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Possible Flaws of General Relativity and a Distinct Approach to Understanding Gravity

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Abstract

There are compelling lines of reasoning that suggest general relativity is flawed. General relativity was primarily formulated through thought experiments. This theory cannot explain why spacetime, arguably not a physical or material entity, should become curved due to the presence of energy-momentum. Since general relativity attempts to generalize Newton's law of gravitation, it can explain certain aspects of gravity. However, because gravity is not a force in this theory, it arguably cannot properly explain the pull of gravity. Furthermore, no attempt to quantize general relativity has been successful yet. It predicts various singularities and even violates the energy and information conservation below the event horizon of black holes, as well as having possible inconsistencies with observations. Most of the problems arguably stem from its foundational assumptions. This paper argues that exploring alternatives to spacetime curvature should provide a more effective representation of gravitational fields.

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Overview

Albert Einstein, motivated by Maxwell's field equations for electromagnetism and using his thought experiments, one of which was the equivalence principle, formulated a frame-independent theory of gravity, known as general relativity, which extended the flat spacetime concept of special relativity to the curvature of spacetime to account for the presence of energy-momentum, the foundation of this theory. General relativity has various shortcomings. Arguably, without energy-momentum, spacetime is much like an abstract mathematical construct; for inertial coordinate systems, the spacetime concept only captures the frame independence of the speed of light in the vacuum, with dimensions of length. No mathematical construct is itself physical. Comparatively recent research has identified key elements of the vacuum, including dynamic properties and fluctuations, that were not satisfactorily addressed in general relativity. Given current theoretical and experimental developments, a more advanced theory of gravity is expected to be formulated in terms of energy, analogous to Newton's law of universal gravitation with appropriate modifications. Replacing the concept of spacetime curvature with energy-based formulations should provide a more comprehensive framework for gravitational theory. Furthermore, it is not quantum mechanical, and yet no scientifically satisfactory quantum mechanical version of gravity and general relativity is known. There are substantial arguments indicating that general relativity may not be amenable to quantization through standard methods; this observation warrants careful consideration within the broader context of theoretical physics. The foundational difficulty arises in quantizing the field of general relativity due to the dual role of the metric tensor [1]. Besides, there is speculation that gravity may emerge from purely quantum mechanical phenomena. A deeper understanding of the Higgs mechanism, quantum entanglement, and other related concepts should be instrumental for comprehending gravity at the quantum level. This approach should require more precise data from experiments and/or observations.

On the other hand, it predicts singularity at the center of black holes [2] along with violation of the energy conservation law below event horizons, because space and time swap signs in a way, and the application of quantum mechanics to black holes predicts a concerning matter: the existence of negative energy particles could result in information loss [3], challenging our fundamental understanding of the physical world. It also predicts the Big Bang singularity [2].

Nature of spacetime

Lorentz invariant quantities for one space dimension and one time dimension, where symbols denote usual meanings, can be expressed as [2,4]:

$$t^2c^2 - x^2 = \tau^2c^2 \qquad (1)$$

$$E^2 - p_x^2c^2 = m^2c^4 \qquad (2)$$

From equation (2), we can write, where symbols denote usual meanings, the following equation:

$$\frac{m^2c^4}{1-\frac{v_x^2}{c^2}} - \frac{m^2v_x^2c^2}{1-\frac{v_x^2}{c^2}} = m^2c^4 \qquad (3)$$

From equation (3), it can be shown easily that equation (1) can be derived. Apart from capturing inertial frame independence of the speed of light in the vacuum, which has an experimental basis, the spacetime relationship in special relativity does not satisfactorily consider some important aspects of the vacuum, as discussed in the introduction, which should be important for a better theory of gravity.

Let's take a closer look at the origins of the concept of spacetime. Time dilation refers to the increase in a system's velocity relative to an observer, which correlates with an increase in the system's momentum. The increase in momentum is associated with the rise in the system's total energy, which is the origin of the unification of space and time into spacetime. It can be inferred that each particle experiences time differently. This reasoning suggests that the framework of energy expressions can replace the concept of time. This discussion compellingly conveys that the invariant energy-momentum relationship can be expressed within the framework of spacetime for an inertial observer. It is essential to recognize that this concept exists independently of higher dimensions, thereby enhancing our understanding of its significance and elegance. By incorporating the postulates of special relativity, an energy-momentum relationship that is independent of inertial observers can be derived as in equation (2). So, spacetime is, in effect, rather much like an abstract mathematical construct†[1].

Moreover, according to special relativity, massless particles do not sense time at all. We know that massive particles can become massless particles and vice versa under suitable conditions. Special relativity and quantum field theory do not provide insight into the origin of these transitions. So, it

[1] †Let's see the working relationship between physics and mathematics. We explored the abstract concept of natural numbers, gaining valuable insights through our observations of the natural world. Natural numbers can be combined to create abstract mathematical constructs by using two fundamental operations: addition and multiplication. Arguably, natural numbers and the two fundamental operations that combine them serve as the foundation of mathematics. Besides, when we apply these concepts to geometrical objects, we can create numerous abstract mathematical constructs, which is why some of them precede years before physicists use them. Some abstract mathematical constructs are useful for expressing physical phenomena. This also explains why we cannot describe the underlying mechanisms of physical phenomena with mathematics. The relationship between physics and mathematics as a whole follows a similar pattern to other branches of science in extending our understanding of the natural world.

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is not surprising that there may be something missing in the spacetime concept in special relativity as well. Time may not be an intrinsic part of the physical world. A better understanding of the Higgs mechanism should provide greater insight into these transitions.

Overall, it can be said that the spacetime concept can be used to state experimentally verified Lorentz-invariant relationships between energy and momentum, much like abstract mathematical frameworks do in physics for various contexts. This relationship also holds for other contexts involving invariant quantities in special relativity.

Field equations for general relativity and possible shortcomings while quantizing them

Einstein sought to modify Newton's law of universal gravitation, motivated by Maxwell's field equations for electromagnetism, by the concept of the curvature of a four-dimensional spacetime of special relativity as the gravitational field due to the presence of energy-momentum, evidenced by the relative or tidal acceleration of a free test particle as gravity, known as general relativity. Einstein's equation for general relativity is the following [2,4]:

$$G_{\mu\nu} \equiv R_{\mu\nu} - \frac{1}{2} R g_{\mu\nu} = 8\pi G T_{\mu\nu} \tag{4}$$

where symbols denote usual meanings. It was not derived from empirical bases, like Newton's law of universal gravitation, Maxwell's field equations for electromagnetism, and even special relativity, for instance. Deriving from empirical bases is the best way to advance in science†[2].

Although foundationally different, since general relativity is an attempt to generalize Newton's law of universal gravitation, general relativity captures some features of gravity. General relativity works when there is energy. It can predict the trajectories of test particles well in gravitational fields, but it cannot satisfactorily describe the pull on them toward the center of the sources, as gravity is not a force in this theory; this should be a limitation of the equivalence principle of this theory. Moreover, there is no scientific observation confirming that spacetime, as described in special relativity, becomes curved due to the presence of energy and momentum; the bending of light rays near massive objects should be understood through interactions between photons and both virtual and real particles, and gravitational waves should be viewed as compelling evidence of energy transfer, as they inherently carry energy themselves, for instance. Besides, several recent observations suggest that there may be fundamental issues with the validity of general relativity.

Overall, general relativity exhibits remarkable flexibility, a trait that can also be viewed as a limitation. This flexibility allows for various interpretations and applications, but it also raises concerns regarding its foundational strength.

Equation (4) can be obtained by using the action principle by taking the Lagrangian density [5]:

$$\sqrt{g} R / 16\pi G \tag{5}$$

with g= det[$g_{\mu\nu}$], where symbols denote usual meanings. One of the two main approaches to quantizing gravity is loop quantum gravity. Loop quantum gravity takes Einstein's general relativity as its point of departure and seeks to incorporate quantum mechanics [6]. Despite its apparent potential, this approach may fall short in providing a robust quantum theory of gravity. The conceptual challenges related to spacetime, together with the arguments presented below, indicate the need for reevaluation.

[2] †Even our imaginations are rooted in empirical foundations. Some of our imaginative ideas are based on logical reasoning derived from these foundations, while others are not. The former approach is the best way to expand human knowledge of the natural world, and it serves as the foundation of science. Consequently, our imaginations can only stretch to certain limits; for instance, we cannot conceive of anything beyond the concept of nothingness.

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Effective field theory requires the inclusion of all possible terms that are consistent with an assumed symmetry. On this basis, there is no reason to take Einstein's general theory of relativity seriously as the foundation of a quantum theory of gravitation, because Einstein's theory is meant to be a theory with a Lagrangian density given by just the term $\sqrt{g}R/16\pi G$ [5].

In summary, along with philosophical difficulties and other limitations, this theory may not be quantum mechanically tractable like other successfully quantized classical theories. A better understanding of quantum entanglement may provide insight into the appropriate Lagrangian for a more comprehensive theory of gravity at the quantum level, which should have a classical limit. There may be a role for gravity in forming quantum entangled states in a way, as entanglement is a universal phenomenon.

The other main approach to quantizing gravity is string theory. String theory offers the potential of unifying gravity and all the other forces of nature and all forms of matter into one unified conceptual structure [7]. String theorists start with the small (quantum theory) and move to embrace the large (gravity) [6]. There is as yet no satisfactory quantized theory of gravity, so that 'graviton' is not really a well-defined notion yet [4]. The metric tensor is the building block of the fields in general relativity. It does not provide any information about the energy content in the vacuum. Metric tensors are the basis of the hypothetical massless spin-2 particles called gravitons. Since gravity is not a force in general relativity, the force carrier gravitons may not be compatible with it; force carriers are purely quantum mechanical concepts for fundamental interactions. Besides, string theory is not a scientifically satisfying theory. One of the weaknesses of string theory is that it is a model with degrees of freedom that are postulated, not derived [8]. In fact, string theory is not a scientifically satisfying theory of physics so far because it has not been derived from empirical bases like other successful theories of physics. Thus, this approach is not scientifically satisfying hitherto.

Foundational difficulty in the quantization of the gravitational field, unlike other classical field theories

Several methods exist for developing a quantum field theory associated with a given classical field theory, expressed in terms of a Lagrangian or Hamiltonian; this approach is particularly dependent on the problems being addressed. Nevertheless, general relativity differs fundamentally from other classical field theories in that every realistic method attempting to formulate the quantum version of general relativity has encountered serious problems [1]. By quantizing the gravitational field like other fields in quantum field theory, the graviton would propagate through curved spacetime as any other particle while also being responsible for creating that curved spacetime. This unique issue does not arise for other quantum field theories that are formulated on a fixed background spacetime and treated classically.

From the previous discussions, it should be convincing that we do not need to quantize spacetime as in general relativity; the statements about the energy fields can replace it, since spacetime can be treated much like an abstract mathematical construct.

Moreover, it's entirely plausible for a quantum theory of gravity to exist without the need for gravitons, offering a new perspective on this complex field. We need to understand the wave-nature of elementary particles better to verify this approach. To gain a deeper understanding of quantum phenomena, experiments that can give necessary information about the turning waves into particles process (U-process [9]) and particles into waves process (R-process [9]), various interactions including gravitational effects among elementary particles in multiple energies and phases, including during the U-process and R-process, and space at different scales, should provide key insight about gravity at the quantum level. Suppose the characteristics of interactions vary during these processes, particularly for gravitational effects. Then, it can be said that quantum effects should play a role in these interactions, which could open up a new window to understanding gravity better at the quantum level.

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Possible inconsistencies of Schwarzschild's solution of general relativity for black holes

Schwarzschild's solution for static black holes is an exact solution to the Einstein field equations, which is the following [10]:

$$c^2 d\tau^2 = \left(1 - \frac{2GM}{c^2 r}\right) c^2 dt^2 - \frac{dr^2}{\left(1 - \frac{2GM}{c^2 r}\right)} - r^2 d\psi^2 \tag{6}$$

where symbols denote usual meanings.

From equation (6), it is obvious that without angular variation, i.e., for radial change, there is a swap of sign between space and time coordinates below event horizons, along with a spacetime singularity at the center of black holes, if we ignore the singularity at the event horizon. It may have several explanations, but from equations (1) and (2), it can be inferred that it violates the law of energy conservation, a fundamental principle in physics, below the event horizon of black holes. This can be seen as an outcome of the foundational flaw of general relativity. However, Newton's law of universal gravitation permits the existence of arbitrarily high mass within a region, which can be classified as a black hole without violating the law of energy conservation.

When quantum mechanics is applied to curved spacetime in black holes, it can be demonstrated that this approach predicts the existence of negative-energy particles, implying information loss in black holes [3]. These arguments also suggest that general relativity is foundationally flawed.

Findings

The analysis revealed that, apart from an attempt to generalize Newton's law of universal gravitation, general relativity is more akin to a model, with degrees of freedom that are postulated through thought experiments, instead of being derived from empirical bases, such as Maxwell's field equations for electromagnetism, for instance. This distinction is important because, as we observe, empirical derivation remains essential for advancing human knowledge across all fields of science. This also explains why even our imaginations are constrained. Furthermore, compelling reasons emerge to view spacetime as much like a mathematical construct. However, there is no known scientifically satisfying quantum mechanical version of general relativity or gravity; general relativity is foundationally different from other classical mechanical theories, which have quantum versions. Additionally, explorations into the concept of the graviton reveal it is not well-defined—gravity is not strictly a force in general relativity, and there are conceptual issues with spacetime. Alternatively, we could explore the possibility of developing a quantum theory of gravity that does not rely on gravitons, which may lead to new insights and advancements in our understanding of gravitational interactions. More critically, general relativity allows for violations of energy conservation and information loss. These evident inconsistencies suggest that representing gravity in terms of energy alone—ignoring spacetime as a dynamical variable—should provide a clearer and quantum-mechanically tractable theoretical framework for gravity.

Important elements

A comprehensive understanding of the outlined quantum phenomena, which should contribute to advances in quantum gravity research, is currently limited by the lack of precise experimental settings, as far as the author is aware. If these configurations become available in the future, experimental findings should directly inform assessments of the previously described approach's validity and potentially guide the direction of further research.

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