

1,6 Limitations of Einstein Gravitational Field Equation

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Principles for Developing the Einstein Gravitational Field Equation

The Einstein General Theory of Relativity was a tremendous advance in physics. The principles on which it is based are profound. The General theory of Relativity provided a solid theoretical foundation for the Special theory of Relativity, which has wide practical applications. The General theory has accurately predicted the relativistic effects of gravity that occur within our solar system, effects that are small but can be very important. However, the primary area where scientists are applying General Relativity theory is cosmology, and in this area it has failed. The problem is that the theory is only approximately valid. The theory applies accurately within the weak gravitational field of our solar system, but is unreliable when applied to cosmology where gravitational fields can be extremely high.

The problem with General Relativity is that the *Einstein Gravitational Field Equation* is not rigorous. The following discussion explains this point. Let us start by reviewing the equations involved in the Einstein theory.

General Relativity calculations start with the metric tensor, which describes the measurement characteristics of space. The metric tensor has two forms: the covariant form (g_{ab}) and the contravariant form (g^{ab}). The product of these two forms is a unit matrix, and so one form can be computed directly from the other. Unless the metric tensor is *diagonal* (meaning that all non-diagonal elements are zero), the equations of General Relativity are far too complicated to be solved analytically, and so Einstein had to limit his application of General Relativity to very simple physical models that yielded diagonal metric tensors. If the metric tensor is diagonal, the diagonal elements of (g^{ab}) are the reciprocals of those of (g_{ab}).

General Relativity specifies gravity to be a curvature of four-dimensional space-time. In the Ricci-Riemann calculus of curved space, the curvature of space is characterized by the Ricci tensor. The Ricci-Riemann theory has formulas for calculating the elements of the covariant Ricci tensor (R_{ab}) from the elements of the (g_{ab} , g^{ab}) metric tensors. Tensors have three forms: the covariant form (D_{ab}), the contravariant form (D^{ab}), and the mixed form (D_a^b). The Ricci-Riemann calculus of curved space provides formulas that use the (g_{ab} , g^{ab}) metric tensor elements to convert any tensor from one of its three forms to another.

Einstein defined the Einstein tensor (G_a^b), which is computed from the mixed Ricci tensor (R_a^b) using the following formulas: for non-diagonal elements ($G_a^b = R_a^b$); and for diagonal elements ($G_a^b = R_a^b - \frac{1}{2} R$), where (R) is the sum of the four diagonal elements of (R_a^b). The reason that Einstein converted the Ricci curvature tensor (R_a^b) to the Einstein curvature tensor (G_a^b) is that the covariant derivative of the Einstein tensor is zero. If the covariant derivative of a vector is zero, the absolute direction of the vector does not change as

the vector is moved from one location to another in curved space. Einstein concluded that his curvature tensor should have this basic property.

If the metric tensor is diagonal, one can use the formulas derived by Dingle, shown in *Addendum* document 5,B Einstein Tensor and Christoffel Symbols for Diagonal Metric Tensor, Section B,5. From these formulas one can directly calculate the elements of the Einstein tensor (G_a^b) from those of the covariant metric tensor (g_{ab}).

To derive his gravitational field equation, Einstein initially assumed that this equation should have the following general form:

$$G_a^b = k_1 T_a^b + k_2 t_a^b$$

where (T_a^b , t_a^b) are tensors and (k_1 , k_2) are constants. Tensor (T_a^b) would characterize matter, and tensor (t_a^b) would characterize the gravitational field. A fundamental requirement of (T_a^b , t_a^b) is that they must be **true tensors**, which means that when converted to a different coordinate system they must change in a precise manner, in accordance with a formula specified by the Ricci-Riemann calculus of curved space. This formula is described in *Addendum* document 5,C *Calculation of Energy-Momentum Tensor*, Section 2.

Einstein was able to derive a true tensor for (T_a^b), which he called the **energy-momentum tensor**, but was unable to derive a true tensor for (t_a^b). Einstein derived a variable that he denoted (t_a^b), which he called the **“energy components of the gravitational field”**. However, this was not a true tensor, and it became known as the **“Einstein pseudo-tensor”**.

The noted physicist Wolfgang Pauli discussed the **Einstein pseudo-tensor** in his book, *Theory of Relativity* [5] (page 176). Einstein had claimed that the elements of his pseudo tensor (t_a^b) were equivalent in certain respects to those of his energy-momentum tensor (T_a^b). Pauli disputed this claim, noting that all of the elements in the Einstein pseudo tensor (t_a^b) can be made zero by an appropriate change of coordinates, and that Schrodinger found that all elements of (t_a^b) are zero when one considers the gravitational field of a point mass. This issue is discussed further in *Addendum* document 5,3 *Aspects of Einstein and Yilmaz Gravitational Theories*, Section 3.

Since Einstein was unable to derive a true tensor to represent (t_a^b), he omitted it in the final equation for his theory. His theory appeared to work without it. However, as will be shown, the failure of the Einstein gravitational field equation to include a tensor characterizing the gravitational field is a severe limitation.

After Einstein presented his final gravitational field equation, measurements were made during two solar eclipses to verify the theory. The measurements found that the Einstein gravitational field equation accurately predicted the bending of a light beam when it passes close to the sun. This result made Einstein famous, and his mysterious tensor equation became enshrined like an untouchable religious deity. Nevertheless, it rests on shaky ground; it was the

best guess that Einstein could make. In 1999, John A. Peacock [6] (p. 19) reported in his authoritative textbook on cosmology, “The Einstein gravitational field equation cannot be derived in a rigorous sense; all that can be done is to follow Einstein and start by thinking of the simplest form that such an equation might take.”

This article shows that the Einstein gravitational field equation has serious limitations, which restrict its use to regions of weak gravitational fields like our solar system. Nevertheless, the principles of General Relativity are sound. Yilmaz applied these principles to derive a different gravitational field equation in a rigorous manner. Yilmaz succeeded because he approached the task from another direction. Einstein attempted to deduce the gravitational field equation directly and failed; whereas Yilmaz derived his metric tensor first, and from this he calculated his gravitational field equation. Yilmaz applied the principles of General Relativity that had been established by Einstein, and used them to build a rigorous and profound theory of gravity. The fact that the Yilmaz theory has solid mathematical and physical integrity proves that the principles of General Relativity that were established by Einstein were correct, even though Einstein failed in his efforts to derive an accurate gravitational field equation.

Unfortunately, most scientists have treated the Einstein gravitational field equation as absolute truth. Based on this assumption, scientists have drawn a multitude of physically impossible conclusions, which include: (1) the Black Hole, which surrounds an infinitely dense singularity; (2) the Big Bang singularity that created our universe; (3) non-physical dark matter; (4) dark energy; (5) parallel universes; (6) worm holes in space; (7) String-Theory matter made of non-observable, infinitesimal strings vibrating in 11-dimensional space; etc. Many hundreds of scientists have devoted their professional careers to theoretical investigations of science-fiction concepts that are based solely on the validity of the Einstein gravitational field equation. Hence we should carefully examine the limitations of that equation. Its most obvious limitation is its prediction of physically impossible singularities. These are summarized here and are discussed in detail in document *1,5 Singularity Predictions of General Relativity*.

The Physically Impossible Black Hole and Big Bang Singularities

The Einstein General Relativity theory has been used to derive Black Hole and Big Bang singularities, which predict an infinitely dense state of matter. Throughout his lifetime, Einstein absolutely rejected the notion of a singularity, which he insisted was physically impossible. He demanded that his theory, or any physical theory, must agree with observational evidence. Failure to do so indicates a failure of the theory.

When discussing the Big Bang theory in 1945, Einstein recognized that General Relativity predicted a singularity of infinite density at the beginning of the universe. He insisted that such a singularity could not have existed, and concluded that his General Relativity equations do not hold accurately under conditions of extreme density of field and matter. [7]

In 1939, Oppenheimer and Snyder [8] applied General Relativity to predict the Black Hole. Einstein [9] absolutely rejected the physical conclusion of that analysis, which predicted that a heavy, dense star with a mass-to-radius ratio exceeding the Schwarzschild limit would collapse “indefinitely” to form a singularity, which was later called a Black Hole. Einstein contended in his rebuttal that the predicted collapse of the star could not actually occur, because

General Relativity equations would require particles to travel at the speed of light, which is impossible. *No scientist attempted to refute Einstein on this point while Einstein was alive.*

A decade after Einstein's death, powerful computers became widely available, which could apply Einstein's equations to much more complicated physical models than Einstein could consider. These computer studies found that Einstein's gravitational field equation absolutely requires that an extremely heavy and dense star must collapse indefinitely to form a "Black Hole" singularity of essentially infinite density. It was therefore concluded by most scientists that any star exceeding the Schwarzschild mass-to-radius limit must collapse indefinitely to form a Black Hole singularity. The Schwarzschild limit is a mass-to-radius ratio that is 236,000 times greater than that for our sun.

When astronomers found massive stellar bodies having mass-to-radius ratios that greatly exceeded the Schwarzschild limit, it was generally assumed that Black Holes must physically exist. Today we are confidently informed by the scientific community that the Black Hole singularity is physical real. *Scientists continually quote Einstein's wisdom as the foundation for this science-fiction concept, even though Einstein always insisted that singularities are physically impossible and cannot exist.*

Scientists who are using Einstein's prestige to support the physically impossible Black Hole singularity are blatantly ignoring the fact that in 1945 Einstein recognized (in his discussion of the Big Bang singularity) that his General Relativity equations *do not hold accurately "for very high density of field and of matter"*, and so cannot be used to justify the physical validity of a singularity. [7] Even though scientists may believe that a singularity of essentially infinite density can physically exist, they have no right to incorrectly quote Einstein to support their position.

It is undoubtedly true that the universe has many massive stars with mass-to-radius ratios greatly exceeding the Schwarzschild limit. Computer studies have apparently proven that the Einstein gravitational field equation predicts that such a star should collapse to form a Black Hole singularity. *However, these facts merely show that the Einstein gravitational field equation does not yield accurate results under conditions of extreme density of field and matter, a conclusion that Einstein acknowledged in 1945.* [7] These massive dense stars are probably massive neutron stars. Scientists have used General Relativity theory to "prove" that a massive neutron star cannot exist, and must collapse to form a *physically impossible Black Hole.*

Cannot Achieve a Multi-Body Solution

In addition to physically impossible singularity predictions, the Einstein gravitational field equation has other weaknesses that are even more serious. Because of the enormous complexity of the General Relativity calculations, these other limitations were not apparent during Einstein's lifetime. The most serious is that General Relativity can only achieve a single-body solution. The theory cannot model the effects of two or more bodies having interacting gravitational fields.

The Single-Body Schwarzschild Solution.

The Schwarzschild analysis of the Einstein theory was only a ***single-body solution***. It merely considered the gravitational field of one body, a single star. When this analysis was applied to calculate the relativistic advance of the Mercury orbit, the analysis assumed a test mass in the orbit of Mercury, which had absolutely no effect on the gravitational field.

The orbit of the planet Mercury advances by 1.39 arc seconds for every orbit. This means that the axis of the elliptical Mercury orbit rotates 1.39 arc seconds for every revolution of Mercury, and this rotation is in the direction of the motion of Mercury. This advance of the Mercury orbit was determined by measuring the cumulative advance of the orbit over many years.

Of this 1.39 arc-second per orbit advance of the Mercury orbit, 1.29 arc seconds can be calculated using Newton's theory of gravity by considering the forces exerted by other planets on Mercury. The remaining 0.10 arc-second per orbit of the Mercury advance was calculated using the Schwarzschild solution of General Relativity. The 1.29 arc-second per orbit advance of the Mercury orbit caused by other planets could not be calculated from the Schwarzschild solution, because that solution could only consider the effect of the gravitational field of the sun.

As Mercury rotates around the sun, the gravitational field of Mercury causes the center of the sun to wobble slightly. The Schwarzschild analysis cannot include this effect, because it is only a ***single body solution***. It can only account for the gravitational field of a single body, the sun. The gravitational field considered in the analysis is not affected by the mass of any planet, including Mercury.

Einstein recognized that his analysis of the Mercury orbit used a ***single-body solution***. He and other scientists were content with this limited analysis because it was not practical during Einstein's lifetime to achieve a multi-body solution with the very complicated tensor equation of the Einstein theory. A multi-body solution of the Einstein gravitational field equation would require a non-diagonal metric tensor, which would result in millions of terms in the analysis. Einstein assumed that his theory could yield a multi-body solution, but the following discussion shows that it cannot. ***More precisely, the Einstein theory cannot yield a multi-body solution with interacting gravitational fields.***

The Analysis of Professor Carroll O. Alley

Professor Carroll O. Alley of the University of Maryland is one of the very few experts in General Relativity theory who has applied his knowledge to practical applications. Alley has supervised several experiments to test the validity of predictions derived from the Einstein theory. This has included laser measurements with retro-reflectors on the moon that have allowed several distances to the moon to be measured with laser beams to an accuracy of 3 centimeters. Another set of experiments measured the relativistic time delay in an atomic clock carried in an aircraft under several flight profiles. [10] Alley is also intimately involved in

applying General Relativity corrections to the Geophysical Positioning System (GPS). The GPS is an array of satellites operated by the U. S. Air Force to provide accurate position coordinates over the world for military and civilian navigation.

Alley became impressed with the Yilmaz theory and has cooperated with Yilmaz. Alley made an important contribution to this issue with his proof that the Einstein gravitational field equation cannot achieve a two-body solution. Let us examine this astonishing claim. Many computer studies using the Einstein theory have appeared to achieve multi-body solutions. However these studies employ artifices that help to make the iterative computer programs converge to solutions. These artifices are inserting results into the solutions that are not actually coming from the Einstein gravitational field equation.

Alley has avoided this problem by considering a simple physical model that can be solved analytically by the Einstein theory. Using the Einstein gravitational field equation, he calculated the gravitational attraction between a pair of infinite slabs of matter separated by a fixed distance. *Alley found that the Einstein theory predicts absolutely no gravitational attraction between the two slabs.* This configuration is physically similar to models used in electronics to calculate capacitance. By assuming that the dimensions of the slabs are infinite relative to the separation between the slabs, one can ignore edge effects. This results in a simple theoretical model to which one can apply the Einstein theory analytically. [10, 11]

The Einstein theory predicts absolutely no gravitational force between the two slabs. This result conflicts not only with Newton's law of gravitational attraction; it also conflicts with experimental evidence. In 1798, Henry Cavendish performed an experiment that determined the value of the gravitational constant G of Newton's theory by measuring the gravitational attraction between two lead spheres. In this classic experiment, Cavendish determined the gravitational constant G within an error of 1.4 percent. The result of Alley's analysis directly conflicts with the Cavendish experiment.

Reason for Failure to Achieve a Two-Body Solution

The following discussion explains why the Alley analysis does not predict a gravitational force between the two slabs.

The Einstein, Ricci, and Energy-Momentum Tensors. The space between the two slabs (which is a vacuum) does not contain matter, and so the energy-momentum tensor must be zero in that space. Since the Einstein gravitational field equation sets the ***Einstein tensor*** proportional to the ***energy-momentum tensor***, the Einstein tensor must be zero in the space between the slabs. If all elements of the Einstein tensor are zero, all elements of the closely related Ricci tensor also must be zero.

Gravity is represented as a curvature of space in the Einstein theory, and the Einstein and Ricci tensors describe the curvature of space. Since the Einstein curvature tensor is zero in the space between the two slabs, there is no gravitational field in that space to produce gravitational attraction between the two slabs.

The Yilmaz theory does not have this problem, because its gravitational field equation has a stress-energy tensor for the gravitational field. With the Yilmaz theory, the stress-energy tensor for the gravitational field is not zero in the space between the slabs, and so the Einstein curvature tensor is not zero. Consequently the Yilmaz theory predicts gravitational attraction between the two slabs.

The Einstein energy-momentum tensor is always identically zero in a vacuum, and so the Einstein and Ricci curvature tensors for the Einstein theory are always identically zero in a vacuum. Nevertheless, the Schwarzschild solution must have a gravitational field in the vacuum of space surrounding the star, because the solution predicts the gravitational effect of the sun on the orbit of Mercury. If the Einstein and Ricci curvature tensors are zero in this vacuum, how can the vacuum have a gravitational field? To explain this we must consider the Riemann tensor.

The Riemann Tensor. The Einstein tensor is a minor modification of the Ricci tensor, and both tensors describe the curvature of space. The Ricci tensor is a reduced version of a very complicated tensor called the Riemann tensor. The Riemann tensor uniquely specifies the curvature of space. If space has no curvature, and hence no gravitational field, all elements of the Riemann tensor are zero. Conversely, if all elements of the Riemann tensor are zero, space has no curvature and no gravitational field. The Riemann tensor is not directly used in Einstein theory calculations.

The Riemann tensor has four indices, and hence has $4 \times 4 \times 4 \times 4$ elements, or 256 elements. This tensor is denoted in the form R_{abcd} . The Ricci tensor is calculated from the Riemann tensor in a process called contraction. The two indices (c) and (d) of the Riemann tensor are set equal to one another, and the Riemann tensor is summed over the four values (0, 1, 2, 3) of these two indices. This summation yields the Ricci tensor R_{ab} , which has 2 indices and hence has 4×4 or 16 elements. Each element of the Ricci tensor is the sum of 16 elements of the Riemann tensor.

If all elements of the Riemann curvature tensor are zero, then all elements of the Ricci and Einstein curvature tensors are zero. On the other hand, the Ricci and Einstein curvature tensors can be identically zero when the Riemann tensor is not zero. This condition occurs in the vacuum of space outside the star in the Schwarzschild solution. Consequently the Schwarzschild solution allows a gravitational field in the vacuum of space outside the star.

But the Schwarzschild solution is a very special case. It has a spherically symmetric gravitational field and is only a single-body solution. In this ***very special case*** the Riemann curvature tensor can be nonzero in the space outside the star, even though all elements of the Ricci curvature tensor are zero. In more general cases, the Riemann tensor must be zero in a region where all elements of the Ricci tensor are zero, because the Ricci tensor is a contraction of the Riemann tensor.

Since each element of the Ricci tensor is the sum of 16 elements of the Riemann tensor, how can nonzero elements of the Riemann tensor add to produce elements of the Ricci tensor that are all identically zero throughout a region of space? This requires that some elements of the Riemann tensor are positive and others are negative, and are ***accurately matched*** to cancel one another. This can only be achieved in a highly symmetric situation such as occurs in the

Schwartzschild solution. In more general cases, the only way that all elements of the Ricci tensor can be zero throughout a region of space is for the Riemann tensor to be zero in that region. Consequently, a vacuum cannot contain a gravitational field when there are two independent bodies with interacting gravitational fields.

In the Alley analysis, all elements of the Ricci tensor are zero throughout the space between the two slabs. Since the geometry does not have spherical symmetry, the Riemann tensor must also be zero, and so there is no curvature (and hence no gravitational field) in the space between the two slabs. Consequently the Einstein gravitational field equation predicts that there is absolutely no gravitational attraction between the two slabs.

As this discussion has shown, there is a fundamental reason why there is no gravitational attraction between the two slabs in the Alley analysis. ***The Alley analysis proves that the Einstein gravitational field equation cannot achieve an interactive multi-body solution.***

Conservation of Matter-Plus-Energy

In order to yield realistic predictions, a relativistic theory must achieve conservation of matter-plus-energy. Since matter can be converted into energy, and vice-versa, it is the sum of matter-plus-energy that must be conserved. This conservation is achieved by placing appropriate constraints on the energy-momentum tensor.

This issue is discussed in Appendix E of *Story* [2]. Although the Einstein and the Yilmaz theories both have energy-momentum tensors, these tensors are not exactly the same. Yilmaz has proven that the energy momentum tensor for the Yilmaz theory (which Yilmaz calls the “stress-energy tensor for matter”) always achieves conservation of matter-plus-energy, but the energy-momentum tensor for the Einstein theory usually does not.

Multiple Solutions from the Einstein Theory

One confusing aspect of the Einstein theory is that it can yield multiple solutions for the same physical model. Constraints that are somewhat arbitrary must be included in the analysis to achieve an answer. This problem is widely recognized by those performing General Relativity studies. As explained in *Believe* [1] Appendix J, Yilmaz has shown that the reason for this problem is that the Einstein gravitational field equation is over-constrained.

In contrast, the Yilmaz theory has a definite solution and can yield only one answer for a particular physical model. The time-varying Yilmaz theory incorporates general constraints, which assure that this condition is always satisfied. Scientists who are familiar with the arbitrary adjustable parameters of the Einstein theory may find it difficult to recognize that the Yilmaz theory does not have this property. A prediction made by the Yilmaz theory depends only on the characteristics of the physical model on which it is based. It is not affected by arbitrary assumptions made by the individual who is applying the Yilmaz theory.

The Einstein Gravitational Field Equation is Not Rigorous

This discussion has shown that there are fundamental flaws in the Einstein gravitational field equation, which characterizes the Einstein theory. Because of the great mathematical complexity of that equation, its flaws have been obscured.

The success of the Schwarzschild solution disguised the fact that this is only a single-body solution, which gives reliable results only in a weak gravitational field. The Schwarzschild limit indicates that the Schwarzschild solution does not work in an intense gravitational field, even for a single-body solution. The Alley analysis has proven that the Einstein gravitational field equation cannot yield an interactive multi-body solution.

The Alley analysis proves that the Einstein gravitational field equation does not provide a rigorous solution to Relativity principles. Confusing results and nonphysical predictions have been derived from the Einstein gravitational field equation because that equation is not mathematically rigorous. The physically impossible Big Bang and Black Hole singularity predictions are examples of this.

Search for a Unified Field Theory

After presenting his General Theory of Relativity, Einstein devoted most of his life in a failed effort to develop a *Unified Field Theory*, which would combine the effects of gravitational fields with those of electro-magnetic fields and atomic nuclear fields. Gravitational fields of General Relativity are not consistent with quantum mechanics, but the other fields are.

In recent years many scientists have pursued this quest. *String Theory* is a highly sophisticated mathematical effort to reconcile General Relativity with quantum mechanics. This theory has postulated that all matter consists of infinitesimal strings that vibrate in 11- dimensional space.

The Yilmaz theory makes the String Theory research irrelevant, because Yilmaz has proven that his gravitational field equation is consistent with quantum mechanics. *The Yilmaz theory directly provides the foundation for a Unified Field Theory.*

The Principles of General Relativity

If a scientist is given the Ricci-Riemann calculus of curved space and the Einstein gravitational field equation, the scientist has all of the information that is needed to apply the General theory of Relativity. Therefore one might think that the Einstein gravitational field equation completely characterizes the General theory of Relativity. But that would be absolutely wrong.

Behind the Einstein gravitational field equation are profound principles that Einstein derived to develop his General theory of Relativity. These principles could only have been deduced by a genius with the broad wisdom of Einstein.

Based on these principles, Einstein struggled for years to deduce a gravitational field equation that would mathematically specify his General Relativity theory. He tried different approaches that failed. Finally he proposed his official gravitational field equation, which he supplemented with the brilliant solution to this equation made by Karl Schwarzschild. (If Karl Schwarzschild had lived, he probably would have become one of the giants of 20th century physics.) When the Schwarzschild solution to the official Einstein gravitational field equation was applied to the curvature of light passing close to the sun, it predicted a result that was confirmed in tests made during a solar eclipse. That confirmation made Einstein famous. Since then, many other tests performed within our solar system have confirmed the high accuracy of the Einstein gravitational field equation when applied within the weak gravitational fields of our solar system.

Today an enormous amount of research has applied the Einstein General theory of Relativity to cosmology. However, cosmology applications were far from Einstein's mind when he began his research to generalize his theory of Relativity. His original Relativity theory published in 1905 (which was later called Special Relativity) was based on the postulate that the speed of light is constant. Einstein soon proved by approximate analyses that this assumption does not hold exactly under conditions of acceleration or in a gravitational field.

Einstein found that when light rises by a distance (h) in a gravitational field, the apparent speed of the light is reduced by a fractional amount approximately equal to $2(gh/c^2)$. This can be expressed as $2(mh/r^2)$, where m is the normalized mass of the gravitational body and r is the distance from the center of that body. The normalized mass (m) of the earth is 4.43 mm, or 4.43×10^{-6} km, and the radius of the earth (r) is 6,380 km. If we assume that a light beam on earth rises a distance (h) of one kilometer, the fractional decrease in the speed of light, which is $2(mh/r^2)$, is equal to $2(4.43 \times 10^{-6} \text{ km})(1.0 \text{ km})/(6380 \text{ km})^2$, which is 0.218×10^{-12} . This represents a fractional decrease in the speed of light of 0.218 parts per trillion, an amount generally too tiny to measure.

Although the quantitative effects of the variation of the speed of light with acceleration or gravity are tiny within our normal experience, they are fundamental. Einstein was compelled to include the effects of acceleration and gravity within his Relativity theory in order to achieve a rigorous theory. He began his research to generalize his Relativity theory soon after his basic theory was published in 1905. It took 11 years of hard research before he published his General theory of Relativity in 1916.

When Einstein began his research to generalize his Relativity theory in 1905, most astronomers believed that the Milky Way galaxy contained our whole universe. It was not until the 1920's that astronomers were able to achieve reliable means for measuring large astronomical distances, and thereby prove that the universe extended far beyond our Milky Way galaxy. It was nearly a quarter century before Hubble discovered in 1929 that our universe is expanding. Einstein recognized that his General Relativity theory had astronomical implications, and he included a "Cosmological Constant" term in his gravitational field equation to make it more applicable to astronomy. Nevertheless, the astronomical application of General Relativity was a minor issue. Einstein's essential requirement was to achieve a solid theoretical foundation for his Relativity concept.

The physical principles of General Relativity, on which Einstein based his gravitational field equation, are sound. Although the characteristics of the gravitational field equation were strongly constrained, that equation was merely Einstein's best guess for a formula to specify the principles of Relativity. It is clear from the material presented in this article that this guess by Einstein was wrong. However, a failure of Einstein's gravitational field equation does not imply a failure in the profound Relativity concepts derived by Einstein that underlie that equation.

Yilmaz built on Einstein's General Relativity principles by deriving a new gravitational field equation in a different manner. Einstein attempted the impossible task of deducing his gravitational field equation directly. Yilmaz took the alternative route of deriving the *metric tensor* in a rigorous manner, and from this he calculated his gravitational field equation. Yilmaz followed Einstein's wisdom by basing his gravitational field equation on the Einstein tensor, which Einstein had correctly determined should be the foundation for a gravitational field equation characterizing Relativity principles.

Yilmaz began this endeavor when he studied Einstein's approximate calculation of the redshift produced by gravity, and realized that he could solve the problem exactly. With his exact formula for gravitational redshift, Yilmaz derived an exact formula for the metric tensor element for time (g_{00}). To extend this finding, Yilmaz postulated the following: ***The speed of light measured locally in a gravitational field is independent of direction.*** With a brilliant analysis (which included the restriction that the gravitational field does not vary with time) Yilmaz proved from this postulate that the metric tensor is diagonal, that the spatial elements g_{11} , g_{22} , g_{33} are equal, and that ($g_{11} = -1/g_{00}$). This gave Yilmaz a rigorous formula to specify the full metric tensor for the static case.

The preceding discussion demonstrates that the Yilmaz theory is a refinement of the Einstein General Relativity of Relativity. The Yilmaz theory has a different gravitational field equation, but it incorporates *all* of the other principles of the Einstein General theory of Relativity. In 1958 Yilmaz published his basic static theory of gravity. In 1973, Yilmaz generalized his theory to achieve a rigorous time-varying relativistic theory of gravity.

The fact that Yilmaz was able to extend the principles of Einstein's theory, to achieve a complete and rigorous relativistic theory of gravity, proves that the principles of Einstein's General theory of Relativity are correct; even though Einstein's gravitational field equation is flawed.

References

- [1] Adrian Bjornson, *A Universe that We Can Believe*, Addison Press, Woburn, MA, 2000, ISBN 09703231-0-7.
- [2] Adrian Bjornson, *The Scientific Story of Creation*, Addison Press, Woburn, MA, 2002, ISBN 09703231-2-3.
- [5] W. Pauli, *Theory of Relativity*, 1958 Pergammon Press, reprint Dover Pub, NY, ISBN 0-486-64152-X

- [6] John A. Peacock, *Cosmological Physics*, 1999, Cambridge U. Press, United Kingdom, ISBN 0-521-42270-1.
- [7] Albert Einstein, *The Meaning of Relativity*, Princeton University Press, 5th ed., 1953, ISBN 0-691-02352-2, (1st ed. 1921), (See appendix for 2nd ed., 1945, p. 129).
- [8] J. R. Oppenheimer and H. Snyder, "On Continued Gravitational Contraction", *Physical Review*, Sept. 1939, vol 56, pp 455-459.
- [9] Albert Einstein, "On a stationary system with spherical symmetry consisting of many gravitating masses", *Annals of Mathematics*, Oct. 1939, vol 40, No 4, pp 922-936 (see p. 936).
- [10] Alley, Carroll O., "Investigation with lasers, atomic clocks [etc.] of gravitational theories of Yilmaz and Einstein", in *Frontiers of Fundamental Physics*, 1994, M. Barone and F. Selleri, eds, pp. 125-137, Plenum Press, NY.
- [11] Carroll O. Alley, "The Yilmaz Theory of Gravity and its Compatibility with Quantum Theory", *Ann New York Acad Science*, 1995 vol 755, pp 464-477.