

# Einstein's Real 'Biggest Blunder': Reveals Itself from the 'Bits'

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## I. INTRODUCTION

Physics is integral to a deep understanding of reality, while information is fundamental to physics. Scientific information is often infused with surprising potential to shape a physical theory, if perceived correctly. The following presents an enlightening example of how understanding information correctly, can bring a paradigm shift in a theory. A deep reflection on the following information, reveals a startling new idea leading to a fundamentally different view of the theory of general relativity (GR):

1. In GR, gravitation is a manifestation of the curvature of the spacetime geometry whose source is matter, represented by the energy-stress tensor  $T^{ik}$  appearing in Einstein's field equations

$$R^{ik} - \frac{1}{2}R g^{ik} = -\frac{8\pi G}{c^4}T^{ik}, \quad (1)$$

where  $R^{ik}$  is the Ricci tensor,  $R$  the Ricci scalar,  $g^{ik}$  the metric tensor,  $G$  the gravitational constant and  $c$  the speed of light in vacuum. Despite its remarkable success, GR has to take refuge in the speculative dark matter, dark energy and inflaton field, which constitute more than 95 percent of the contents of  $T^{ik}$  but do not have any direct observational support. The biggest mystery of  $T^{ik}$  is not that the majority of its content cannot be seen, but that it cannot be comprehended! Moreover, the most favoured candidate of dark energy - the cosmological constant - is plagued with horrible fine-tuning problems.

2. It is believed that the source of curvature present in a solution of (1), is primarily  $T^{ik}$ , in the absence of which the solution must have a singularity, serving as the source.

However, there exists a solution of

$$R^{ik} = 0, \tag{2}$$

(to which equations (1) reduce for vanishing  $T^{ik}$ ) discovered by Ozsváth and Schucking [1], which is curved but singularity-free, defying the conventional wisdom.

3. The complete Einstein's equations (1), with a non-vanishing  $T^{ik}$ , have never been tested directly in any experiment. Let us recall that the classical tests of GR consider  $T^{ik} = 0$  in (1), and hence they have remained limited to test (2) only.
4. It has been shown recently [2] that all the cosmological observations can be explained successfully in the framework of Milne model (a homogeneous and isotropic solution of (2)) (obviously, without requiring the dark components, as  $T^{ik}$  is absent in this model). Moreover, the model averts the long-standing problems of the standard cosmology, such as the horizon, flatness and cosmological constant problems. This may seem like an extraordinary coincidence, as the Milne model is not believed to represent the real Universe!

This information perhaps hints that the properties of gravity are beyond the standard paradigm and we might have misunderstood the true nature of a geometric theory of gravitation because of the way the ideas have evolved historically. It perhaps signals towards a subtler way of incorporating source of gravitation/curvature in the theory than the conventional one by  $T^{ik}$ , intimating that a geometric theory of gravitation should not have any bearing on the energy-stress tensor.

Einstein always viewed with suspicion the representation of the source of gravitation by  $T^{ik}$ . He emphasized that the 'source term'  $T^{ik}$  should include all the sources of energy, momenta and stresses, including those of the gravitational field (which also gravitates). Although, the tensor  $T^{ik}$  in (1) includes in it all the sources of gravitation including the cosmological constant or any other dark energy candidate, but *except the gravitational field itself*. Failing to find a tensor representation of the gravitational field, Einstein admitted that "*the energy tensor can be regarded only as a provisional means of representing matter*". Alas, a century-long dedicated effort to discover a unanimous formulation of the energy-stress tensor of the gravitational field, has failed, concluding that a proper energy-stress tensor of the gravitational field does not exist.

The doubt Einstein had about representing matter by  $T^{ik}$ , is further strengthened by a recent foundational analysis which discovers some surprising inconsistencies and paradoxes in the formulation of the energy-stress tensor of the matter fields, concluding that the formulation of  $T^{ik}$  does not seem consistent with the geometric description of gravitation [3].

This surprising discovery, taken together with the above-mentioned points, makes a strong case to examine whether it is not possible to interpret the real Universe (with matter) without having recourse to  $T^{ik}$ . Intriguing though it may appear, however we shall see in the following that the so-called ‘vacuum’ field equations (2) do not represent an empty spacetime, since the energy, momenta and angular momenta of the gravitational and the material fields do exist in the metric field, whose effects are revealed through the geometry, *without including any formulation of the energy-stress tensor*. This results in a complete reconceptualization of the source of curvature in GR, leading to a paradigm shift in the theory.

## II. THE SPACETIME METRIC APPEARS AS THE FIELD

Let us recall the curved solutions of Einstein’s equations which are obtained in the absence of  $T^{ik}$ . As the presence of curvature conclusively signifies the existence of some source, we need to examine critically the conventional dictum that the space will remain empty in the absence of  $T^{ik}$ . Let us start the examination with the well-known Schwarzschild solution of equations (2):

$$ds^2 = \left(1 + \frac{K}{r}\right) c^2 dt^2 - \frac{dr^2}{(1 + K/r)} - r^2 d\theta^2 - r^2 \sin^2 \theta d\phi^2, \quad (3)$$

where  $K$  is a constant of integration. The solution represents a static, isotropic spacetime structure outside an isotropic mass, say  $M$ , placed at  $r = 0$ . As  $M$  is not included in (2) through  $T^{ik}$  and the solution (3) still has curvature, there must be some hidden source inherently built in equations (2) itself. Let us unveil it.

Being a local theory, GR assigns the intrinsic curvature present at a particular point, to the matter-energy present at that very point. The locality of the theory is necessary because GR has no action at a distance. Hence, we should not expect any curvature at the points for  $r > 0$  in (3), as supposedly there is no source there! A mass situated at  $r = 0$  should not be expected to curve the space of (3) at the points where  $r > 0$ .

A little reflection suggests that the agent responsible for the curvature in (3) at the points

for  $r > 0$ , must be the gravitational energy, which can definitely exist in an empty space. However, as no formulation of the gravitational energy is included in equations (2) (neither in equations (1)) but it does show its presence in (3), it can emerge only through the metric field. However, if this is true, can we calculate the gravitational energy from solution (3)? Yes, we can certainly do this by the following simple observation:

The metric (3) departs from the flat spacetime in the term  $K/r$ , implying that this term must contain the source of curvature.

This implies that  $K/r$  must be the gravitational energy in (3). This is in perfect agreement with the Newtonian concept of gravitational energy to which GR should reduce in the case of a weak gravitational field, implying

$$K = -\frac{2GM}{c^2}. \quad (4)$$

It is thus established that the source of curvature in (3) is the energy of the gravitational field present at the points exterior to  $r = 0$ . Thus the long-sought-after gravitational energy appears through the geometry of equations (2), *without including any formulation thereof!* This also establishes beyond doubts that the gravitational energy does gravitate and equations (2) do contain source.

If the mass  $M$  rotates as well, the spacetime structure around it is given by the Kerr solution and it can be shown similarly that the angular momentum of the gravitational field is also present in equations (2). This further corroborates the futility of the energy-stress tensor wherein there is no place for the angular momentum in the framework of GR.

One would not show much inhibition to agree that the gravitational energy is inherently present in equations (2) (without incorporating any formulation thereof) resulting from the non-linearity of the equations. Nevertheless, one would maintain that equations (2) represent otherwise empty space *outside* the matter source. However, this interpretation does not appear compatible with another important solution of equations (2) - the Kasner solution:

$$ds^2 = c^2 dt^2 - (1 + nt)^{2p_1} dx^2 - (1 + nt)^{2p_2} dy^2 - (1 + nt)^{2p_3} dz^2, \quad (5)$$

where  $n$  is an arbitrary constant and the constants  $p_1$ ,  $p_2$  and  $p_3$  satisfy  $p_1 + p_2 + p_3 = 1 = p_1^2 + p_2^2 + p_3^2$ . The solution was discovered in this form by V. V. Narlikar and K. R. Karmarkar

[4], which can easily be transformed to the standard form by suitable transformations.

The conventional interpretation of the Kasner solution is obscure and questionable. The solution is interpreted in terms of an empty homogeneous Universe expanding/contracting anisotropically (for instance, it expands in two directions and contracts in the third). However, what actually expands/contracts is sharply controversial in this interpretation: How is it possible for space, which is utterly empty, to expand/contract? How can nothing expand/contract? It does not make sense to think of expanding/contracting space *without* matter.

The source of curvature in the Kasner solution is attributed to a singularity, which appears at  $t = -1/n$  in (5). However, the singularity does *not* appear at any other time, whereas the solution is curved at all times! A past singularity, which does not exist now, fueling the gravitational energy now without any other source, does not appear logical.

Another possibility is to interpret the source of curvature in (5) in terms of a net non-zero momentum resulting from the anisotropic expansion/contraction of the homogeneous space. But again this becomes meaningless in the absence of matter. Hence, the conventional interpretation of this solution has either no physics, or wrong physics, and the Kasner solution has remained an unexplained mystery.

An important point regarding the Kasner solution, which has not been paid attention to, is that unlike the Schwarzschild and Kerr solutions, the Kasner solution represents a cosmological solution, which is not expected to have any ‘outside’. Since the ultimate source of the gravitational field is matter, the matter source present at  $t = -1/n$ , must be present at all other times as well, as it *must not* disappear mysteriously! This simply means that the Kasner solution represents a homogeneous distribution of matter expanding/contracting anisotropically! This can give rise to a net non-zero momentum density serving as the source of curvature present in (5). However, if this is correct, can we extract it from (5)? Yes, this can similarly be done by realizing that

For  $n = 0$ , metric (5) reduces to the Minkowski metric<sup>1</sup>, implying that the source of curvature, given in terms of the momentum density, say  $\mathcal{P}$ , must be contained in  $n$ .

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<sup>1</sup> Though (5) can also reduce to the Minkowskian form for vanishing  $p_1$ ,  $p_2$  and  $p_3$ , however they are pure numbers and cannot support the momentum density.

It is indeed possible to express  $n$  in terms of  $\mathcal{P}$ ,  $G$  and  $c$  in order to meet its natural dimension in (5) (which is of the dimension of the inverse of time). Hence,  $n$  finds a unique expression

$$n = m\sqrt{\frac{G\mathcal{P}}{c}}, \quad (6)$$

where  $m$  is some dimensionless constant. It is difficult to verify (6) with a classical analogue (as we could do in the case of the Schwarzschild metric) since in the Newtonian gravitational theory, the field is independent of the motion of the source.

This simply means that like the energy, momentum and angular momentum of the gravitational field, those of the matter fields are also included implicitly in equations (2), whose effects are revealed through the geometry! This might appear baffling and orthogonal to the usual understanding, nevertheless, if the source mass  $M$ , producing the gravitational field in (3), can appear (through a constant) without taking recourse to the energy-stress tensor, the same can happen for the matter fields as well. This results in a new paradigm which holds promise for understanding many unexplained mysteries in a unified manner, as we shall see in the following.

### III. INTERNAL CONSISTENCY OF THE NEW PARADIGM

It would be interesting to note that a homogeneous, isotropic cosmological solution of equations (2) becomes Minkowskian. As this solution appears naturally in Milne's kinematic cosmological theory [2], it is generally called the Milne solution.

It would prove challenging for the standard paradigm to explain why Milne solution is flat, while solutions (3, 5) are curved, when all the solutions belong to the same equations (2) and the absence of  $T^{ik}$ . It is generally believed that the curved solutions of equations (2) must belong to a spacetime structure outside a mass, otherwise they must be flat. However, we have already seen, in the Kasner solution (5), that this is not correct. Thus, how a simple change from anisotropy to isotropy can reduce the curved solution (5) into a flat Milne solution, or why this change removes the singularity from the Milne solution, cannot be answered by the conventional wisdom.

Remarkably, a convincing resolution comes from the new paradigm only. As the geometry of equations (2) contains inherently built-in ingredients of the gravitational and the material fields, the structure of the geometry would be determined by the net contribution from the

material and the gravitational fields of the chosen matter distribution. Hence, the Milne solution is flat because it represents a homogeneously distributed matter throughout the space at all times, which is either expanding or contracting isotropically. As the positive energy of the matter field would be exactly balanced, point by point, by the negative energy of the resulting gravitational field (contrary to the case of the Schwarzschild solution where there is only the gravitational energy and no matter at the points represented by the metric), this would provide a net vanishing energy. Neither there would be any momentum contribution from the isotropic expansion or contraction of the material system (contrary to the case of the Kasner solution). Hence, in the absence of any net non-zero energy, momentum or angular momentum, the spacetime of Milne solution must not have any curvature.

This also appears consistent with several investigations and results which indicate that the total energy of the Universe is zero. Hawking and Milodinoz have argued recently that the total energy of the Universe must always remain zero, as the positive energy of the matter can balance the negative gravitational energy [5].

The new paradigm receives the strongest support from the singularity-free curved solution of Ozsváth and Schucking [1], which reveals the inadequacy of the conventional interpretation of the source of curvature by a singularity in the absence of  $T^{ik}$ . The presence of curvature in this solution guarantees the presence of matter fields in equations (2) and strongly supports the novel representation of the source through geometry, reducing  $T^{ik}$  as a redundant part of Einstein's equations.

This seems consistent with Einstein's earlier belief that *"on the basis of the general theory of relativity, space as opposed to 'what fills space' has no separate existence"*. Thus the mere consideration of a spacetime structure should be equivalent to considering the accompanying fields (material and gravitational) also, and there should be no need to add any extra formulation thereof to the field equations. This explains the mystery why the Milne model, which is (mis)believed empty and unphysical, is consistent with all observations without requiring the epicycles of the standard paradigm. The observations actually reveal a simpler and more elegant Universe than anyone could have imagined! The resultant theory becomes Machian, since the so-called 'vacuum' solutions do not describe a spacetime devoid of matter. The Big Bang singularity of the standard cosmology is also circumvented in the new paradigm, in the Minkowskian form of the homogeneous, isotropic Universe.

Thus, different pieces appear to fit consistently in the framework of the new paradigm and

the conceptual difficulties of the standard paradigm are removed. The absence of flawless energy-stress tensors of the material and the gravitational fields, and the appearance of these fields through the metric field in equations (2), leave the canonical equation  $R^{ik} = 0$  as the only possibility for a consistent field equation of gravitation. This may be called the geometrization of matter, which appears as an intrinsic characteristic of a geometric theory of gravitation (like GR). That is, the existence of matter should be understood in terms of the geometry of spacetime.

It is generally argued that a consistent field equation of gravitation should reduce to the Poisson equation  $\nabla^2\psi = 4\pi G\rho$  in the case of a weak stationary gravitational field. However, this requirement has already been compromised in the concordance  $\Lambda$ CDM cosmology. It should be noted that the Einstein field equations with a non-zero  $\Lambda$  do *not* fulfill this requirement [6]. While, there is no scope in the standard paradigm to mend this shortcoming, it would not be correct to compare the new paradigm (being a fundamentally different theory wherein matter does not appear explicitly in the dynamical equations) with the Poisson equation (wherein matter appears explicitly).

#### IV. CONCLUSION

The assumption that the matter can be incorporated into the field equations through the energy-stress tensor  $T^{ik}$  only, leads to inadequacy of interpretations to some solutions. Kasner solution and Ozsváth-Schucking solution are noteworthy examples. The curved Ozsváth-Schucking solution, which is free from any singularity, casts doubt over the conventional wisdom that the singularity is the sole cause of curvature in the absence of  $T^{ik}$ . The puzzle cannot be overlooked by arguing that all the solutions of Einstein's theory may not be physically meaningful. This would raise doubt over the general validity of the theory.

In this view, the new discovery that the energy, momentum and angular momentum of the gravitational field and those of the material fields, are built-in ingredients of the geometry of spacetime, provides a promising possibility for a new paradigm. This may be called the geometrization of matter, which appears as an intrinsic characteristic of a geometric theory of gravitation. Interestingly, the new paradigm provides a Machian theory which is consistent with observations at all scales and averts the problems of the standard paradigm, without requiring the epicycles of the standard paradigm which have shaky foundations.

This reminds us of Einstein's so-called 'biggest blunder' wherein he was so convinced that the Universe was unchanging. In fact, this was assumed by everyone at that time, though there were plenty of currents of thought which were against the idea. We have a similar situation at the present time where everyone thinks that the Universe would remain empty unless we *fill* it with  $T^{ik}$  though ignoring numerous evidences earnestly indicating otherwise. It appears that the revolution that Einstein began a century ago, is not yet over!

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