=\Gamma_\infty+\Delta\Gamma(\eta,v)\quad(v<\eta) \tag{10a}$$

where η is the information-wave speed of OA(η), $\Gamma_\infty\equiv1$ is **the Galilean factor**, and $\Delta\Gamma(\eta,v)\geq0$ is the observational-effect factor of IOR:

$$\begin{cases}\Gamma_\infty=\lim\limits_{\eta\to\infty}\Gamma(\eta,v)=1\\ \Delta\Gamma(\eta,v)=\dfrac{1}{2}\dfrac{v^2}{\eta^2}+\dfrac{1\cdot3}{2\cdot4}\dfrac{v^4}{\eta^4}+\dfrac{1\cdot3\cdot5}{2\cdot4\cdot6}\dfrac{v^6}{\eta^6}+\cdots\end{cases} \tag{10b}$$

where $\Gamma_\infty\equiv1$ represents the objective and real physical reality; $\Delta\Gamma(\eta,v)\geq0$ represents the purely observational effects caused by OA(η).

In Einstein special relativity, the inertially spacetime-transformation factor $\gamma=1/\sqrt{(1-v^2/c^2)}$ can be referred to as the Lorentz factor [5-8], where the speed of light c is an invariant and the value of γ depends on the speed v of P. Based on this, Einstein believed that the relativistic effects of inertial spacetime were real natural phenomena and the root and essence were decided by matter motion.

However, the IOR factor $\Gamma=\Gamma(\eta,v)$ indicates that the value of Γ essentially depends on the information-wave speed η of OA(η): given the moving speed v of P, the larger the value of η, the weaker the inertially-relativistic effects exhibited by P would be; if η is infinite, the inertial spacetime would have no relativistic phenomena. Thus, the theory of IOR discovered that the relativistic effects of matter motion in inertial spacetime are not the objective and real physical reality, but rather the observational effects and apparent phenomena caused by the observational locality ($\eta<\infty$) of the observation agent OA(η).

The IOR factor of spacetime transformation generalizes both the Lorentz factor and the Galilean factor, unifying them within the theory of IOR.

(I) The IOR Factor Generalizing the Lorentz Factor

As $\eta\to c$, OA(η)$\to$OA(c), the IOR factor $\Gamma(\eta,v)$ strictly converges to the Lorentz factor $\gamma=\Gamma(c,v)$:

$$\gamma=\Gamma(c,v)=\lim_{\eta\to c}\frac{1}{\sqrt{1-v^2/\eta^2}}=\frac{1}{\sqrt{1-v^2/c^2}}. \tag{11}$$

It is thus clear that the Lorentz factor $\gamma=\Gamma(c,v)$ is relativistic due to the optical observation agent OA(c) with the observational locality of $c<\infty$. Thus, the optical agent OA(c) and Einstein special relativity present observational inertially-relativistic effects.

(II) The IOR Factor Generalizing the Galilean Factor

As $\eta\to\infty$, OA(η)$\to OA_\infty$, the IOR factor $\Gamma(\eta,v)$ strictly converges to the Galilean factor $\Gamma_\infty=\Gamma(\infty,v)$:

$$\Gamma_\infty=\Gamma(\infty,v)=\lim_{\eta\to\infty}\frac{1}{\sqrt{1-v^2/\eta^2}}=1 \tag{12}$$

It is thus clear that the Galilean factor $\Gamma_\infty\equiv1$ is non-relativistic due to the idealized observation agent OA_∞ with no observational locality ($\eta\to\infty$). Thus, the idealized agent OA_∞ and Galileo-Newtonian inertial mechanics present the objective and real inertial spacetime.

So, OA_∞ might be referred to as **the God's Eye**.

5.1.2 The IOR Spacetime Transformation

As shown in Eq. (1), the transformation equation of

IOR inertial spacetime deduced based on the definition of OR time is originally in differential form. Integrating it, the algebraic form of it can be obtained, which is called **the general Lorentz transformation**:

$$O' \to O: \quad \begin{cases} x = \Gamma(x'+vt') \\ y = y' \\ z = z' \\ t = \Gamma\left(t' + vx/\eta^2\right) \end{cases} \qquad O' \to O: \quad \begin{cases} x' = \Gamma(x-vt) \\ y' = y \\ z' = z \\ t' = \Gamma\left(t - vx/\eta^2\right). \end{cases} \tag{13}$$

Just as the Lorentz transformation represents Einstein's theory of special relativity, the general Lorentz transformation represents the theory of IOR.

The general Lorentz transformation generalizes both the Lorentz transformation and the Galilean transformation, unifying them within the theory of IOR.

(I) The IOR Spacetime Transformation Generalizing the Lorentz Transformation

As $\eta \to c$, OA(η)$\to$OA(c), $\Gamma(\eta,v) \to \Gamma(c,v)=\gamma$, and the spacetime transformation of IOR strictly converges to the Lorentz transformation:

$$\lim_{\eta\to c}\begin{cases} x = \Gamma\left(x'+vt'\right) \\ y = y' \\ z = z' \\ t = \Gamma\left(t' + vx'/\eta^2\right) \end{cases} = \begin{cases} x = \gamma\left(x'+vt'\right) \\ y = y' \\ z = z' \\ t = \gamma\left(t' + vx'/c^2\right). \end{cases} \tag{14}$$

(II) The IOR Spacetime Transformation Generalizing the Galilean Transformation

As $\eta \to \infty$, OA(η)$\to$OA$_\infty$, $\Gamma(\eta,v) \to \Gamma_\infty \equiv 1$, and the spacetime transformation of IOR strictly converges to the Galilean transformation:

$$\lim_{\eta\to \infty}\begin{cases} x = \Gamma\left(x'+vt'\right) \\ y = y' \\ z = z' \\ t = \Gamma\left(t' + vx'/\eta^2\right) \end{cases} = \begin{cases} x = x'+vt' \\ y = y' \\ z = z' \\ t = t' = \tau. \end{cases} \tag{15}$$

The IOR 4d spacetime-transformation equation (13), in which space and time are originally interdependent, splits into two independent equations: (1) the 3d space equation {$x=x'+vt'$; $y=y'$; $z=z'$}, which is exactly the Galilean transformation; (2) the 1d time equation $t=t'=\tau$ where different observers O and O' have the same observed time ($t=t'$), i.e., the objective and real time τ.

This suggests that, in the objective and real physical world, space and time are independent of each other, just like Newton's statement [31]: Space exists immutably; Time flows silently.

5.1.3 The IOR Law of Speed Addition

Originally, human being's physics believed in Galileo's law of speed addition. However, after the birth of Einstein theory of special relativity, physics turned to believe in Einstein's relativistic law of speed addition.

The theory of IOR also deduces the relativistic law of speed addition: based on the differential form (Eq. (1)) of IOR spacetime transformation, one can directly derive the IOR speed-addition formula:

$$u = \frac{\mathrm{d}x}{\mathrm{d}t} = \frac{u'+v}{1+vu'/\eta^2} \quad \text{or} \quad u' = \frac{\mathrm{d}x'}{\mathrm{d}t'} = \frac{u-v}{1-vu/\eta^2}. \tag{16}$$

The IOR relativistic law of speed addition generalizes both Einstein's relativistic law of speed addition and Galileo's classical law of speed addition, unifying them within the theory of IOR.

(I) The IOR Speed Addition Generalizing Einstein's Speed Addition

As $\eta \to c$, OA(η)$\to$OA(c), the IOR law of speed addition strictly converges to Einstein's speed addition:

$$u = \lim_{\eta\to c}\frac{u'+v}{1+vu'/\eta^2} = \frac{u'+v}{1+vu'/c^2}. \tag{17}$$

(II) The IOR Speed Addition Generalizing Galileo's Speed Addition

As $\eta \to \infty$, OA(η)$\to$OA$_\infty$, the IOR law of speed addition strictly converges to Galileo's speed addition:

$$u = \lim_{\eta\to \infty}\frac{u'+v}{1+vu'/\eta^2} = u'+v. \tag{18}$$

As a physical model of the idealized observation agent OA$_\infty$, Galileo's law of speed addition is the true natural law in line with human reason and intuition.

5.1.4 The IOR Observed Mass

In Einstein's special theory, the matter in inertial spacetime has two types of mass: the rest mass m_o and the moving mass m (or called relativistic mass). According to Einstein's mass-speed relation: $m=m_o/\sqrt{(1-v^2/c^2)}$.

The theory of IOR deduces the relativistic mass-speed relation of the general observation agent OA(η):

$$\mathrm{OA}(\eta): \quad m(\eta) = \frac{m_o}{\sqrt{1+v^2/\eta^2}}. \tag{19}$$

where the IOR mass also has two types: the rest mass m_o and the moving mass m.

However, according to Eq. (19), the IOR mass $m=m(\eta)$ depends on the observation agent OA(η) and on the information-wave speed η of OA(η). This suggests that the so-called relativistic mass, both the IOR $m(\eta)$ and the Einstein $m(c)$, is actually a sort of observational or observed mass containing observational effect and is not entirely objective and real.

The IOR mass-speed relation generalizes both Einstein's relativistic inertial mass and Newton's classical inertial mass, unifying them within the theory of IOR.

(I) The IOR Observed Mass Generalizing Einstein's Relativistic Inertial Mass

As $\eta \to c$, OA(η)$\to$OA(c), the IOR mass-speed relation strictly converges to Einstein's mass-speed relation:

$$\mathrm{OA}(\eta): \quad m(c) = \lim_{\eta\to c}\frac{m_o}{\sqrt{1+v^2/\eta^2}} = \frac{m_o}{\sqrt{1+v^2/c^2}}. \tag{20}$$

(II) The IOR Observed Mass Generalizing Newton's Classical Inertial Mass

The concept of **Inertial Mass** originated from Newton. According to the IOR definition of inertial mass observed with OA(η) in Eq. (19), Newton's inertial mass m_I should be the IOR observed mass $m_\infty=m(\infty)$ as $\eta\to\infty$, i.e., the IOR mass observed with OA_∞:

$$m_I = m_\infty = m(\infty) = \lim_{\eta\to\infty}\frac{m_o}{\sqrt{1+v^2/\eta^2}} = m_o. \qquad (21)$$

Equation (21) has important enlightening significance:

Newton's inertia mass m_I is exactly Einstein's rest mass m_o. According to Eq. (21), the so-called rest mass m_o is the mass observed with the idealized agent OA_∞, i.e., the objective and real mass of matter, and is equal to Newtonian classical mass m_∞ and Newtonian inertial mass m_I.

It turns out that mass is mass: $m_o=m_\infty=m_I$.

5.1.5 The IOR Observed Momentum

In his special relativity, Einstein defined the momentum p of a material particle as the product of its relativistic mass m and its speed v: $p=mv$. In the theory of IOR, the momentum p of the observed object P is also defined as the product of the relativistic mass m and speed v of P:

$$p(\eta) = m(\eta)v = \frac{m_o v}{\sqrt{1+v^2/\eta^2}}. \qquad (22)$$

The momentum formula of IOR generalizes both Einstein's momentum formula and Newton's momentum formula, unifying them within the theory of IOR.

(I) IOR Observed Momentum Generalizing Einstein's Relativistic Momentum

As $\eta\to c$, OA(η)$\to$OA(c), the IOR observed momentum $p=p(\eta)$ strictly converges to Einstein's relativistic momentum $p=p(c)$:

$$p(c) = \lim_{\eta\to c}\frac{m_o v}{\sqrt{1+v^2/\eta^2}} = \frac{m_o v}{\sqrt{1+v^2/c^2}}. \qquad (23)$$

(II) IOR Observed Momentum Generalizing Newton's Classical Momentum

In Newton's inertial mechanics, the momentum of a material particle is defined as the product of the inertial mass m_I or classical mass m_∞ and moving speed v: $p_\infty=m_I v=m_\infty v$, that is, Newton's classical momentum.

As $\eta\to\infty$, OA(η)$\to OA_\infty$, $m_o=m_\infty=m_I$, the IOR observed momentum $p=p(\eta)$ strictly converges to Newton's classical momentum $p_\infty=p(\infty)$:

$$p_\infty = p(\infty) = \lim_{\eta\to\infty}\frac{m_o v}{\sqrt{1+v^2/\eta^2}} = m_o v = m_I v = m_\infty v \qquad (24)$$

5.1.6 The IOR Observed Energy

People always take delight in talking about Einstein's mass-energy relation, i.e, famous Einstein formula $E=mc^2$. However, the theory of OR discovers that $E=mc^2$ is only an integral constant in Einstein's derivation of kinetic-energy formula, and does not represent the objective and real energy of matter. Einstein's rest energy $E_o=m_oc^2$ is also an integral constant and not the objective physical existence. What really has physical significance is the kinetic energy of the material particle P: $K=E-E_o$.

During the derivation of the kinetic-energy formula, the theory of IOR also involves two integral constants: (1) $E=m\eta^2$; (2) $E_o=m_o\eta^2$ of P. It is worth noting that: $E=m\eta^2$ generalizes Einstein formula $E=mc^2$; $E_o=m_o\eta^2$ generalizes Einstein's rest energy $E_o=m_oc^2$.

In the inertial spacetime of IOR, the energy formula with the objective and real physical significance is only the kinetic-energy formula of IOR:

$$K = E - E_o = \left(\Gamma(\eta,v)-1\right)m_o\eta^2$$
$$\left(\Gamma = 1\Big/\sqrt{1-v^2/\eta^2},\ E = m\eta^2,\ E_o = m_o\eta^2\right). \qquad (25)$$

where $K=K(\eta)$ is the observational kinetic-energy observed by the general observation agent OA(η).

The kinetic-energy formula $K=K(\eta)$ of IOR generalizes both Einstein's relativistic kinetic-energy formula and Newton's classical kinetic-energy formula, unifying them within the theory of IOR.

(I) IOR Observed Kinetic-Energy Generalizing Einstein's Relativistic Kinetic-Energy

As $\eta\to c$, OA(η)$\to$OA(c), the IOR observed kinetic-energy $K=K(\eta)$ strictly converges to Einstein's relativistic kinetic-energy $K=K(c)$:

$$K(c) = \lim_{\eta\to c}\left(\left(\sqrt{1-v^2/\eta^2}\right)^{-1}-1\right)m_o\eta^2 = \left(\left(\sqrt{1-v^2/c^2}\right)^{-1}-1\right)m_oc^2. \qquad (26)$$

(II) IOR Observed Kinetic-Energy Generalizing Newton's Classical Kinetic-Energy

In Newton's inertial mechanics, a matter particle has neither the mass energy E nor the rest energy E_o, but only kinetic energy: $K=m_Iv^2/2=m_\infty v^2/2$.

Actually, as $\eta\to\infty$, the IOR mass-energy $E=m\eta^2\to\infty$ and the IOR rest energy $E_o=m_o\eta^2\to\infty$. According to the principle of physical observability, both E and E_o are not observable. In other words, both the mass energy E and the rest energy E_o are not the objectively physical existence.

However, as $\eta\to\infty$, OA(η)$\to OA_\infty$, the IOR observed kinetic-energy $K=K(\eta)$ strictly converges to Newton's classical kinetic-energy $K=K(\infty)=K_\infty$:

$$K_\infty = K(\infty) = \lim_{\eta\to\infty}\left(\left(\sqrt{1-v^2/\eta^2}\right)^{-1}-1\right)m_o\eta^2 = \frac{1}{2}m_ov^2 = \frac{1}{2}m_Iv^2 = \frac{1}{2}m_\infty v^2. \qquad (27)$$

Section 5.1 demonstrates that the theory of IOR is logically consistent with both Einstein's theory of special relativity and Galileo-Newtonian inertial mechanics. This from one aspect confirms that the theory of IOR is logically self-consistent and theoretically correct. For details see Chapter 8 of the 1st volume IOR of OR [12-15].

5.2 The Unity of Newton and Einstein in GOR

Tables A2 in Appendix A demonstrates the unification of Newton's theory of universal gravitation and Einstein's theory of general relativity in the theory of GOR: as $\eta\to c$, the theory of GOR strictly reduces to Einstein's theory of general relativity; as $\eta\to\infty$, the theory of GOR strictly reduces to Newton's theory of universal gravitation.

The following basic relations in the theory of GOR are demonstrated as a few typical examples, in which the corresponding relations in Einstein's theory of general relativity and Newton's theory of universal gravitation are familiar to everyone.

5.2.1 The GOR Factor of Spacetime Transformation

The GOR factor of spacetime transformation is the OR factor of gravitational spacetime transformation under the general observation agent OA(η):

$$\Gamma(\eta,v,\chi)=\frac{1}{\sqrt{1-v^2/\eta^2+2\chi/\eta^2}} \tag{28}$$

where η is the information-wave speed of OA(η), v is the moving speed of the observed object P in gravitational spacetime, χ is the Newtonian gravitational potential where P is located. Obviously, the GOR factor $\Gamma(\eta,v,\chi)$ generalizes the IOR factor $\Gamma(\eta,v)$

The GOR factor $\Gamma=\Gamma(\eta,v,\chi)$ is also referred to as the relativistic gravitational factor: the larger the value of Γ, the more significant the relativistic or observational effects of P exhibited in gravitational spacetime would be, which can be decomposed in terms of Taylor series:

$$\Gamma(\eta,v)=\Gamma_\infty+\Delta\Gamma(\eta,v,\chi) \tag{29a}$$

where; Γ_∞ remains the Galilean factor, and $\Delta\Gamma(\eta,v,\chi)\geq 0$ is the observational-effect factor of GOR:

$$\begin{cases}\Gamma_\infty=\lim\limits_{\eta\to\infty}\Gamma(\eta,v,\chi)=1\\ \Delta\Gamma(\eta,v,\chi)=\dfrac{1}{2}\dfrac{\alpha^2}{\eta^2}+\dfrac{1\cdot 3}{2\cdot 4}\dfrac{\alpha^4}{\eta^4}+\dfrac{1\cdot 3\cdot 5}{2\cdot 4\cdot 6}\dfrac{\alpha^6}{\eta^6}+\cdots\end{cases} \tag{29b}$$

$$\left(\alpha<\eta,\ \alpha=\sqrt{v^2-2\chi}\right)$$

where $\Gamma_\infty\equiv 1$ represents the objective and real physical reality; $\Delta\Gamma(\eta,v,\chi)\geq 0$ represents purely observational effects caused by the observation agent OA(η).

In Einstein general relativity, the gravitational spacetime-transformation factor is $\gamma=1/\sqrt{(1-v^2/c^2+2\chi/c^2)}$ [9], or $\gamma=1/\sqrt{(1+2\chi/c^2)}$ without considering the moving speed v of P. Due to the speed of light c invariant, the value of γ depends on the gravitational potential χ. Based on this, Einstein believed that the relativistic effects of gravitational spacetime were real natural phenomena and the root and essence were decided by gravitational interaction.

However, the IOR factor $\Gamma=\Gamma(\eta,\chi)$ indicates that the value of Γ essentially depends on the information-wave speed η of OA(η): given the gravitational potential χ where P is located, the larger the value of η, the weaker the gravitationally-relativistic effects exhibited by P would be; if η is infinite, the gravitational spacetime would have no relativistic phenomena. Thus, the theory of GOR discovered that the relativistic effects of matter interaction in gravitational spacetime are not the objective and real physical reality, but rather the observational effects and apparent phenomena caused by the observational locality ($\eta<\infty$) of the observation agent OA(η).

The GOR factor of spacetime transformation generalizes both Einstein's relativistic gravitational factor and Newton's classical gravitational factor, that is, the Galilean factor, unifying them within the theory of GOR.

(I) The GOR Factor Generalizing the Einstein factor

As $\eta\to c$, OA(η)→OA(c), the GOR factor $\Gamma(\eta,v,\chi)$ strictly converges to Einstein's factor of gravitational spacetime transformation $\gamma=\Gamma(c,v,\chi)$:

$$\begin{aligned}\Gamma(c,v,\chi)&=\lim_{\eta\to c}\frac{1}{\sqrt{1-v^2/\eta^2+2\chi/\eta^2}}\\&=\frac{1}{\sqrt{1-v^2/c^2+2\chi/c^2}}=\gamma(c,v,\chi).\end{aligned} \tag{30}$$

It is thus clear that Einstein's factor $\gamma=\Gamma(c,v,\chi)$ of gravitational-spacetime transformation is relativistic due to the optical observation agent OA(c) with the observational locality of $c<\infty$. Thus, the optical agent OA(c) and Einstein general relativity presents observational gravitationally-relativistic effects.

(II) The GOR Factor Generalizing the Newtonian factor

As $\eta\to\infty$, OA(η)→OA$_\infty$, the GOR factor $\Gamma(\eta,v,\chi)$ strictly converges to Newton's factor of gravitational spacetime transformation $\Gamma=\Gamma(\infty,v,\chi)$:

$$\Gamma(\infty,v,\chi)=\lim_{\eta\to\infty}\frac{1}{\sqrt{1-v^2/\eta^2+2\chi/\eta^2}}=1=\Gamma_\infty \tag{31}$$

This is exactly the Galilean factor: $\Gamma_\infty\equiv 1$.

It is thus clear that Newton's factor $\Gamma_\infty\equiv 1$ of gravitational-spacetime transformation is non-relativistic due to the idealized observation agent OA$_\infty$ with no observational locality ($\eta\to\infty$). Thus, the idealized agent OA$_\infty$ and Newton's theory of universal gravitation presents the objective and real gravitational spacetime.

So, OA$_\infty$ might be referred to as **the God's Eye**.

5.2.2 The GOR Metric Equations of Spacetime

In order to remove the influence of gravitationally relativistic effects on the measurement of gravitational spacetime, that is, to remove the observational effects of the optical agent OA(c), Einstein established the formulae of determining the standard time dτ and physical space dl for OA(c) in his theory of general relativity. By following Einstein's logic, the theory of GOR derives the formulae (Eq. (3) and Eq. (4)) of determining the standard time dτ and physical space dl for the general agent OA(η).

The metric equation (3) of the GOR standard time dτ and the metric equation (4) generalizes and unifies Einstein's metric relations of relativistic spacetime and Newton's metric equations of classical spacetime.

(I) The GOR Metric Equations Generalizing Einstein's Metric Relations

As $\eta\to c$, OA(η)→OA(c), the GOR metric equation (3) of the standard time strictly converges to Einstein's metric equation of the standard time dτ:

$$\mathrm{d}\tau=\lim_{\eta\to c}\sqrt{1+\frac{2\chi}{\eta^2}}\mathrm{d}t(\eta)=\sqrt{1+\frac{2\chi}{c^2}}\mathrm{d}t(c). \tag{32}$$

where dt=dt(c) is called by Einstein the coordinate time, but in theory of GOR, dt=d$t(\eta)$, including dt=d$t(c)$, is called the observed time.

As $\eta\to c$, OA(η)→OA(c), the GOR metric equation (4) of the physical space strictly converges to Einstein's metric equation of the physical spacetime dl:

$$\mathrm{d}l^2=\lim_{\eta\to c}\gamma_{ik}(\eta)\mathrm{d}x^i\mathrm{d}x^k=\gamma_{ik}(c)\mathrm{d}x^i\mathrm{d}x^k. \tag{33}$$

(II) The GOR Metric Equations Generalizing Newton's Metric Relations

As $\eta\to\infty$, OA(η)→OA$_\infty$, the GOR metric equation (3) of the standard time strictly converges to Newton's classical time dt_∞=dτ:

$$\mathrm{d}\tau=\lim_{\eta\to\infty}\sqrt{1+\frac{2\chi}{\eta^2}}\mathrm{d}t(\eta)=\mathrm{d}t(\infty)=\mathrm{d}t_\infty. \tag{34}$$

It is thus clear that, as the idealized observed time of OA$_\infty$, Newton's classical time dt_∞ is exactly the standard time dτ, that is, the objective and real proper time.

As $\eta\to\infty$, OA(η)→OA$_\infty$, the metric of gravitational spacetime converges to the Minkowski metric $\eta_{\mu\nu}$= diag(+1,–1,–1,–1), the metric of physical space $\gamma_{ik}(\eta)\to$ diag(1, 1, 1), and the GOR metric equation (4) of the physical space strictly converges to Newton's classical space:

$$\begin{aligned}\mathrm{d}l^2&=\lim_{\eta\to\infty}\gamma_{ik}(\eta)\mathrm{d}x^i\mathrm{d}x^k=(\mathrm{d}x^i)^2\\&=\mathrm{d}x^2+\mathrm{d}y^2+\mathrm{d}z^2\quad(\gamma_{ik}=g_{0i}g_{0k}/g_{00}-g_{ik}).\end{aligned} \tag{35}$$

It is thus clear that, as the idealized observed space of OA$_\infty$, Newton's classical space dl_∞ is exactly the Cartesian space, that is, the objective and real physical space.

5.2.3 The GOR Gravitational-Field Equation

Just as Einstein's gravitational-field equation represents Einstein's theory of general relativity and Newton's gravitational-field equation represents Newton's theory of universal gravitation, the GOR gravitational-field equation (5) represents the theory of GOR.

The GOR gravitational-field equation (5), which extends Einstein's gravitational-field equation from the optical agent OA(c) to the general observation agent OA(η), not only generalizes Einstein's gravitational-field equation, but also generalizes Newton's gravitational-field equation, unifying them within the theory of GOR.

(I) The GOR Field Equation Generalizing Einstein's Field Equation

As $\eta\to c$, OA(η)→OA(c), the GOR gravitational-field equation (5) strictly converges to Einstein's gravitational-field equation:

$$\begin{cases}R_{\mu\nu}(c)-\dfrac{1}{2}g_{\mu\nu}(c)R(c)=-\kappa_E(c)T_{\mu\nu}(c)\\ \kappa_E(c)=8\pi G/c^2.\end{cases} \tag{36}$$

(II) The GOR Field Equation Generalizing Newton's Field Equation

Defining the extended Newtonian gravitational potential $\chi_{\mu\nu}$, the GOR field equation can be rewritten as:

$$\Box\chi_{\mu\nu}\equiv\frac{\eta^2}{2}\left(R_{\mu\nu}-\frac{1}{2}g_{\mu\nu}R\right)=-\frac{\eta^2}{2}\kappa_{\mathrm{GOR}}T_{\mu\nu}. \tag{37}$$

As $\eta\to\infty$, OA(η)→OA$_\infty$, the GOR gravitational-field equation (5) strictly converges to Newton's gravitational-field equation, that is, the Poisson equation of Newton's law of universal gravitation:

$$\nabla^2\chi=4\pi G\rho\quad\begin{cases}\Box\chi_{\mu\nu}=0\quad(\mu\nu\neq00)\\ \Box\chi_{00}=\Box\chi=-\nabla^2\chi\end{cases} \tag{38}$$

where the only non-trivial term is the Poisson equation.

5.2.4 The GOR Gravitational-Motion Equation

Einstein once supposed that his theory of general relativity should consist of two fundamental equations: the first was a gravitational-field equation that described how gravitational spacetime was curved; the second was a gravitational-motion equation that described how an object moves in the curved gravitational spacetime.

Later, Einstein et al. [32] and Fock [33] independently proved that Einstein field equation and Einstein motion equation are equivalent.

However, this does not deny the independent value of Einstein field equation or Einstein motion equation. The calibration of Einstein field-equation coefficient κ_{GOR} not only needs the gravitational-field equation but also needs the gravitational-equation [9].

The GOR gravitational-field equation and the GOR gravitational-motion equation more clearly demonstrate the equivalence between the field equation and the motion equation in gravitational spacetime. Likewise, the calibration of the GOR field-equation coefficient κ_{GOR} not only needs the GOR field equation but also needs the GOR motion equation [12-15].

The GOR gravitational-motion equation (6), which extends Einstein's gravitational-field equation from the optical agent OA(c) to the general observation agent OA(η), not only generalizes Einstein's gravitational-field equation, but also generalizes Newton's gravitational-field equation, unifying them within the theory of GOR.

(I) The GOR Motion Equation Generalizing Einstein's Motion Equation

As $\eta\to c$, OA(η)→OA(c), the GOR gravitational-motion equation (6) strictly converges to Einstein's gravitational-motion equation:

$$\begin{cases}\dfrac{\mathrm{d}^2x^\mu}{\mathrm{d}\tau^2}+\Gamma^\mu_{\alpha\beta}(c)\dfrac{\mathrm{d}x^\alpha}{\mathrm{d}\tau}\dfrac{\mathrm{d}x^\beta}{\mathrm{d}\tau}=0\quad(\mu=0,1,2,3)\\ \Gamma^\mu_{\alpha\beta}(c)=\dfrac{1}{2}g^{\mu\nu}(c)\big(g_{\alpha\nu,\beta}(c)+g_{\nu\beta,\alpha}(c)-g_{\beta\alpha,\nu}(c)\big).\end{cases} \tag{39}$$

(II) The GOR Motion Equation Generalizing Einstein's Motion Equation

As $\eta\to\infty$, OA(η)→OA$_\infty$, and as in the Galilean transformation, the GOR 4d motion equation (6), in which space and time are originally interdependent, splits into two independent equations of space and time:

$$\frac{\mathrm{d}^2t}{\mathrm{d}\tau^2}=0\quad\text{and}\quad\frac{\mathrm{d}^2x^i}{\mathrm{d}\tau^2}=-\frac{\partial\chi}{\partial x^i}\quad(i=1,2,3) \tag{40}$$

where the 1d time equation suggests that the observed time dt in Newton's gravitational spacetime is exactly the standard time (proper time) dτ, consistent with the Galilean transformation; the 3d space equation strictly reduces to Newton's motion equation, that is, the inverse-square formula of Newton's universal-gravitation law:

$$F^i = -m\frac{\partial \chi}{\partial x^i} \quad \left(i=1,2,3;\ \chi=-GM/r\right)$$
$$\text{or} \quad |F| = \frac{GMm}{r^2} \tag{41}$$

5.2.5 The GOR Observed Mass

Based on the GOR relativistic factor $\Gamma=\Gamma(\eta,v,\chi)$ (Eq. (28)), we have the general mass-speed relation:

$$m(\eta,v,\chi) = \frac{m_o}{\sqrt{1-v^2/\eta^2+2\chi/\eta^2}} \tag{42}$$

where m_o is the intrinsic rest mass of the observed object P, $m(\eta,v,\chi)$ is the general relativistic mass observed with of OA(η), which is related to both the Newtonian gravitational potential χ and speed v of P. But essentially, m depends on the information-wave speed η of OA(η). Therefore, $m(\eta,v,\chi)$ contains observational effects and is not entirely objective and real.

Based on the GOR mass-speed relation (Eq. (42)), under the general observation agent OA(η), the theory of OR defines the following two concepts for matter mass.

OA(η) Observed Inertial Mass $m_I(\eta)$:

$$m_I(\eta) = \Gamma(\eta,v,\chi)\big|_{\chi=0}\, m_o = \frac{m_o}{\sqrt{1-v^2/\eta^2}}. \tag{43}$$

OA(η) Observed Gravitational Mass $m_G(\eta)$:

$$m_G(\eta) = \Gamma(\eta,v,\chi)\big|_{v=0}\, m_o = \frac{m_o}{\sqrt{1+2\chi/\eta^2}}. \tag{44}$$

The GOR observed inertial mass formula (Eq. (43)) generalizes both Einstein's relativistic inertial mass and Newton's classical inertial mass; the GOR observed gravitational mass formula (Eq. (44)) generalizes both Einstein's relativistic gravitational mass and Newton's classical gravitational mass. In this way, the GOR observed mass relations (Eq. (43) and Eq. (44)) unify Einstein's relativistic mass and Newton's classical mass.

(I) GOR Observed Mass Generalizing Einstein's Relativistic Mass

As $\eta \to c$, OA(η)→OA(c), the OR inertial mass $m_I(\eta)$ (Eq. (43)) observed with OA(η) strictly converges to the inertial mass $m_I(c)$ observed with Einstein's OA(c):

$$m_I(c) = \lim_{\eta\to c}\Gamma(\eta,v,\chi)\big|_{\chi=0}\, m_o = \frac{m_o}{\sqrt{1-v^2/c^2}}. \tag{45}$$

As $\eta \to c$, OA(η)→OA(c), the OR gravitational mass $m_G(\eta)$ (Eq. (44)) observed with OA(η) strictly converges to the gravitational mass $m_G(c)$ observed with OA(c):

$$m_G(c) = \lim_{\eta\to c}\Gamma(\eta,v,\chi)\big|_{v=0}\, m_o = \frac{m_o}{\sqrt{1+2\chi/c^2}}. \tag{46}$$

(II) GOR Observed Mass Generalizing Newton's Classical Mass

As $\eta\to\infty$, OA(η)→OA$_\infty$, the OR inertial mass $m_I(\eta)$ (Eq. (43)) observed with OA(η) strictly converges to the inertial mass $m_I(\infty)$ observed with Newton's OA$_\infty$:

$$m_I(\infty) = \lim_{\eta\to\infty}\Gamma(\eta,v,\chi)\big|_{\chi=0}\, m_o = m_o = m_\infty \tag{47}$$

The concept of **Gravitational Mass** originated from Newton. Intuitively, people believe that Newton's gravitational mass m_G should be equal to Newton's inertial mass m_I, i.e., $m_G=m_I$, and may also be referred to as Newtonian classical mass, labeled as m_∞.

As $\eta\to\infty$, OA(η)→OA$_\infty$, the OR gravitational mass $m_G(\eta)$ (Eq. (44)) observed with OA(η) strictly converges to the gravitational mass $m_G(\infty)$ observed with OA$_\infty$:

$$m_G(\infty) = \lim_{\eta\to\infty}\Gamma(\eta,v,\chi)\big|_{v=0}\, m_o = m_o = m_\infty \tag{48}$$

Like Eq. (21), Eq. (48) also has important enlightening significance. Combining Eq. (21) and Eq. (48), the theory of OR has discovered that:

(i) Newton's classical mass m_∞ is exactly Einstein's rest mass m_o, both the inertia m_I and the gravitational m_G;

(ii) Newton's inertial mass m_I and gravitational mass m_G are equal -- no need to distinguish the inertia m_I and the gravitational m_G;

(iii) Newton's classical mass $m_\infty=m_o$ is the objective and real mass, i.e., the intrinsic mass of matter, whereas Einstein's relativistic mass $m=m_o+\Delta m(c)$ contains the untrue part of $\Delta m(c)$.

5.2.6 The GOR Observed Energy

In gravitational spacetime, the observed object P has both the kinetic energy K and the potential energy V, and the total energy $H=K+V$ of P must be conserved.

Based on the GOR mass-speed relation (Eq. (42)), under the general observation agent OA(η), the theory of OR defines the following two concepts for matter energy.

OA(η) Observed Kinetic Energy $K(\eta)$:

$$K = K(\eta) = \left(\Gamma(\eta,v,\chi)\big|_{\chi=0} - 1\right) m_o\eta^2. \tag{49}$$

OA(η) Observed Potential Energy $V(\eta)$:

$$V = V(\eta) = \left(1 - \Gamma(\eta,v,\chi)\big|_{v=0}\right) m_o\eta^2. \tag{50}$$

Thus, the total energy of the observed object P moving in the GOR gravitational spacetime is

$$\begin{aligned} H &= H(\eta) = K(\eta) + V(\eta) \\ &= \left(\Gamma(\eta,v,\chi)\big|_{\chi=0} - \Gamma(\eta,v,\chi)\big|_{v=0}\right) m_o\eta^2. \end{aligned} \tag{51}$$

The GOR observed kinetic-energy formula (Eq. (49)) generalizes both Einstein's relativistic kinetic energy and Newton's classical kinetic energy; the GOR observed potential-energy formula (Eq. (50)) generalizes both Einstein's relativistic potential energy and Newton's classical potential energy. In this way, the GOR observed mass relations (Eq. (49) and Eq. (50)) unify Einstein's relativistic energy and Newton's classical energy.

(I) GOR Observed Energy Generalizing Einstein's Relativistic Energy

As $\eta\to c$, OA(η)→OA(c), the OR kinetic energy $K(\eta)$ (Eq. (49)) observed with OA(η) strictly converges to the kinetic energy $K(c)$ observed with Einstein's OA(c):

$$K(c)=\lim_{\eta\to c}K(\eta)=\left(\Gamma(c,v,\chi)\big|_{\chi=0}-1\right)m_o c^2. \qquad (52)$$

As $\eta\to c$, OA(η)→OA(c), the OR potential energy $V(\eta)$ (Eq. (50)) observed with OA(η) strictly converges to the potential energy $K(c)$ observed with OA(c):

$$V(c)=\lim_{\eta\to c}V(\eta)=\left(1-\Gamma(c,v,\chi)\big|_{v=0}\right)m_o c^2. \qquad (53)$$

Naturally, as $\eta\to c$, the total-energy $H(\eta)$ (Eq. (51)) of the object P moving in the GOR gravitational spacetime observed by the general observation agent OA(η) strictly converges to the total-energy $H(c)$ of P observed by Einstein's optical agent OA(c):

$$\begin{aligned}H(c)&=K(c)+V(c)\\&=\left(\Gamma(c,v,\chi)\big|_{\chi=0}-\Gamma(c,v,\chi)\big|_{v=0}\right)m_o c^2\end{aligned} \qquad (54)$$

(II) GOR Observed Energy Generalizing Newton's Classical Energy

You might be a bit surprised that, as $\eta\to\infty$, OA(η)→ OA$_\infty$, the OR kinetic energy $K(\eta)$ (Eq. (49)) observed with OA(η) strictly converges to Newton's classical kinetic energy $K_\infty=K(\infty)$ observed with Newton's OA$_\infty$:

$$\begin{aligned}K_\infty&=K(\infty)=\lim_{\eta\to\infty}K(\eta)\\&=\lim_{\eta\to\infty}\left(\Gamma(\eta,v,\chi)\big|_{\chi=0}-1\right)m_o\eta^2=\frac{1}{2}m_o v^2.\end{aligned} \qquad (55)$$

Equation (55) is exactly Newton's classical kinetic-energy formula: $K_\infty=m_\infty v^2/2$.

You might be a bit surprised that, as $\eta\to\infty$, OA(η)→ OA$_\infty$, the OR potential energy $V(\eta)$ (Eq. (50)) observed with OA(η) strictly converges to Newton's classical potential energy $V_\infty=V(\infty)$ observed with Newton's OA$_\infty$:

$$\begin{aligned}V_\infty&=V(\infty)=\lim_{\eta\to\infty}V(\eta)\\&=\lim_{\eta\to\infty}\left(1-\Gamma(\eta,v,\chi)\big|_{v=0}\right)m_o\eta^2=-\frac{GMm_o}{r}\end{aligned} \qquad (56)$$

Equation (56) is exactly Newton's classical potential-energy formula: $V_\infty=-GMm_\infty/r$.

Naturally, $\eta\to\infty$, the total-energy $H(\eta)$ (Eq. (51)) of the object P moving in the GOR gravitational spacetime observed by the general observation agent OA(η) strictly converges to the total-energy $H_\infty=H(\infty)$ of P observed by Newton's idealized agent OA$_\infty$:

$$H_\infty=K_\infty+V_\infty=\frac{1}{2}m_\infty v^2-\frac{GMm_\infty}{r} \qquad (57)$$

5.2.7 The GOR Celestial-Motion Equation

Based on the GOR field equation (5) and the GOR motion equation (6), the theory of GOR establishes a observational model of the celestial two-body system (M,m) under the general observation agent OA(η):

$$\text{OA}(\eta):\quad \frac{\mathrm{d}^2u}{\mathrm{d}\varphi^2}+u=\frac{GM}{h_K^2}\left(1+\frac{3h_K^2}{\eta^2}u^2\right) \qquad (58)$$

where M is the massive celestial body acting as the gravitational source; m is a small celestial body acting as the observed object P moving in the gravitational field of M, and could be a planet or a satellite, or even a photon of starlight; $h_K\equiv r^2\mathrm{d}\varphi/\mathrm{d}\tau$ is the velocity moment of m, r is the radius vector of m, φ is the angle of the radius vector r, and u=1/r is the reciprocal of r.

The GOR celestial-motion equation (58) generalizes and unifies Einstein's celestial-motion equation of OA(c) and Newton's celestial-motion equation of OA$_\infty$.

(I) GOR Generalizing Einstein's Celestial-Motion Equation

As $\eta\to c$, OA(η)→OA(c), the GOR celestial-motion equation (58) under OA(η) strictly converges to Einstein's celestial-motion equation under OA(c):

$$\text{OA}(c):\quad \frac{\mathrm{d}^2u}{\mathrm{d}\varphi^2}+u=\frac{GM}{h_K^2}\left(1+\frac{3h_K^2}{c^2}u^2\right). \qquad (59)$$

It is worth noting that, compared to Newton's celestial-motion equation, Einstein's celestial-motion equation (59) has an additional item: $3h_K u^2/c^2$, that is, the orbital precession term. With it, Einstein made a prediction for the orbit precession of Mercury: Mercury's perihelion would precess 43.03″ every 100 years.

However, it is puzzling that the data of astronomical observation indicates that Mercury's perihelion actually processes 5600.73 arcseconds every 100 years, of which Einstein's predicted value is less than 8‰. Why could not Einstein predict the rest 99.2%?

The GOR celestial-motion equation (58) also has an orbital precession term: $3h_K u^2/\eta^2$. However, the GOR celestial-motion equation indicates that such orbital precession depends on the observation agent OA(η) and the information-wave speed η of OA(η), being an observational effect or an apparent phenomenon caused by the observational locality (η<∞) of OA(η). The Mercury's data of 5600.73 arcseconds is sourced from the optical astronomical observation, and the observation agent is naturally the optical agent OA(c). If the data of 5600.73 arcseconds does indeed contain the 43.03″ predicted by Einstein, then it just means that the Mercury's data does indeed record the observational effects and apparent phenomena of the optical agent OA(c) caused by the observational locality (c<∞) of OA(c).

So, the Mercury's data of astronomical observation is not the support for Einstein's theory of general relativity, but rather the support for the theory of GOR.

(II) GOR Generalizing Newton's Celestial-Motion Equation

As $\eta\to\infty$, OA(η)→OA$_\infty$, the GOR celestial-motion equation (58) under OA(η) strictly converges to Newton's celestial-motion equation under OA$_\infty$:

$$\text{OA}_\infty:\quad \frac{\mathrm{d}^2u}{\mathrm{d}\varphi^2}+u=\lim_{\eta\to\infty}\frac{GM}{h_K^2}\left(1+\frac{3h_K^2}{\eta^2}u^2\right)=\frac{GM}{h_K^2} \qquad (60)$$

This is exactly Newton's classical celestial-motion equation in the form of Binet equation.

Section 5.2 demonstrates that the theory of GOR is logically consistent with both Einstein's theory of general relativity and Newton's theory of universal gravitational. This from one aspect confirms that the theory of GOR is logically self-consistent and theoretically correct. For details see Chapter 20 of the 2^{st} volume GOR of OR [12-15].

Section 5 indicates that: Einstein's theory of relativity, both the special and the general, is that of optical observation with the optical agent OA(c); Galileo's doctrine and Newton's mechanics are that of idealized observation with the idealized agent OA_∞.

Section 5 and Tables A1 and A2 in Appendix A tell us that the theory of OR not only has generalized Einstein theory of relativity, but also has generalized Newtonian mechanics, ultimately unifying Newtonian mechanics and Einstein theory of relativity in the same theoretical system under the same axiom system.

It is thus clear that, logically, the theory of OR is not isomorphically consistent with Einstein's relativity theory, but also isomorphically consistent with Newton's classical mechanics. This confirms the logical self-consistency and theoretical correctness of OR.

6 New Discoveries and New Insights

The theory of OR is based on a more basic axiom system with more basic premises. As a theory of the general observation agent OA(η) ($0<\eta<\infty$; $\eta\to\infty$), it possesses a more broader perspective, and therefore, has the high degree of generalization and unification.

The theory of OR has uncovered the essence of the relativistic phenomena of matter motion and matter interactions presented in spacetime, and even has uncovered the essence of quantum effects. In particular, the theory of OR has generalized and unified Newton's classical mechanics and Einstein's relativity theory, becoming what Hawking called a **Complete Theory**, and marching towards the unification of relativity theory and quantum theory.

The theory of OR has brought new discoveries and new insights into human being's physics.

6.1 OR Justifying Galileo and Newton

OR Clearing Galileo' Name

The Galilean transformation is not an approximation of the Lorentz transformation, but rather a natural law of the physical world; whereas the Lorentz transformation is only a model of optical observation, presenting us with an optical mapping of spacetime transformation. Galileo's law of speed addition is not an approximation of Einstein's relation of relativistic speed addition, but a natural law of speed addition; whereas Einstein's relation of speed addition is only a law of optical observation, not entirely objective and real.

OR Clearing Newton's Name

Newton's mechanics is not an approximation of Einstein's theory of relativity, but rather a true portrayal of the physical world, representing the objective and real natural world; whereas Einstein's theory of relativity, both the special and the general, is that of optical observation, presenting us only with an optical image of the physical world that could be effective and valid only under the optical observation agent OA(c).

6.2 The Significant Discoveries of OR

The theory of OR has discovered that: Mankind's perception of the objective world not only depends on but also is restricted by observation; All the theoretical systems in physics, including Galileo's doctrine, Newton's mechanics, Einstein's relativity theory, and even quantum theory, must be branded with observations.

Einstein's theory of relativity, including the special and the general, is the theory of optical observation that is effective and valid only in optical observation armed with the optical agent OA(c). The information-wave speed of OA(c) transmitting observed information is the speed of light c and is limited. Therefore, the optical observation agent OA(c) has the observational locality of $c<\infty$, so that matter motion and gravitational interaction exhibit relativistic effects in Einstein's observational spacetime.

Galileo's doctrine and Newton's mechanics are that of idealized observation armed with the idealized agent OA_∞. The information-wave speed of OA_∞ transmitting observed information is idealized as infinite, and therefore, OA_∞ has no observational locality and might be referred to as **the God's Eye**. So, Galileo's doctrine and Newton's mechanics represent the objective and real physical world.

However, there is no the idealized observation agent OA_∞ in reality. The objective and real natural world could only be touched by human reason.

The theory of OR has discovered that: In essence, all relativistic effects or relativistic phenomena of matter motion and matter interactions presented in spacetime are observational effects and apparent phenomena, rooted from the observation locality of the human observation agent OA(η) ($\eta<\infty$).

So, the speed of light is not really invariant, and spacetime is not really curved.

The theory of OR has discovered that: In essence, all quantum effects or quantum uncertainty presented in microscopic spacetime are observational effects, rooted from the observational perturbation of the human observation agent OA(η) ($h_\eta>0$: $h_\eta\eta\equiv hc$) (see Chapter 6 of the 1^{st} volume IOR in [12-15]).

Heisenberg's uncertainty [34] is only the observational perturbation effects of the informons (photons) of the optical observation agent OA(c).

6.3 OR and the Big Puzzles in Physics

The theory of OR has listed 15 big puzzles in modern physics [12-15]: BP-01~15. The interpretations on these big puzzles made by the mainstream school of physics are well-known, and mostly are based on Einstein's perspective from the optical observation agent OA(c). Now, based on the theory of OR, we have had a broader perspective from the general observation agent OA(η) ($0<\eta<\infty$; $\eta\to\infty$) to re-examine these big puzzles. Perhaps, we will have new discoveries and new insights.

Below is a brief overview of the interpretations on some of these big puzzles made by OR. For details see Chapter 9 of the 1^{st} volume IOR and Chapter 21 of the 2^{nd} volume GOR in **The Theory of Observational Relativity: The Unity of Newton and Einstein** [12-15].

BP-02: On Photon Mass

Photons have the rest mass m_o of their own, that is, the objective and real mass of matter. According to the theoretical calculation of OR, a photon with the frequency f weighs $m_o=m=hf/c^2$.

BP-04: On Planck Constant

Planck constant h is the energy-frequency ratio of photons, or to be more exact, is the energy-frequency ratio of the informons of the optical agent OA(c); whereas the energy-frequency ratio of the informons of the general observation agent OA(η) can be called **the general Planck constant** and denoted as h_η: $h_\eta=hc/\eta$.

BP-06: On Uncertainty Principle

In the theory of OR, Heisenberg's principle of uncertainty or $\sigma_x\sigma_p\geq\hbar/2$ is just a special case of the principle of general uncertainty: $\sigma_x\sigma_p\geq\hbar_\eta/2$.

BP-07: On De Broglie Wave

De Broglie wave is not the inherent wave of matter, but rather the information wave of the optical agent OA(c).

BP-10: On Mercury Precession

Based his general relativity, Einstein predicted that Mercury's perihelion precesses 43″ every 100 years. However, Einstein's prediction is not the objective and real precession of Mercury, but rather the observational effect and apparent phenomenon of the optical agent OA(c).

BP-13: On Gravitational Waves

The gravitational waves predicted by Einstein based on his theory of general relativity is not the objective and real gravitational radiation, but the information wave of the optical agent OA(c); the speed κ of gravitational waves is definitely not the speed c of light.

LIGO, the Laser Interferometer Gravitational-Wave Observatory in the United States, claimed that they had detected gravitational waves came from deep space [35,36], and that the speed κ of gravitational waves determined by LIGO was exactly the speed c of light [37]. However, the gravitational-radiation signals detected by LIGO dis not come from the distant deep space of the universe, but rather from some electromagnetic matter systems, like Gamma-ray burst or X-ray, that carried their won gravitational fields, passing over the earth and invading the spacetime around the LIGO detector at close quarters. It was not that the speed of gravitational radiation was the speed of light, but rather that the gravitational fields of those electromagnetic matter systems moved at the speed of light with their electromagnetic systems.

The theory of OR does not doubt the existence of gravitational waves and gravitons. In the theory of OR, **Gravitational Wave** is regarded as the equivalent concept of **Gravity** or **Gravitational Radiation**.

According to Laplace's theoretical calculation, the speed κ of gravitational radiation is much higher than the speed c of light: $\kappa>7\times10^6c$ [38]; whereas Flandern's calculation is $\kappa=2\times10^{10}c$ [39]. This is reasonable, otherwise it would be difficult for us to imagine how photons could be acted by gravitational radiation, or as Flanders put it: the universe would lose its existing stable structure.

If the speed κ of gravitational radiation were equal to the speed c of light, then how could gravitational waves or gravitons escape from black holes and interact gravitationally with external celestial bodies?

BP-14: On Black Holes

The theory of OR cannot deny the existence of black holes. In fact, the theory of GOR and Newton's theory of universal gravitation can also deduce the theory of black holes. However, the black-hole theory in modern physics is derived from Einstein's theory of general relativity is only that of the optical agent OA(c) and cannot represent the objective and real physical existence of massive celestial bodies or black holes.

Based on the theory of OR or GOR, from the perspective of the general observation agent OA(η), black-hole scholars, including Hawking, will definitely find that black holes are different from what they imagined.

BP-15: On the Big Bang

Like the theory of black holes, the theory of Big Bang in modern physics is also a product of the so-called **Modern General Relativity** that is based on Einstein's general relativity from the perspective of the optical observation agent OA(v). Therefore, the so-called **Big Bang** could only be an optical illusion or mirage, not the objective and real physical reality.

Cosmological redshift does not imply that the universe has had the Big Bang and is expanding.

According to the theory of OR or GOR, spacetime is not really curved, nor does it curl up to the so-called singularity of the Big Bang.

So, the universe did not undergo the Big Bang.

The interpretations of OR for the big puzzles in modern physics are not necessarily right. They are only for readers and physicists to examine, promoting our understanding of these big puzzles in physics.

7 Theoretical Validity and Empirical Basis

Physics is both empirical and speculative.

The theory of OR nees both empirical evidence and speculative thinking.

So, is the theory of OR logically and theoretically correct and supported by observations and experiments?

The theory of OR is purely the product of logic and theory, but at the same time, supported by all the observations and experiments to date. In particular, the theory of OR conforms to human experience and intuition, to human reason and logic, and to what Swedish physicist Alfvén called **Common Sense** [40].

7.1 Is the Theory of OR Right?

Actually, the theory of OR, including IOR and GOR, is logically concise and easy to understand.

As demonstrated in Sec. 5 as well as Tables A1 and A2 of Appendix A, the theory of OR is isomorphically consistent with both Einstein's relativity theory and Newton's classical mechanics. As the theory of the general observation agent OA(η) ($0<\eta<\infty$; $\eta\to\infty$), the theory of OR has generalized Newton's classical mechanics of the idealized agent OA_∞ and Einstein's relativity theory of the optical agent OA(c), unifying the two great theoretical systems of human being's physics in the same theoretical system under the same axiom system.

This isomorphic consistency, as well as, the generalization and unification, confirm the logical self-consistency and theoretical validity of the theory of OR including IOR and GOR from one aspect.

The theory of OR has uncovered the essence of the relativistic phenomena of matter motion and matter interactions presented in spacetime. This seemingly fulfills Hawking's statement that we are beginning to understand the mind of God.

Perhaps, you could not understand the logical deduction of OR based on the definition of OR time as the first principle. In this regard, Sec. 4.3 specifically depicts for readers the different logical paths that could also lead to the theory of OR. Different logical paths could lead to the same destination of OR, which from one more aspect confirms the logical self-consistency and theoretical validity of the theory of OR.

Especially, Sec. 4.3.4 describes PGC logic path 1 leading to the theory of OR. You only need to replace the light speed c of the optical agent OA(c) in Einstein's relativity theory with the information-wave speed η of the general observation agent OA(η), and you could directly obtain the whole theoretical system of OR including IOR and GOR. Thus, you could certainly predict the isomorphic consistency between the theory of OR and Einstein's relativity theory, and the OR's generalization for Einstein relativity theory, include the special and the general.

However, you might not necessarily understand the isomorphic consistency between the theory of OR and Galileo-Newtonian mechanics, and the OR's generalization for Galileo-Newtonian mechanics.

Actually, it is an accident and unexpected for the theory of OR to generalize and unify Galileo-Newtonian mechanics and Einstein relativity theory. In a sense, this further confirms the logical self-consistency and theoretical validity of the theory of OR including IOR and GOR.

7.2 Does the Theory of OR Have Empirical Basis?

Einstein's theory of relativity, including the special and the general, is revered as the Bible of human being's physics for it has empirical evidence, supported by most observations and experiments.

So, what about the theory of OR?

7.2.1 Why do Observations and Experiments Mostly Support Einstein?

The theory of OR repeatedly emphasizes that: Galileo's doctrine and Newton's mechanics are that of idealized observation that are the true portrayal of the objective physical world; Einstein's theory of relativity, both the special and the general, is that of optical observation that presents us with only an optical image of the physical world, and is not entirely objective and real.

Now that Galileo is more right than Lorentz and Newton is more right than Einstein, why do human observations and experiments mostly tend to support Einstein?

The reason is simple: most of human observations and experiments currently take use of optical observation systems, that is, the optical agent OA(c), and so they naturally tend to support Einstein.

However, this does not mean that Einstein was more right than Newton. It only means that Einstein relativity theory is just a theory of optical observation.

Actually, it is not so much that those observations and experiments support Einstein, but rather they support the theory of OR. With the advancement of science and technology, mankind will master superluminal observation techniques, invent superluminal observation agents, and observe the more objective and real physical world. At that time, human observations and experiments will be more inclined to support Galileo and Newton.

7.2.2 Is the Theory of OR Supported by Observations or Experiments?

As a matter of fact, an observation or experiment that supports Einstein's relativity theory must be a support for the theory of OR, such as the Michelson-Morley experiment; an observation or experiment that supports Galileo's doctrine or Newton's mechanics must also be a support for the theory of OR, such as the Galilean transformation and Galileo's principle of speed addition.

Therefore, to some extent, the theory of OR is supported by all the observations and experiments to date.

(I) The Theory of OR and the Michelson-Morley Experiment

Indeed, in the Michelson-Morley experiment [3], the speed of light appears to be invariant. However, the theory of OR finds that this is merely an apparent phenomenon.

In the Michelson-Morley experiment, light or photons serve as both the observed object of Michelson and Morley and the observation medium transmitting observed information for Michelson and Morley. In other words, the observation agent OA(η) of Michelson and Morley was the optical agent OA(c), and naturally, the information-wave speed η of OA(c) is the speed of light c.

It is thus clear that, in the Michelson-Morley experiment, the invariance of light speed is only a phenomenon, the invariance of information-wave speeds is the essence.

So, the Michelson-Morley experiment is not a support for Einstein's theory of relativity, but rather a suppose for the theorem of the invariance of information-wave speeds and the theory of OR.

(II) The Theory of OR and Galileo's Principle of Speed Addition

Originally, mankind believed in Galileo's principle of speed addition, which is in fact a direct inference from the Galilean transformation.

Relative to the observer on the platform, the speed u of a passenger on the train is equal to the speed v of the train plus the speed u' of the passenger walking on the train [41]: $u=u'+v$, that is, Galileo's principle of speed addition.

After Einstein's special theory, however, people believe Galileo's speed addition is only an approximation of Einstein's speed addition in the case of low speeds.

Now, the theory of OR has discovered that Einstein's speed addition is the product of the optical agent OA(c) and optical observation. The optical agent OA(c) has the observational locality of $c<\infty$, presenting observational effects and apparent phenomena. Thus, Einstein's speed addition is not entirely objective and real.

According to the theory of OR, the higher the information-wave speed η of the observation agent OA(η) or the lower the moving speed v of the observed object, the weaker the observational effects and apparent phenomena of OA(η) become, and our observations would be closer to the objectively physical reality observed by the idealized agent OA_∞.

In daily life, i.e., in the case of macroscopic low-speed, the speed addition observed by people conforms to Galileo's principle of speed addition. This confirms the logical conclusion of OR: Galileo's principle of speed addition is the product of the idealized agent OA_∞, and it is an objective and true natural law of speed addition.

It is thus clear that human daily observations, human common sense, and human rationality, are more in line with the idealized observation of the idealized agent OA_∞, supporting Galileo's principle of speed addition. This demonstrates that Galileo's principle of speed addition and human daily observations support the theory of OR.

8 OR Significance

The theory of OR not only has theoretical significance for physics, but also has practical value, the realistic and the potential. Furthermore, it will serve as a crucial guide for experimental physics.

8.1 The Theoretical Significance of OR

Hawking ever remarked that [1]: human being's physics was increasingly fragmented and divided into more and more partial theories; the ultimate goal of physicists was to unify them.

The theory of OR, as a new theory of physics, is built under more basic logical premises and has a more boarder perspective. Therefore, it not only has uncovered the root and essence of the relativistic effects in macroscopic spacetime, unifying Newtonian classical mechanics and Einstein relativity theory in the same theoretical system under the same axiom system, but also has uncovered the root and essence of the quantum effects in microscopic spacetime, marching towards the unification of relativity theory and quantum theory.

This undoubtedly has great theoretical significance.

Naturally, the theory of OR is far from being the ultimate theory. In fact, as the theory of OR points out, due to the observational locality, mankind will never be able to reach the realm of absolute truth.

So, there is no the so-called ultimate theory in physics.

In a sense, however, OR is a complete theory, that is, a triumph of human reason in Hawking's words.

The theory of OR will inject fresh blood and new ideas into human being's physics. Based on the theory of OR, mankind will reshape his view of nature.

8.2 The Practical Significance of OR

Einstein's theory of relativity, as a special case in the theory of OR with the optical agent OA(c), has had practical applications, such as the GPS positioning system. In addition to the OR of the optical agent OA(c), both the OR of the subluminal agent OA(η) ($\eta<c$) and the OR of the superluminal agent OA(η) ($\eta>c$) possess the potential value of practical applications.

8.2.1 Optical OR: for GPS System

The best-known application of Einstein relativity theory as a special case of OR with the optical agent OA(c) is for the GPS positioning system to determine and calibrate the time of GPS satellites.

In the GPS system, the satellites orbit the earth at a speed (v) of over 7.9 k/s in the gravitational field (χ), and therefore, both the inertial and gravitational relativistic effects have to be taken into account. So, the determination and calibration of GPS time have employed Einstein relativity theory: $d\tau=dt(c)\sqrt{(1-v^2/c^2+2\chi/c^2)}$, where the speed c of light or electromagnetic radiation is the information-wave speed c of the optical agent OA(c).

Actually, in the GPS system, the satellites communicate between each other by radio. Naturally, its observation agent is the optical agent OA(c), and the determination and calibration of GPS time must rely on the theory of OR with the optical agent OA(c), that is, Einstein's theory of relativity. So, the GPS system is an applied example of OR in the case of the optical agent OA(c).

Of course, the practical applications of OR are not limited to the optical agent OA(c). According to the theory of OR, Einstein relativity theory would inevitably become invalid under the non-optical observation agent OA(η) ($\eta\neq c$). In that case, we would have to adopt the theory of OR with non-optical agents: either the subluminal ($\eta<c$) or the superluminal ($\eta>c$).

8.2.2 Subluminal OR: for the Multi-Robot System Operating Collaboratively in Deep Sea

In the future, the deep sea will be the important exploring areas of mankind, and the exploration for deep sea will be the important scientific activity of mankind.

The robot Jiaolong of China has already been able to dive down to 10,000 meters underwater. As multi robots work collaboratively in deep sea, they will face the same problems as GPS satellites: how to calibrate time; how to determine space.

Underwater communication cannot adopt light or electromagnetic wave. Underwater robots, like dolphins, must use underwater ultrasonic wave as the observation medium, employing the dolphin agent OA(v_U): $\eta=v_U\approx1450$ m/s, much lower than the speed of light c. Particularly, the ratio of the underwater robot's speed to underwater ultrasound is much greater than the ratio of the GPS satellites' speed to the light speed, and the gravitational field in deep sea is much stronger than that where GPS satellites are. Therefore, the dolphin agent OA(v_U) must present more significant relativistic effects than the optical agent OA(c).

So, the collaborative operation of multi robots in deep sea requires the subluminal theory of OR with the dolphin agent OA(v_U) listed in Table 1.

This is a potential application of subluminal OR.

8.2.3 Superluminal OR: for Gravitational Wave Astronomy

As shown in an increasing number of quantum entanglement experiments [23,24], the physical world indeed has the superluminal forms of matter motion. In the future, with the development of science and technology, mankind will invent superluminal observation agents ($\eta > c$). At that time, mankind must use the superluminal theory of OR.

LIGO's exploration [35,36] for gravitational waves has led to a new concept [42]: **Gravitational Wave Astronomy**. Of course, as the theory of OR has clarified, the speed κ of real gravitational waves is more in line with the calculations of Laplace [38] and Flandern [39], much higher than the speed of light ($\kappa >> c$) -- It is definitely not the speed of light envisioned by Einstein and LIGO.

In order to develop gravitational wave astronomy in the true sense, physics needs the gravitational agent OA(κ) employing gravitational radiation as the observation medium and the superluminal theory of OR.

To this end, the primary task of experimental physics is to measure and determine the speed κ of gravitational radiation or gravitational waves.

With the help of the superluminal theory of OR and superluminal agents, mankind will "**see**" or observe a more objective and real physical world.

This is a potential application of superluminal OR.

8.3 The Guiding Significance of OR: for Experimental Physics

The theory of OR tells us: What we perceive or observe may not necessarily be the objectively physical reality; Phenomena may not necessarily be the essence.

However, experimental physicists often thought that observation represents the reality; phenomena represent the essence. Such observationalist views of nature has misled human being's physics.

The theory of OR has important guiding significance for experimental physics.

Due to the current level of science and technology, our observations and experiments mostly rely on the optical agent OA(c). This is why most of observations and experiments support Einstein. Actually, in many cases, experimental physicists are not sure and concerned about what their observation agents are or who is transmitting the observed information for them.

According to the theory of OR, an experimental physicists conducting a physical experiment must first give a definite answer to the questions: what the observation agent OA(η) for his experiment is; what the information-wave speed η of OA(η) is.

In the theory of OR, the OR factor of spacetime transformation $\Gamma(\eta)=1/\sqrt{(1-v^2/\eta^2+2\chi/\eta^2)}$ can be decomposed into Γ_∞ and $\Delta\Gamma(\eta)$: $\Gamma(\eta)=\Gamma_\infty+\Delta\Gamma(\eta)$, in which $\Gamma_\infty \equiv 1$ is the Galilean factor representing the objectively physical reality; $\Delta\Gamma(\eta)$ is the relativistic factor representing the pure observational effects and apparent phenomena exhibited in observations and experiments, depending on the information-wave speed η of OA(η), rooted from the observational locality ($\eta < \infty$) of OA(η). So, in order to determine the objective and real physical quantities of observed objects, experimental physicists must manage to remove $\Delta\Gamma(\eta)$ from $\Gamma(\eta)$.

If experimental physicists introduce the observation-agent concept of OR into experimental physics, they will definitely have new discoveries and new understandings.

Conclusion

Now, physics has had a new theory: **Observational Relativity** (OR), the theory of OR.

The theory of OR has unexpectedly generalized and unified the two great theoretical systems of human being's physics, Newton's classical mechanics and Einstein's relativity theory, in the same theoretical system under the same axiom system. The unity of Newton and Einstein in OR goes beyond the original intention and expectation of OR. As the author repeatedly stressed, the theory of OR is not deliberately designed and manufactured, which is only a scientific discovery.

The theory of OR is not only the inheritance and development of Einstein's theory of relativity, but also the inheritance and development of Galileo's doctrine and Newton's mechanics.

However, the theory of OR is not a mechanical repetition of old theories in physics.

The theory of OR has already formed a complete theoretical system [12-15]: The 1st volume, **Inertially Observation Theory** (IOR), has generalized and unified Galileo-Newtonian inertial mechanics and Einstein's theory of special relativity; The 2nd volume, **Gravitationally Observation and Relativity** (GOR), has generalized and unified Newton's theory of universal gravitation and Einstein's theory of general relativity.

In order to clarify the logical self-consistency and theoretical validity of OR, as well as, to clarify the empirical basis and practical value of OR, this article condenses the theory of OR, focusing on the logical deduction of OR, the new discoveries and new insights of OR, and the unity of Galileo-Newtonian mechanics and Einstein theory of relativity wihin the theory of OR.

In fact, the theory of OR is logically concise and easy to understand, which is in line with Alfvén's common sense [38], with human experience and intuition, with human rationality and logic, and at the same time, with human plain and simple view of nature. The unity of Newton and Einstein in the theory of OR, from one aspect, confirms the logical self-consistency and theoretical validity of the theory of OR.

Section 4 of this article clarifies that, logically, the theory of OR originates from the definition of OR time as the first principle, based on a more basic axioma system with more basic logical premises, so it has had a broader perspective of the general observation agent OA(η) ($0<\eta<\infty$; $\eta\to\infty$). Readers perhaps could not understand the logical deduction of OR derived from the definition of OR time, then Sec. 4.3 depicts a few more concise logical paths let to the theory of OR, including PGC logical path 1 in Sec.

4.3.4 paved by PGC principle in Sec. 3.3. The fact that different logical paths can also lead to the theory of OR further confirms the logical and theoretical correctness of OR. As shown in Tables A1 and A2 in Appendix A, Secs. 5 and 7.1 demonstrate that the theory of OR is logically isomorphically consistent with both Galileo-Newtonian mechanics and Einstein relativity theory. This isomorphic consistency also provides a strong support for the logical self-consistency and theoretical correctness of OR.

Section 6 of this article briefly reports on the new discoveries and ideas of OR theory as a product of logic and theory, elucidating the important scientific value and theoretical significance of OR. For more details, please refer to the references [12-15].

It should be point out that the theory of OR is not a castle in the air. As clarified in Sec. 7.2, the theory of OR has solid empirical basis and sufficient empirical evidence, and in a sense, is supported by all the observations and experiments to date. Section 8 of this article has clarified that the theory of OR not only has great theoretical significance, but also has great practical value. Furthermore, the theory of OR will provide important guiding significance for experimental physics.

We have reason to believe that the theory of OR is the scientific truth that can withstand empirical testing, withstand rational reasoning, withstand questioning and criticizing, and withstand the test of time and history. The theory of OR will inject fresh blood and new ideas into human being's physics. Mankind will re-examine his physics and reshape his view of nature.

However, as a new doctrine of physics, the theory of OR is bound to face questioning and criticizing.

The statements of the theory of OR may not necessarily be very rigorous. The theory of OR welcomes questioning and criticizing.

As the great German philosopher Arthur Schopenhauer ever remarked: "All truth passes through three stages: first, it is ridiculed; second, it is vehemently opposed; third, it is accepted as being self-evident."

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Appendix A: The Corresponding Relationships between OR and Newton as well as between OR and Einstein

Table A1 lists the fundamental relations of Inertially Observational Relativity (IOR) as well as the corresponding relations of Galileo-Newtonian Inertial Mechanics and Einstein's theory of special relativity. Table A2 lists the fundamental relations of Gravitationally Observation Relativity (GOR) as well as the corresponding relations of Newton's theory of universal gravitation and Einstein's theory of general relativity.

Table A1. The Unity of Newton and Einstein in the Theory of IOR (See Chapter 8 of the 1st Volume IOR in OR References [12-15])

	The Theory of IOR (the general observation agent OA(η))	Einstein Special Relativity (the optical agent OA(c): $\eta \to c$)	Galileo-Newtonian Inertial Mechanics (the idealized agent OA$_\infty$: $\eta \to \infty$)
IOR-01	OA(η) and IOR spacetime $X^{4d}(\eta)$: $\mathrm{OA}(\eta)=\left\{\begin{array}{l} X^{4d}(\eta):\left\{\begin{array}{l}x^0=\eta t\\ x^1=x\\ x^2=y\\ x^3=z\end{array}\right\} \\ \mathrm{d}s^2=\eta^2\mathrm{d}t^2-\mathrm{d}x^2-\mathrm{d}y^2-\mathrm{d}z^2\end{array}\right\}$	OA(c) and Minkowski spacetime $X^{4d}(c)$: $\mathrm{OA}(c)=\lim_{\eta\to c}\mathrm{OA}(\eta)$ $=\left\{\begin{array}{l} X^{4d}(c):\left\{\begin{array}{l}x^0=ct\\ x^1=x\\ x^2=y\\ x^3=z\end{array}\right\} \\ \mathrm{d}s^2=c^2\mathrm{d}t^2-\mathrm{d}x^2-\mathrm{d}y^2-\mathrm{d}z^2\end{array}\right\}$	OA$_\infty$ and Cartesian spacetime $X^{4d}{}_\infty$: $\mathrm{OA}_\infty=\lim_{\eta\to\infty}\mathrm{OA}(\eta)$ $=\left\{\begin{array}{l} X^{4d}{}_\infty:\left\{\begin{array}{l}x^0=\infty t\\ x^1=x,x^2=y,x^3=z\end{array}\right\} \\ \mathrm{d}t=\mathrm{d}\tau \\ \mathrm{d}l=\sqrt{\mathrm{d}x^2+\mathrm{d}y^2+\mathrm{d}z^2}\end{array}\right\}$
IOR-02	IOR invariance of information-wave speeds: $\mathrm{OA}(\eta):\ \forall v\in(-\eta,\eta)\ \ \eta\oplus v=\eta$ The information-wave speed η of OA(η) is observationally invariant.	Einstein invariance of light speed: $\mathrm{OA}(c):\ \forall v\in(-c,c)\ \ c\oplus v=c$ If OA(η) is the optical agent OA(c), then the speed of light c is observationally invariant.	Cartesian invariance: $\mathrm{OA}_\infty:\ \forall v\in(-\infty,\infty)\ \ \infty\oplus v=\infty$ The information-wave speed of the idealized agent OA$_\infty$ is infinite, and so naturally invariant.
IOR-03	The IOR factor: $\Gamma=\Gamma(\eta)$ $\Gamma=\Gamma(\eta)=\dfrac{1}{\sqrt{1-v^2/\eta^2}}$	The Lorentz factor: $\gamma=\Gamma(c)$ $\gamma=\Gamma(c)=\lim_{\eta\to c}\Gamma(\eta)=\dfrac{1}{\sqrt{1-v^2/c^2}}$	The Galilean factor: $\Gamma_\infty=\Gamma(\infty)$ $\Gamma_\infty=\lim_{\eta\to\infty}\Gamma(\eta)=\lim_{\eta\to\infty}\dfrac{1}{\sqrt{1-v^2/\eta^2}}=1$
IOR-04	The general Lorentz transformation: $O'(\eta)\to O(\eta)$ $\mathrm{OA}(\eta):\ \left\{\begin{array}{l}x=\Gamma(\eta)(x'+vt')\\ y=y'\\ z=z'\\ t=\Gamma(\eta)\left(t'+\dfrac{vx'}{\eta^2}\right)\end{array}\right.$	The Lorentz transformation: $\mathrm{OA}(c):\ \{x\ y\ z\ t\}^T$ $=\lim_{\eta\to c}\left\{\begin{array}{l}\Gamma(\eta)(x'+vt')\\ y'\\ z'\\ \Gamma(\eta)\left(t'+\dfrac{vx'}{\eta^2}\right)\end{array}\right\}=\left\{\begin{array}{l}\gamma(x'+vt')\\ y'\\ z'\\ \gamma\left(t'+\dfrac{vx'}{c^2}\right)\end{array}\right.$	The Galilean transformation: $\mathrm{OA}_\infty:\ \{x\ y\ z\ t\}^T$ $=\lim_{\eta\to\infty}\left\{\begin{array}{l}\Gamma(\eta)(x'+vt')\\ y'\\ z'\\ \Gamma(\eta)\left(t'+\dfrac{vx'}{\eta^2}\right)\end{array}\right.=\left\{\begin{array}{l}x'+vt'\\ y'\\ z'\\ t'\end{array}\right.$
IOR-05	IOR law of speed addition: $u(\eta)=\dfrac{u'+v}{1+u'v/\eta^2}$	Einstein's law of speed addition: $u(c)=\lim_{\eta\to c}\dfrac{u'+v}{1+u'v/\eta^2}=\dfrac{u'+v}{1+u'v/c^2}$	Galileo's law of speed-addition: $u_\infty=\lim_{\eta\to\infty}\dfrac{u'+v}{1+u'v/\eta^2}=u'+v$
IOR-06	IOR observational mass: $m=m(\eta)=\dfrac{m_o}{\sqrt{1-v^2/\eta^2}}$	Einstein's relativistic mass: $m(c)=\lim_{\eta\to c}\dfrac{m_o}{\sqrt{1-v^2/\eta^2}}=\dfrac{m_o}{\sqrt{1-v^2/c^2}}$	Newton's classical mass: $m_\infty=\lim_{\eta\to\infty}\dfrac{m_o}{\sqrt{1-v^2/\eta^2}}=m_o$
IOR-07	IOR observational momentum: $p=p(\eta)=m(\eta)v=\dfrac{m_ov}{\sqrt{1-v^2/\eta^2}}$	Einstein's relativistic momentum: $p(c)=\lim_{\eta\to c}\dfrac{m_ov}{\sqrt{1-v^2/\eta^2}}=\dfrac{m_ov}{\sqrt{1-v^2/c^2}}$	Newton's classical momentum: $p_\infty=\lim_{\eta\to\infty}\dfrac{m_ov}{\sqrt{1-v^2/\eta^2}}=m_ov=m_\infty v$
IOR-08	IOR mass-energy relation: $E=E(\eta)=m\eta^2=\dfrac{m_o\eta^2}{\sqrt{1-v^2/\eta^2}}$	Einstein's mass-energy relation: $E(c)=\lim_{\eta\to c}\dfrac{m_o\eta^2}{\sqrt{1-v^2/\eta^2}}$ $=\dfrac{m_oc^2}{\sqrt{1-v^2/c^2}}=mc^2$	Newton's mass-energy relation: $E_\infty=\lim_{\eta\to\infty}E(\eta)$ $=\lim_{\eta\to\infty}\dfrac{m_o\eta^2}{\sqrt{1-v^2/\eta^2}}=\infty$
IOR-09	IOR rest energy: $E_o=E_o(\eta)=m_o\eta^2$	Einstein's rest energy: $E_o(c)=\lim_{\eta\to c}E_o(\eta)=\lim_{\eta\to c}m_o\eta^2=m_oc^2$	Newton's rest energy: $E_{o\infty}=\lim_{\eta\to\infty}E_o(\eta)=\lim_{\eta\to\infty}m_o\eta^2=\infty$

	The Theory of IOR (the general observation agent OA(η))	Einstein Special Relativity (the optical agent OA(c): $\eta\to c$)	Galileo-Newtonian Inertial Mechanics (the idealized agent OA$_\infty$: $\eta\to\infty$)
IOR-10	IOR observational kinetic energy: $K=K(\eta)=E(\eta)-E_o(\eta)$ $=(\Gamma(\eta)-1)m_o\eta^2$	Einstein's relativistic kinetic energy: $K(c)=\lim\limits_{\eta\to c}K(\eta)=\lim\limits_{\eta\to c}(E(\eta)-E_o(\eta))$ $=(\Gamma(c)-1)m_oc^2=(\gamma-1)m_oc^2$	Newton's classical kinetic energy: $K_\infty=\lim\limits_{\eta\to\infty}K(\eta)=\lim\limits_{\eta\to\infty}(E(\eta)-E_o(\eta))$ $=\lim\limits_{\eta\to\infty}(\Gamma(\eta)-1)m_o\eta^2=\frac{1}{2}m_\infty v^2$

Notes: The theory of IOR has generalized and unified Einstein's theory of special relativity and Galileo-Newtonian Inertial Mechanics. All formulae or relationships in the theory of IOR, as $\eta\to c$, strictly converge to that of Einstein's special relativity; as $\eta\to\infty$, strictly converge to that of Galileo-Newtonian inertial mechanics. It is thus clear that the theory of IOR is logically consistent not only with Einstein's special relativity, but also with Galileo-Newtonian inertial mechanics. Moreover, such strict corresponding relationship between different theoretical systems, from one aspect, confirms the logical self-consistency and theoretical validity of the theory of IOR and even OR.

Table A2. The Unity of Newton and Einstein in the Theory of GOR (See Chapter 20 of the 2nd Volume GOR in OR References [12-15])

	The Theory of GOR (the general observation agent OA(η))	Einstein's General Relativity (the optical agent OA(c): $\eta\to c$)	Newton's Gravitational Theory (the idealized agent OA$_\infty$: $\eta\to\infty$)
GOR-01	OA(η) and GOR spacetime $X^{4\mathrm{d}}(\eta)$: $\mathrm{OA}(\eta)=\left\{\begin{matrix} X^{4\mathrm{d}}(\eta):\left\{\begin{matrix}x^0=\eta t\\ x^1=x\\ x^2=y\\ x^3=z\end{matrix}\right\} \\ \mathrm{d}s^2=g_{\mu\nu}\mathrm{d}x^\mu\mathrm{d}x^\nu \\ \left(g_{\mu\nu}=g_{\mu\nu}(x^\alpha,\eta)\right)\end{matrix}\right\}$	OA(c) and Minkowski spacetime $X^{4\mathrm{d}}(c)$: $\mathrm{OA}(c)=\lim\limits_{\eta\to c}\mathrm{OA}(\eta)$ $=\left\{\begin{matrix} X^{4\mathrm{d}}(c):\left\{\begin{matrix}x^0=ct\\ x^1=x\\ x^2=y\\ x^3=z\end{matrix}\right\} \\ \mathrm{d}s^2=g_{\mu\nu}\mathrm{d}x^\mu\mathrm{d}x^\nu \\ \left(g_{\mu\nu}=g_{\mu\nu}(x^\alpha,c)\right)\end{matrix}\right\}$	OA$_\infty$ and Cartesian spacetime $X^{4\mathrm{d}}_\infty$: $\mathrm{OA}_\infty=\lim\limits_{\eta\to\infty}\mathrm{OA}(\eta)$ $=\left\{\begin{matrix} X^{4\mathrm{d}}_\infty:\left\{\begin{matrix}x^0=\infty t\\ x^1=x,x^2=y,x^3=z\end{matrix}\right\} \\ \mathrm{d}t=\mathrm{d}\tau \\ \mathrm{d}l=\sqrt{\mathrm{d}x^2+\mathrm{d}y^2+\mathrm{d}z^2}\end{matrix}\right\}$
GOR-02	The GOR factor of spacetime transformation: $\Gamma=\Gamma(\eta)$ $\Gamma=\Gamma(\eta)=\dfrac{1}{\sqrt{\left(\sqrt{1+\frac{2\chi}{\eta^2}}-\gamma_i\frac{v^i}{\eta}\right)^2-\frac{v^2}{\eta^2}}}$	The Einstein factor: $\gamma=\Gamma(c)$ $\gamma=\Gamma(c)=\lim\limits_{\eta\to c}\Gamma(\eta)$ $=\dfrac{1}{\sqrt{\left(\sqrt{1+2\chi/c}-\gamma_iv^i/c\right)^2-v^2/c^2}}$	The Newtonian factor: Γ_∞ $\Gamma_\infty=\lim\limits_{\eta\to\infty}\Gamma(\eta)=1$
GOR-03	The determination of GOR standard time: $\mathrm{OA}(\eta)\text{:}\ \mathrm{d}\tau=\frac{\mathrm{d}s(\eta)}{\eta}=\sqrt{g_{00}(\eta)}\mathrm{d}t(\eta)$ $=\sqrt{1+\frac{2\chi}{\eta^2}}\mathrm{d}t(\eta)$	The determination of Einstein's standard time: $\mathrm{OA}(c)\text{:}\ \mathrm{d}\tau=\frac{\mathrm{d}s(c)}{c}=\sqrt{g_{00}(c)}\mathrm{d}t(c)$ $=\sqrt{1+\frac{2\chi}{c^2}}\mathrm{d}t(c)$	The determination of Newton's classic time: $\mathrm{OA}_\infty\text{:}\ \mathrm{d}\tau=\lim\limits_{\eta\to\infty}\sqrt{1+\frac{2\chi}{\eta^2}}\mathrm{d}t(\eta)=\mathrm{d}t_\infty$ Newton's clasical time dt_∞ is exactly the objective and real time dτ.
GOR-04	The determination of GOR physical space: $\mathrm{OA}(\eta)\text{:}\ \mathrm{d}l^2=\gamma_{ik}(\eta)\mathrm{d}x^i\mathrm{d}x^k$	The determination of Einstein's physical space: $\mathrm{OA}(c)\text{:}\ \mathrm{d}l^2=\gamma_{ik}(c)\mathrm{d}x^i\mathrm{d}x^k$	The determination of Newton's physical space: $\mathrm{OA}(c)\text{:}\ \mathrm{d}l^2=\lim\limits_{\eta\to\infty}\gamma_{ik}(\eta)\mathrm{d}x^i\mathrm{d}x^k$ $=x^2+y^2+z^2$ Newton's phyaical space is exactly the objective and real Cartesian space.
GOR-05	The GOR field equation: $\Box\chi_{\mu\nu}(\eta)=-\frac{\eta^2}{2}\kappa_{\mathrm{GOR}}T_{\mu\nu}(\eta)$ $\left\{\begin{matrix}\Box\chi_{\mu\nu}\equiv\frac{\eta^2}{2}\left(R_{\mu\nu}-\frac{1}{2}g_{\mu\nu}R\right)\\ \kappa_{\mathrm{GOR}}=8\pi G/\eta^4\end{matrix}\right.$	Einstein's field equation: $\Box\chi_{\mu\nu}(c)=\frac{c^2}{2}\left(R_{\mu\nu}-\frac{1}{2}g_{\mu\nu}R\right)$ $=-\frac{c^2}{2}\kappa_ET_{\mu\nu}(c)\quad\left(\kappa_E=\frac{8\pi G}{c^4}\right)$ As $\eta\to c$, the GOR field equation reduces to Einstein's field equation.	Newton's field equation: $\nabla^2\chi=4\pi G\rho$ $\left\{\begin{matrix}\Box\chi_{\mu\nu}=0\ \ (\mu\nu\neq 00)\\ \Box\chi_{00}=-\nabla^2\chi=-4\pi G\rho\end{matrix}\right.$ As $\eta\to\infty$, the GOR field equation reduces to Newton's law of universal gravitation in the form of Poisson equation.

	The Theory of GOR (the general observation agent OA(η))	Einstein's General Relativity (the optical agent OA(c): $\eta\to c$)	Newton's Gravitational Theory (the idealized agent OA$_\infty$: $\eta\to\infty$)
GOR-06	The GOR motion equation: (i.e., the GOR geodesic equation) $$\frac{d^2x^\mu}{ds^2}+\Gamma^\mu_{\alpha\beta}(\eta)\frac{dx^\alpha}{ds}\frac{dx^\beta}{ds}=0 \quad (\mu=0,1,2,3)$$	Einstein's motion equation: $$\frac{d^2x^\mu}{ds^2}+\Gamma^\mu_{\alpha\beta}(c)\frac{dx^\alpha}{ds}\frac{dx^\beta}{ds}=0 \quad (\mu=0,1,2,3)$$ As $\eta\to c$, the GOR motion equation reduces to Einstein's motion equation.	Newton's motion equation: $$\begin{cases}\frac{d^2t}{d\tau^2}=0\\ \frac{d^2x^i}{d\tau^2}=-\frac{\partial\chi}{\partial x^i}\end{cases}\quad \left(F^i=-m\frac{\partial\chi}{\partial x^i};i=1,2,3\right)$$ As $\eta\to\infty$, the GOR motion equation splits into two independent relations: the 1d temporal (dt) and the 3d spatial (dr) that is exactly Newton's law of universal gravitation $\|F\|=GMm/r^2$.
GOR-07	The GOR spacetime metric: $$g_{\mu\nu}(\eta):\begin{cases}g_{00}(\eta)=1+2\chi/\eta^2\\ g_{11}(\eta)=-(1+2\chi/\eta^2)^{-1}\\ g_{22}(\eta)=-r^2\\ g_{33}(\eta)=-r^2\sin^2\theta\\ g_{\mu\nu}(\eta)=0\quad(\mu\neq\nu)\end{cases}$$	Einstein's spacetime metric: $$\underset{\eta\to c}{g_{\mu\nu}(c)}:\begin{cases}g_{00}(c)=1+2\chi/c^2\\ g_{11}(c)=-(1+2\chi/c^2)^{-1}\\ g_{22}(c)=-r^2\\ g_{33}(c)=-r^2\sin^2\theta\\ g_{\mu\nu}(c)=0\quad(\mu\neq\nu)\end{cases}$$	Newton's spacetime metric: $$g_{\mu\nu}=\lim_{\eta\to\infty}g_{\mu\nu}(\eta)=\eta_{\mu\nu}=\mathrm{diag}(+1,-1,-r^2,-r^2\sin^2\theta)$$ As $\eta\to\infty$, the GOR metric $g_{\mu\nu}$. converges to the Minkowski metric $\eta_{\mu\nu}$.=diag(+1,–1,–1,–1).
GOR-08	The GOR spacetime line-element: $$ds^2=(1+2\chi/\eta^2)\eta^2dt^2-(1+2\chi/\eta^2)^{-1}dr^2-r^2d\theta^2-r^2\sin^2\theta d\varphi^2$$	Einstein's spacetime line-element: $$ds^2=(1+2\chi/c^2)c^2dt^2-(1+2\chi/c^2)^{-1}dr^2-r^2d\theta^2-r^2\sin^2\theta d\varphi^2$$	Newton's spacetime line-element: $$\begin{cases}dt=d\tau\\ dr^2=dx^2+dy^2+dz^2\end{cases}$$ As $\eta\to\infty$, the GOR line-element ds splits into two independent relation: 1d time-element dt and 3d space-element dr.
GOR-09	The GOR observed energy: Kinetic energy $K(\eta)$ of the object P: $$K=K(\eta)=\left(\Gamma(\eta)\big\|_{\chi=0}-1\right)m_o\eta^2$$ Potential energy $V(\eta)$ of the object P: $$V=V(\eta)=\left(1-\Gamma(\eta)\big\|_{v=0}\right)m_o\eta$$ Total energy $H(\eta)$ of the object P: $$H=H(\eta)=K(\eta)+V(\eta)=\left(\Gamma(\eta)\big\|_{\chi=0}-\Gamma(\eta)\big\|_{v=0}\right)m_o\eta^2$$	Einstein's relativistic energy: Kinetic energy $K(c)$ of the object P: $$K=K(c)=\left(\Gamma(c)\big\|_{\chi=0}-1\right)m_oc^2$$ Potential energy $V(c)$ of the object P: $$V=V(c)=\left(1-\Gamma(c)\big\|_{v=0}\right)m_oc$$ Total energy $H(c)$ of the object P: $$H=H(c)=\lim_{\eta\to c}H(\eta)=K(c)+V(c)=\left(\Gamma(c)\big\|_{\chi=0}-\Gamma(c)\big\|_{v=0}\right)m_oc^2$$	Newton's classical energy: Kinetic energy K_∞ of the object P: $$K=\lim_{\eta\to\infty}K(\eta)=\frac{1}{2}m_\infty v^2=K_\infty$$ Potential energy V_∞ of the object P: $$V=\lim_{\eta\to\infty}V(\eta)=\chi m_\infty=V_\infty$$ Potential energy H_∞ of the object P: $$H=H_\infty=\lim_{\eta\to\infty}H(\eta)=K_\infty+V_\infty=\frac{1}{2}m_\infty v^2-\frac{GMm_\infty}{r^2}$$
GOR-10	The GOR motion equation of celestial two-body system (M,m): $$\mathrm{OA}(\eta):\ \frac{d^2u}{d\varphi^2}+u=\frac{GM}{h_K^2}\left(1+\frac{3h_K^2}{\eta^2}u^2\right)$$	Einstein's motion equation of celestial two-body system (M,m): $$\mathrm{OA}(c):\ \frac{d^2u}{d\varphi^2}+u=\frac{GM}{h_K^2}\left(1+\frac{3h_K^2}{c^2}u^2\right)$$	Newton's motion equation of celestial two-body system (M,m): $$\mathrm{OA}_\infty:\ \frac{d^2u}{d\varphi^2}+u=\frac{GM}{h_K^2}$$
GOR-11	The GOR precession-angle equation of planet orbits: $\Delta\varphi_{\mathrm{GOR}}$ $$\Delta\varphi_{\mathrm{GOR}}=\Delta\varphi_{\mathrm{OA}(\eta)}=\frac{6\pi G^2M^2}{\eta^2h_K^2}$$	Einstein's precession-angle equation of planet orbits: $\Delta\varphi_E$ $$\Delta\varphi_E=\Delta\varphi_{\mathrm{OA}(c)}=\lim_{\eta\to c}\Delta\varphi_{\mathrm{OA}(\eta)}=\frac{6\pi G^2M^2}{c^2h_K^2}$$	Newton's precession-angle equation of planet orbits: $\Delta\varphi_N$ $$\Delta\varphi_N=\Delta\varphi_{\mathrm{OA}_\infty}=\lim_{\eta\to\infty}\varphi_{\mathrm{OA}(\eta)}=0$$
GOR-12	The GOR gravitational-deflection angle of light sweeping over the sun: δ_{GOR} The optical agent OA(c): $\eta=c$ $$\delta_{\mathrm{GOR}}=\delta_{\mathrm{OA}(\eta)}=\frac{4GM}{R_Sc^2}\quad(\eta\to c)$$ The the superluminal agent OA(η): $\eta>>c$ $$\delta_{\mathrm{GOR}}=\delta_{\mathrm{OA}(\eta)}=\frac{2GM}{R_Sc^2}\left(1+\frac{c^2}{3c^2+2\eta^2}\right)$$	Einstein's gravitational-deflection angle of light sweeping over the sun: δ_E ($\eta=c$) $$\delta_E=\delta_{\mathrm{OA}(c)}=\lim_{\eta\to c}\delta_{\mathrm{OA}(\eta)}=\frac{4GM}{R_Sc^2}$$	Newton's gravitational-deflection angle of light sweeping over the sun: δ_N ($\eta>>c$) $$\delta_N=\delta_{\mathrm{OA}_\infty}=\lim_{\eta\to\infty}\delta_{\mathrm{OA}(\eta)}=\lim_{\eta\to\infty}\frac{2GM}{R_Sc^2}\left(1+\frac{c^2}{3c^2+2\eta^2}\right)=\frac{2GM}{R_Sc^2}$$

	The Theory of GOR (the general observation agent OA(η))	Einstein's General Relativity (the optical agent OA(c): $\eta \to c$)	Newton's Gravitational Theory (the idealized agent OA$_\infty$: $\eta \to \infty$)
GOR-13	The GOR gravitational-redshift equation of light: Z_{GOR} $Z_{\text{GOR}} = Z_{\text{OA}(\eta)} = \dfrac{1\big/\sqrt{g_{00}(r_{\text{B}})} - 1\big/\sqrt{g_{00}(r_{\text{A}})}}{K_{F\eta}\big/m_o\eta^2 - \left(1 - 1\big/\sqrt{g_{00}(r_{\text{B}})}\right)}$ $\begin{pmatrix} K_{F\eta} = \left(\Gamma\|_{\chi=0} - 1\right) m_o \eta^2 \\ \Gamma\|_{\chi=0} = 1\big/\sqrt{1 - c^2/\eta^2} \\ g_{00}(r) = 1 + \dfrac{2\chi}{\eta^2};\ \ \chi(r) = -\dfrac{GM}{r} \end{pmatrix}$ where $\eta\,(\geq c)$ is the information-wave speed of the general observation agent OA(η); the speed of light c is the speed of the photon m as the observed object P.	Einstein's gravitational-redshift equation of light: Z_E $Z_E = Z_{\text{OA}(c)} = \lim\limits_{\eta \to c} Z_{\text{OA}(\eta)} = 1 - \dfrac{\sqrt{g_{00}(r_{\text{B}})}}{\sqrt{g_{00}(r_{\text{A}})}}$ $\left(g_{00}(r) = 1 + \dfrac{2\chi}{c^2};\ \chi(r) = -\dfrac{GM}{r}\right)$	Newton's gravitational-redshift equation of light: Z_N $Z_N = Z_{\text{OA}_\infty} = \lim\limits_{\eta \to \infty} Z_{\text{OA}(\eta)} = \dfrac{2GMr_{\text{B}}}{r_{\text{B}}c^2 + 2GM}\left(\dfrac{1}{r_{\text{B}}} - \dfrac{1}{r_{\text{A}}}\right)$
GOR-14	The GOR information-wave equation: $\nabla^2 h^-_{\mu\nu}(\eta) - \dfrac{1}{\eta^2}\dfrac{\partial^2}{\partial t^2} h^-_{\mu\nu}(\eta) = 0$ where the wave function $h^-_{\mu\nu}(\eta)$ is the metric-perturbation tensor under OA(η).	Einstein's information-wave equation: $\nabla^2 h^-_{\mu\nu}(c) - \dfrac{1}{c^2}\dfrac{\partial^2}{\partial t^2} h^-_{\mu\nu}(c) = 0$ As $\eta \to c$, the GOR wave equation reduces to Einstein's wave equation.	Newton's information-wave equation: $\nabla^2 h^-_{\mu\nu} = 0 \quad \text{or} \quad \nabla^2 \chi = 0$ As $\eta \to \infty$, the GOR wave equation reduces to Newton's wave equation.

Notes: The theory of GOR has generalized and unified Einstein's theory of general relativity and Newton's theory of universal gravitation. All formulae or relationships in the theory of GOR, as $\eta \to c$, strictly converge to that of Einstein's theory of general relativity; $\eta \to \infty$, strictly converge to that of Newton's theory of universal gravitation. It is thus clear that the theory of GOR is logically consistent not only with Einstein's theory of general relativity, but also with Newton's theory of universal gravitation. Moreover, such strict corresponding relationship between different theoretical systems, from one aspect, confirms the logical self-consistency and theoretical validity of the theory of GOR and even OR.